VG401
Development of a disease indexing package to predict crop losses in peas & beetroot

Rob O'Brien, Dominie Wright, Matthew Skett
Queensland Department of Primary Industries

Know-how for Horticulture™

VG401
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FINAL PROJECT REPORT

VG401: Development of a disease indexing package to predict crop losses in peas and beetroot

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Matthew Skett

December 1998

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CONTENTS

TECHNICAL SUMMARY

Several fungicides were screened for activity against common pathogens of beetroot and peas. Metalaxyl as a drench or seed dressing was effective in controlling damping-off due to *Pythium* sp. while tolclofos methyl was similarly effective against *Rhizoctonia solani*. None of the fungicides tested (including foestyl, dimethomorph and thiram) were effective against *Aphanomyces euteiches* or *A. cochlioides*.

A technique for indexing disease severity in soil was developed for both beetroot and pea crops. By using different fungicide seed dressings (thiram, metalaxyl, tolclofos-methyl) it was possible to focus on the potential of different organisms.

Although the technique was reliable i.e. it could consistently rank different soil samples, the correlation of results with field disease severity was less consistent. Field variables (weather conditions, cultural practices) impacted on the relationship between a field's disease potential and the actual disease severity.

INDUSTRY SUMMARY

Due to crop specialisation associated with the production of processing crops, soil-borne disease problems can progressively increase. These are seen as establishment problems (patchy stands) or lower productivity (low vigour crops due to inefficient root system). In beetroot, it is mainly an establishment problem due to the fungi *Aphanomyces cochlioides* and *Pythium* sp. These are particularly active in wet seasons, hence the severity of the problem varies from year to year. Root disease problems in peas are commonly due to *Aphanomyces euteiches*, *Fusarium solani, Pythium* sp. and *Ascochyta pinodella*. They exert a debilitating effect on the plant.

Protective fungicidal seed dressings such as thiram and metalaxyl offer protection against some of the establishment losses due to *Pythium* sp. but are not effective against *Aphanomyces* sp. or debilitating diseases.

In this project we developed a method of estimating the disease potential in beetroot and pea soils. It is based on a bioassay of a representative soil sample and can be completed within four weeks. We compared results of this bioassay with actual field disease severity at many locations and found there was a reasonable correlation. The major factor influencing the correlation between test and field results was the variability of seasonal conditions. The test is designed to predict disease losses in seasons which are conducive to disease. In dry years field disease severity is usually less than predicted. For growers, perhaps the major benefit of soil indexing is to pinpoint which fields are at risk so they can be scheduled for rotation with alternative crops.

1. INTRODUCTION

1.1 THE INDUSTRIES

BEETROOT. Production of beetroot (*Beta vulgaris* var. *cicla*) for processing in the Lockyer and Fassifern Valleys is an important horticultural industry. In 1995, 30 000 t were produced at an average farm gate price of $130.00 per tonne. Processing, carried out by Golden Circle and Simplot Australia (formerly Edgells) carries a high value adding component since the cost of raw product is only approximately 12% of the value of the processed tinned beetroot. The value of the processed crop is approximately $33 m. The area produces about 90% of Australia's beet crop.

Beetroot is somewhat tolerant of high salt levels and is a very useful crop for farms with a moderate salinity problem. Maintenance of beetroot production as an industry is essential for the viability of many such farms.

A viable beetroot industry requires the cost of the final product to be comparable with that of imported product, usually from countries with lower labour costs. This requires efficient field production through high production per unit area and efficient utilisation of processing plant through an extended harvesting period.

There are many factors which stand in the way of efficient production but an important one for this industry is crop establishment problems due to soil-borne diseases. Two main contributing factors are, the specialisation of many farms as beetroot producers with, often, short rotations and the demands by processors to extend the growing season into high disease risk (summer) periods. Early season crops, e.g. February plantings, face high temperatures and more frequent wet weather periods than those sown later. Soil fungi such as *Aphanomyces cochlioides, Pythium* spp. and *Rhizoctonia solani* are more active and losses (pre-emergence and post-emergence) can be high.

PEAS. During the course of this project, the processing pea industry in south-east Queensland continued its decline due to commercial decisions by the processors. Formerly an industry of 10 000 acres, it is now reduced to about 1 000 acres producing 6000 t at an average price of $350.00 per tonne ($2.1 m). The value of the local processed product is approximately $7 m. The commercial factors governing these decisions are based on profitability, cost of production, efficient use of processing plant, market changes (lower demand for frozen peas) and ability to import lower cost frozen product from New Zealand subsidiary companies. Processed peas in Queensland are now predominantly for the canning trade.

The edible pea crop throughout the world is affected by soil-borne disease problems, principally *Aphanomyces euteiches*. With intensive pea production, root rot severity increases and productivity declines. This disease organism is widespread in south-east Queensland and also in the main Australian pea growing area of northern Tasmania. On-farm observations during the project indicated that the importance of root rot in south-east Queensland was declining, possibly due to the smaller crop and longer rotation period. The need for a disease prediction test under these conditions is of lower priority but it may be useful in areas, e.g. Tasmania, where intensive production occurs and root rot continues to be an impediment to efficient production.

1.2 SOIL-BORNE DISEASES AND THEIR CONTROL

BEETROOT. Previous experience has shown the fungi associated with seedling death in beetroot are:

Aphanomyces cochlioides. This organism was first recognised in Queensland in 1979 (Hutton & O'Brien i986). It causes post-emergence death for up to six weeks after emergence. Plants which are affected but survive past this stage, may recover or remain unthrifty, depending on environmental conditions. Wet conditions in high risk soils can lead to large, black depressed lesions on mature beet.

The first sign in the field is usually reddening of young seedling leaves. Infected roots are at first pale brown but turn dark brown-black as the disease progresses. The stem above and below ground level becomes black. Seedling death follows. *Aphanomyces cochlioides* survives in the soil for extended periods as oospores. Plant infections are initiated by swimming zoospores which are produced then released from zoosporangia during wet conditions. The fungus is well adapted to a wet environment, hence severe disease outbreaks are usually associated with frequent showery weather. There is no known plant resistance and no outstandingly effective fungicides effective against *A. cochlioides.* It has a limited host range (main commercially important hosts are sugar beet and beetroot — both strains of *Beta vulgaris*). Extended rotations should therefore lead to reduced severity.

Rhizoctonia solani. This fungus can cause both pre- and post-emergence death of seedlings. Post-emergence infection is usually more common and occurs as a dark pinched area near ground level. The stem usually collapses at this point. Infection of mature beets can occur if there is a high disease potential. Infection can be extensive and seen as an irregular i.e. bumpy, depressed dark lesion. Webs of grey-brown mycelium are often seen on the surface of lesions. *R. solani* colonises dead organic matter in the soil and its importance as a pathogen is associated with the quantity of food available in the soil. Sowing too soon after ploughing in a cover crop can lead to high losses. The standard seed dressing, thiram, is inadequate to prevent these losses. Rhizoctonia specific fungicides such as tolclofos-methyl (Rizolex) are effective but not yet registered for use in beetroot.

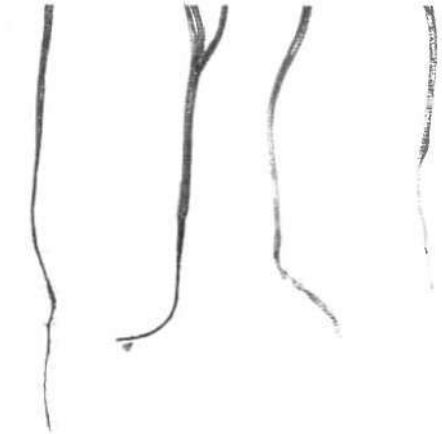
***Pythium* spp.** cause pre- and post-emergence losses. In young seedlings the fungus spreads quickly from roots to the stem which becomes soft and watery before the seedling collapses. Clumps of seedlings are often affected. Infection of roots of mature plans may occur causing death of sections of feeder roots. *Pythium* spp. are adapted to thrive under wet soil conditions and disease spread is by motile zoospores. Long term survival is by thick walled oospores.

The standard seed dressing, thiram, is inadequate to control losses when disease potential is high. Apron 350SD (metalaxyl) is much more effective and is commercially available.

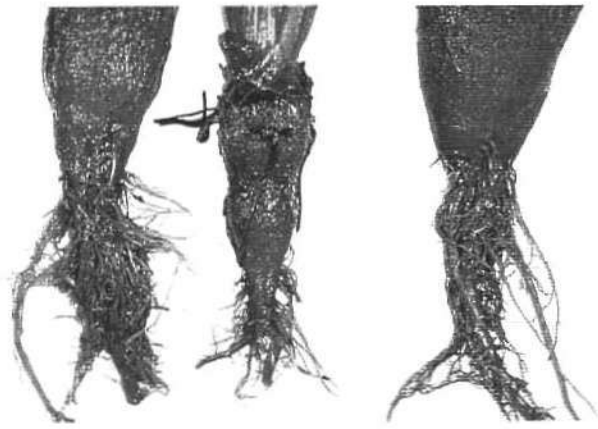
PEAS. Based on our experience with pea root rot in the Lockyer and Fassifern Valleys of south-east Queensland, the following pathogens can be associated with damping-off (seedling death) and root rot of peas.

***Pythium* spp.** is the major cause of damping off (pre- and post-emergence death of young plants). Its occurrence is as described for beetroot.

Some Root Diseases of Beetroot in S.E. Qld

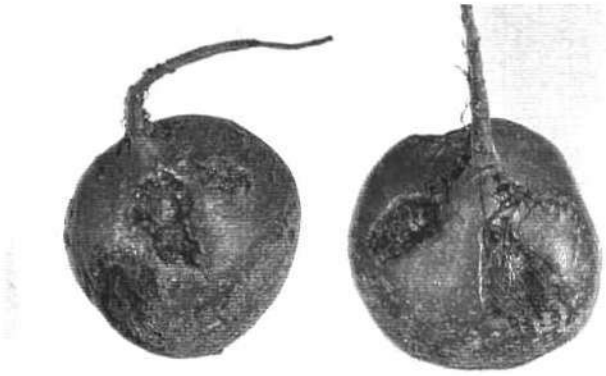


Damping off - *Pythium* sp. and *Aphanomyces cochliodes*



Beet hairy root - infections of mature beet by a complex of soil pathogens

Aphanomyces cochlioides - (left) root rot

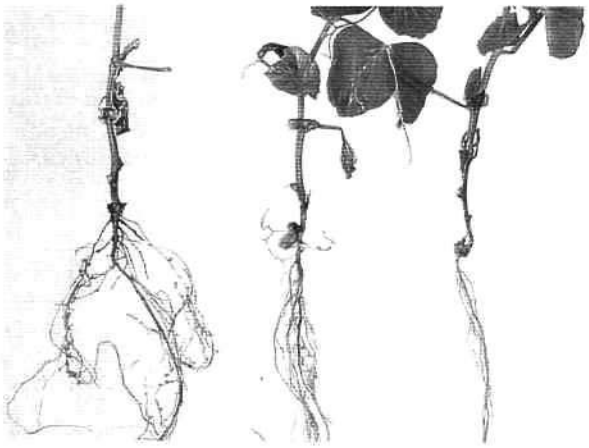


Aphanomyces cochlioides - beet lesions

Rhizoctonia solani - beet lesions

Wrinkled beet - genetic/nutritional disorder

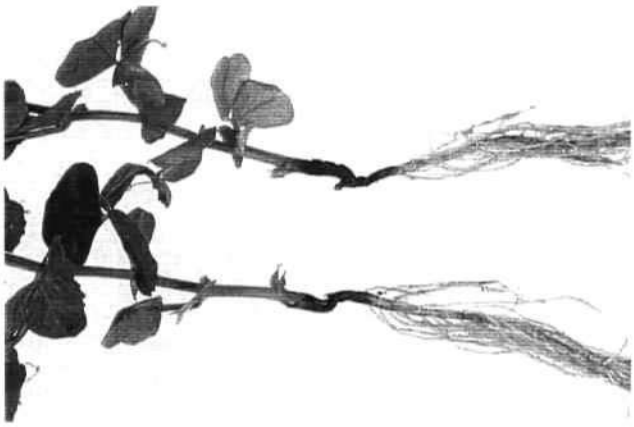
Some Root Diseases of Peas in S.E. Qld



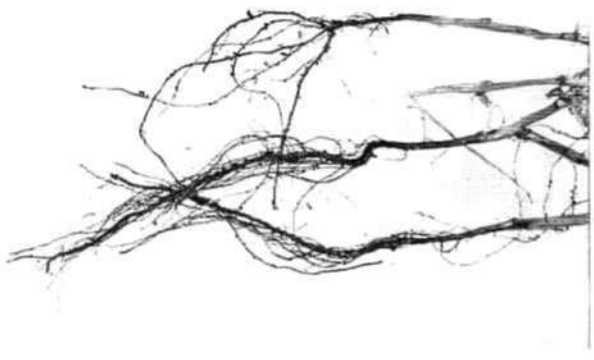
Aphanomyces euteiches

Ascochyta pinodella

Soil borne pathogens have a debilitating effect on root and plant growth



Fusarium solani



Chalara elegans

Rhizoctonia solani can also be associated with seedling damping-off and red sunken stem lesions on more mature plants .

Aphanomyces euteiches is probably the most important fungus causing root rot in peas. Under field conditions it is seldom associated with complete death of plants but, rather, causes debilitation of plants by destroying much of the root system. *A. euteiches* has a host range which includes beans (*Phaseolus vulgaris*) and lucerne (*Medicago sativa*) which are commonly grown crops in south-east Qld. Infection occurs through zoospore infection of rootlets. Outer root tissues are, at first, pale yellow but become darker. Fine roots are destroyed. The outer tissue of larger roots becomes loosely attached to the central stele and can be easily stripped off between thumb and index finger. *A. euteiches* has a similar life cycle to *A. cochlioides* being adapted to wet soil conditions, little useful plant resistance and lack of adequate fungicidal control measures. Rotations should avoid the other known hosts, i.e. beans and lucerne.

Fusarium solani causes a reddish-brown discolouration of roots. The disease usually commences near the seed piece then extends to the extremities of the root system. Plant growth is slow due to loss of feeder roots. In severe cases the lower section of the stem above ground level is affected. The disease is favoured by high soil temperatures (>25) and is therefore not usually an important problem in the winter growing season in south-east Qld.

Ascochyta pinodella causes foot rot –a disease which affects the crown of the plant. The root extremities may be unaffected but the dark brown rot at the base of the plant causes slow growth.

Chalara elegans. is a comparatively rare cause of root rot in south-east Qld. but can occur as an important pathogen in small areas. Roots of mature plants are dark-brown – black. Microscopically the complex chlamydospores can be seen embedded in root tissue. *Chalara elegans* exists as many strains which attack a wide range of commercially important plants, e.g. ornamentals, lettuce, cotton and tobacco.

1.3 INDEXING SOILS FOR DISEASE POTENTIAL

There have been many reports of various soil indexing procedures to measure root rot potential in peas caused by A. *euteiches* since Sherwood and Hagedorn (1958) described the basic technique. In comparison, predicting the potential of *A. cochlioides* in either beetroot or sugarbeet has received little attention. Fink (1948) sampled 24 sugarbeet fields and estimated the percentage infected seedlings after 30 days growth in potted soil. He found a correlation of 0.925 between percentage of seedlings killed by *A. cochlioides* in the greenhouse and field crop loss estimates. A different approach to controlling sugarbeet establishment losses has been taken in Japan where seedlings are established in small pots then field transplanted.

Indexing pea soils has been found a useful technique for recognising, then avoiding, high risk soils for over 40 years. The usual test involves collecting a representative soil sample, filling three or four pots (15 cm diam, 10 cm deep), sowing 10-12 seed 2 cm deep then growing at close to field capacity for 14-28 days. Roots are then rated for disease severity on a 0-4 scale where 0 indicates no disease and 4 indicates roots are completely diseased/plant dead.

The risk of field disease increases between 0 and 4 and a warning is issued at an index of about 2.5.

Biddle (1984), in the U.K., related the results obtained from soil indexing several hundred fields with subsequent yield and suggested there was a high probability of yield reduction at indexes higher than 2.2 with yield losses of 0.2 t/ha expected for every 0.1 increase.

Disease indexing is usually directed at the complex of disease organisms which contribute to root rot. In some areas *A. euteiches* may predominate, in others *Ascochyta* sp. or a combination of several different fungi may be more important.

Since most pathogens are affected by soil moisture levels, it is recognised that standardised watering practices must be part of the test. In general, the most practical method is to maintain soils at, or close to, field capacity once the seedlings have emerged.

Disease indexing can help to recognise which diseases are most important, in particular districts or fields. Isolations from test plants will indicate which fungi are present and their frequency. In some cases there may be effective fungicide treatments, e.g. metalaxyl for Pythium control. For other pathogens, e.g. Aphanomyces, avoiding high risk soils and including them in long-term rotation is the only alternative.

The suppressiveness of soils to pathogens is an area which deserves more attention for the long-term control or reduction of soil-borne diseases. Worku and Gerhardson (1996) found 11 of 71 soils tested were suppressive to *A. euteiches*. Suppressiveness was due to a biological component in the soil since it was destroyed by heat treatment. Understanding how to foster suppressiveness should be a long-term goal for control of soil borne diseases. Oyazan *et.al* (1997) found *A. euteiches* was the most dangerous pea pathogen in Holland since most of the 12 soils tested were receptive to *A. euteiches* and soil populations increased, even in the absence of pea crops.

As a general rule, improving soil structure and microbial complexity in the soil through mulching improves the chance of increased natural suppressiveness to pathogens. Pea and beetroot producers in south-east Qld are using green manures more frequently and thus could gradually reduce the importance of root disease problems. The use of a soil disease indexing test could play an important role in identifying the fields most in need of rejuvenation.

1.4 THE DEVELOPMENT OF SOIL INDEXING TESTS FOR BEETROOT AND PEA CROPS IN SOUTH-EAST QUEENSLAND

A disease indexing test is a bioassay. A sample of field soil is taken and sown to the crop. After a period of time (3-4 weeks) counts are made of some indicator of disease activity, e.g. seedling emergence, disease severity on roots or seedling death. The soil environment in pots is different from that in the field. Pots are generally watered daily which provides, on average, higher soil moisture than occurs in the field. The soil structure is also different — soil samples are sieved so that rocks and plant trash are removed and to ensure the sample is well mixed and uniform in replicate pots.

Initially, we conducted soil tests in 15 cm pots with up to 20 seed sown in each. During the course of the project we made alterations to procedures to improve the speed and convenience of the test as well as adapting it for the local suite of pathogens. For these

reasons, there are some minor differences in procedures used as the project progressed. These included:

- Smaller pot size with increased replications. We found with large pots, there was secondary spread of disease from early infections. This over-emphasised the importance of fast growing, early infecting pathogens such as *Pythium* and *Rhizoctonia* at the expense of *Aphanomyces* which is mainly a post-emergence pathogen. Smaller soil samples, 50 or 100 mL per pot, instead of 1 000 mL samples for 15 cm diameter pots, seemed to overcome this problem as well as reducing the size of the field sample (3-5 L instead of 16 L). Bench space requirements were also greatly reduced.

- **Seed dressings.** The three genera of disease organisms (Pythium, Rhizoctonia and Aphanomyces) are major components of root rot and damping-off in both pea and beetroot soils. Experiments showed that the fungicidal seed dressings Apron 350SD and Rizolex 500 WP were very specific and very effective in controlling *Pythium* spp. and *R. solani* respectively. By using different combinations of these, it was possible to judge the relative importance of each pathogen.

- **Monogerm seed in the beetroot test.** Several tests were conducted in which we used monogerm seed (cv. Monolith) instead of polyembryonic seed in an attempt to obtain more accurate figures for pre-emergence losses. Unfortunately, monogerm seed gave low, variable emergence rates and we returned to using polyembryonic seed.

The final test procedure for beetroot was:

- Collect a representative soil. Take small samples (about 250 mL) from just below the soil surface. Avoid collecting rocks, sticks or hard clods. Take at least 40 such samples in a W pattern over the field. Depending on the size and uniformity of the paddock, more than one representative sample may be required. Mix the 10+ litres thoroughly and keep 3-5 L for the test.

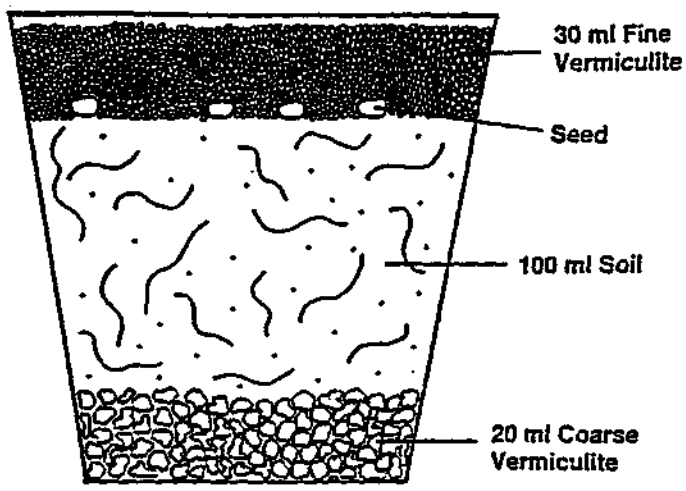
- A sub-sample (1 L) is steam sterilized or autoclaved after sieving through a 6mm mesh screen.

- A test is conducted in 24 150 mL pots in a pot holder (Fig.1-2). Twenty mL of coarse vermiculite is placed in the bottom of each pot, then 100 mL soil. Four pots are filled with sterile soil while the remainder (20) are filled with natural field soil. The soil is wet to field capacity.

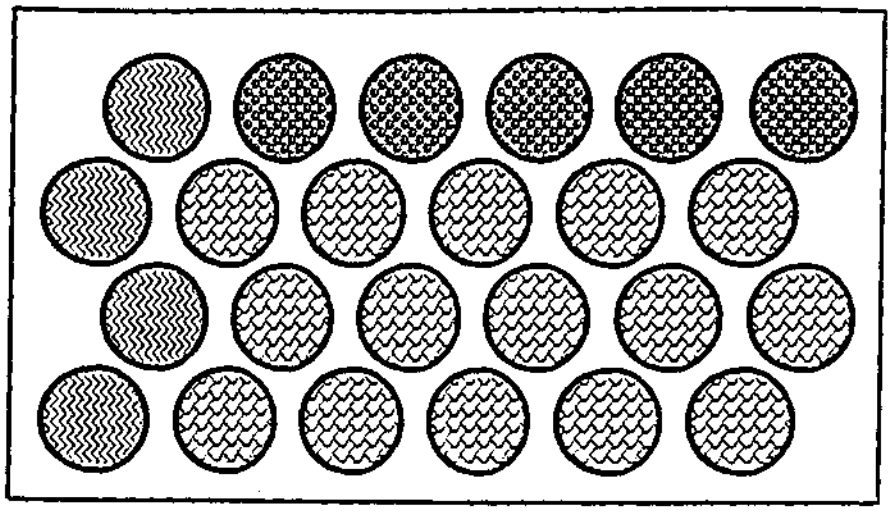
- Seed treated with Apron 1.5 g/kg + Rizolex 1.5 g/kg + Thiram 2 g/kg (A+R+T) is placed on the soil surface of 15 pots (12 seed/pot). Thiram treated seed is sown in the remaining five pots of natural soil and in four pots of sterile soil. The cultivar should be representative of the local commercial types.

- Thirty mL of fine vermiculite is used to cover the seed in each pot, and lightly watered.

- Pots are covered with an inverted tray until germination. This prevents seed being harvested by rodents which occasionally infest glasshouses. It also provides a uniform environment for germination.



Setting up a pot for indexing.



Layout of 24 pots in an indexing test.

- Sterile Soil
- Thiram Treated Seed
- Apron + Rizolex + Thiram Treated Seed

- Irrigation of pots is usually 1/day to bring soil to field capacity.

- Dead seedlings are removed every three days until 21 days after sowing and recorded as a progressive count for each pot.

- Between 14-21 days after sowing, isolations are made from the diseased seedlings in the natural soil or thiram treated seed pots to determine the range of organisms present.

- The disease index is calculated on a 0-5 basis for each pot.

  0 - no dead/diseased seedlings
  1 - 1-3 dead/diseased seedlings
  2 - 4-8 dead/diseased seedlings
  3 - 9-12 dead/diseased seedlings
  4 - >12 dead/diseased seedlings but some still alive
  5 - all seedlings dead

Since polyembryonic seed is used, reference is made to the sterilised soil pots for a guide to probable seedling populations from 12 seed. It is usually >18 and may be as high as 24, depending on the seed source.

A less accurate, but also less time consuming option is simply to remove dead seedlings without counting them every three days, and allocate the 0-5 rating at the end of 21 days using the populations in the sterile soil as a guide to numbers lost.

- **Interpretation of results.** This depends on both the disease index and pathogen identity. The index obtained with the A+T+R treated seed is the result of Aphanomyces activity. Losses in the thiram treated seed gives the total disease potential of the soil. Isolations will show the contribution of Pythium or Rhizoctonia to the increased index in this test.

  A high Aphanomyces activity results in high figures for both seed treatments.

0 - 1.5	low risk		
1.5 - 2 5	low – moderate	—	may be patches in high rainfall
2.5 - 3.5	moderate	—	risky, severity will depend on weather
3.5 - 5.0	high risk	—	avoid sowing for 3 years if possible. Use green manure crops to improve soil structure.

If Pythium is active as indicated by a high index and high Pythium recovery in the thiram treated seed — use Apron to treat seed before sowing.

If Rhizoctonia has been active in the test (as shown by frequent isolation from diseased seedlings), irrigate and cultivate to break down organic residues before sowing. Use Rizolex (or other effective seed dressing) if it becomes registered.

For peas, a similar test was used except:-

- three seed were sown per pot

• disease ratings (Aphanomyces) were made on washed roots after 21 days using a 0-5 rating scale. For rating other root pathogens, the test should run for 4-6 weeks.

0 - no disease
1 - trace disease – small areas on feeder roots <10%
2 - low disease – 10-<25% root system affected
3 - moderate disease 25-<50% root system affected
4 - severe 50% - 75%
5 - plant dead or >75%

2. BEETROOT

2.1 EXPERIMENTS WITH SEED DRESSINGS AND SOIL DRENCHES

Fungicidal seed dressings are cheap and involve only small quantities of agrochemicals. A seed dressing which is active against the main beetroot pathogens would supplement the soil disease indexing test. While thiram is the standard fungicide used, it is a protectant and does not effectively protect seedlings once they extend outside the limited protection zone. More modern fungicides such as Aliette (74% fosetyl Al), Apron (35% metalaxyl), Rizolex (50% tolclofos methyl) and CME15103 (50% dimethomorph) have a systemic mode of action and could offer extended protection. Aliette, Apron and dimethomorph are active against Pythiaceous fungi while Rizolex is a Rhizoctonia specific fungicide registered for use on potatoes in Australia.

2.11 Experiment 1: Fungicidal seed dressings to protect beetroot against *Aphanomyces, Pythium* and *Rhizoctonia*

SUMMARY. *Five fungicides were used as seed dressings to control Aphanomyces, Pythium and Rhizoctonia in beetroot. Apron (35% metalaxyl) and Rizolex (50% tolclofos-methyl) gave excellent results against Pythium and Rhizoctonia respectively. No fungicide was effective against Aphanomyces.*

PROCEDURE. A 1:1 mixture of sterile (autoclaved) soil from a beetroot farm and U.C. medium was used in this experiment.

Inoculum was grown on sterile millet seed then incorporated at the rate of 250 mL per 12 L of potting mix (2%). The isolates of *A. cochlioides, R. solani* and *Pythium* spp. were obtained from beetroot. Each type of inoculum was mixed independently to give four soil inoculation treatments (3 fungi + non-infested), and used to fill 10 cm diameter pots.

Beetroot seed (Monolith single germ) was slurry treated with:

Apron (35% metalaxyl) 2 g/kg seed
Aliette (74% fosetyl Al) 4 g/kg seed
Rizolex (50% tolclofos methyl) 2 g/kg seed
CME151 (50% dimethomorph) 2 mL/kg seed
Thiram (50% thiram) 2 g/kg seed
Untreated

After seed had dried, 20 were added to the surface of each pot and covered with a layer of vermiculite.

Pots were watered daily and surviving healthy plants counted 16 days after sowing.

RESULTS.

Table 1

Effect of six fungicide seed dressing treatments on survival of beetroot seedlings in soil infested with *Aphanomyces, Pythium* and *Rhizoctonia*. Figures are means of 4 reps.

Fungicide treatment	Seedling survival (Max = 20)		
	Aphanomyces	*Pythium*	*Rhizoctonia*
Apron	0	14	0
Aliette	0	1	0
Rizolex	0	1	14
CME15103	1	0	0
Thiram	0	6	0
Untreated	1	2	0
LSD P = 0.05	NS	4	1

DISCUSSION. Each of the fungi was highly pathogenic in this test. Apron and Rizolex treatments gave complete protection against *Pythium* and *Rhizoctonia* respectively. No seed dressing was effective against *Aphanomyces*. Thiram was partially effective against Pythium. In summary, it seems that routine seed treatment with Rizolex and Apron would be much more effective than the standard seed dressing of Thiram. If a suitable seed treatment for *Aphanomyces* cannot be found, the estimation of disease organisms in the soil should be directed at this organism.

2.12. Experiment 2: Efficacy of beetroot seed dressings in controlling a complex of seedling diseases

SUMMARY. Potting mix contaminated with different levels of a mixture of R. solani, A. cochlioides, and Pythium spp. was used to test beetroot seed dressings of Apron, thiram, Rizolex and a combination. The use of Rhizolex allowed emergence but did not prevent post emergence deaths, presumably by Aphanomyces.

PROCEDURE. Contaminated potting mix from the previous test was used in this experiment. Equal quantities of contaminated mix of the three organisms was combined with clean UC mix in the ratios 100-0; 75-25; 50-50; 25-75 and 0-100. Small 100 mL round pots were filled to within 1 cm of the top, seed sown (5 per pot) and covered with vermiculite.
Seed treatments were: untreated, thiram 2 g/kg, Apron 2 g/kg, Rizolex 2 g/kg, a combination of these, no seed dressing. There were three replicates. The experiment was sited in a CEC at 22°C and 12/12 light regime.

Emergence counts were made 10 days after sowing and survival counts 17 days after sowing.

RESULTS. Stand counts are shown in Table 2. Good initial emergence was achieved with the combination seed treatment but survival was low. There was little difference in results between the infestation rates.

Table 2

Emergence and survival of beetroot treated with various seed dressings in UC mix contaminated with different levels (0, 25%, 50%, 75%, 100%) of *A. cochlioides*, *R. solani* and *Pythium* spp.

Seed treatment	Emergence (survival) max = 5				
	0	25	50	75	100
1 Untreated	3 (3.3)	1.3 (0)	0 (0)	0 (0)	0 (0)
2 Apron 2 g/kg	4.3 (3.3)	0 (0)	0 (0)	0 (0)	0 (0)
3 Rizolex 2 g/kg	4.3 (3.3)	3.6 (0)	2.3 (1.0)	1.3 (0)	1.6 (0)
4 Thiram 2 g/kg	2.6 (3.3)	1.0 (0)	0 (0)	0 (0)	0 (0)
5 2+3+4	4.3 (4.3)	3.6 (0.3)	4.0 (0)	2.3 (0.3)	4.6 (0)
LSD P = 0.05	NS (NS)	2.0 (NS)	0.4 (NS)	NS (NS)	0.8 (NS)

DISCUSSION. *Rhizoctonia solani* was a potent pre- emergence pathogen since there was no emergence in Apron treated seed. *Pythium* caused declining emergence figures in Rizolex treated seed. Thiram was much less effective against *R. solani* than Rizolex and there was practically no emergence. Use of a combination of seed dressings gave best results in controlling pre-emergence deaths but did not prevent post emergence death of seedlings presumably due to *Aphanomyces cochlioides.*

2.13 Experiment 3. The effect of fungicide soil drenches on survival of beetroot seedlings in potting mix infested with *Aphanomyces*, *Pythium* and *Rhizoctonia*

SUMMARY. Metalaxyl drench was specifically active against Pythium spp. and Rizolex against Rhizoctonia. Aliette showed limited activity against Pythium and Rhizoctonia; Dimethomorph was completely ineffective; thiram was promising against Aphanomyces.

INTRODUCTION. Fungicides may be applied as either seed dressings or as row applied drenches to prevent damping off. In a previous experiment, metalaxyl (Apron) and tolclofos methyl (Rizolex) as seed dressings were highly effective in controlling Pythium and Rhizoctonia respectively.

PROCEDURE. Inoculum to infest UC mix was grown on sterile white millet grain. The isolates of *Aphanomyces cochlioides, Pythium* spp. and *Rhizoctonia solani* originated from diseased beetroot seedlings.

Grain inoculum was mixed with UC mix at the rate of 250 mL/12L i.e. 2% by vol. Each isolate was kept separate.

Pots (10 cm diam.) were filled to within 15 mm of the top, wetted up and drenches applied. Metalaxyl was applied as 5% a.i. granules mixed into the soil at the rate of 0.25 g/L. The other products were added at the rate of 20 mL/pot. Fungicide drenches were: Aliette (74%) 4 g/L; Rizolex (50%) 2 g/L; dimethomorph (50%) 2 g/L; thiram (80%) 2 g/L. Twenty untreated seed of cv. Monolith were sown in each pot, covered with 1 cm vermiculite and lightly watered. There were 4 replications.

Counts of surviving plants were made at 10d and 17d after sowing.

RESULTS. There was some emergence in all treatments in the *Aphanomyces* infested pots. Most plants died except those treated with thiram which remained alive but stunted and unthrifty.

Metalaxyl was the only effective treatment for *Pythium* and tolclofos methyl the only effective treatment for *R. solani* (Table 3).

Table 3

The effect of fungicide soil drenches on emergence (at 10 days) and survival (at 17 days) of beetroot seedlings in the presence of *Pythium, Aphanomyces* and *Rhizoctonia.*

PATHOGEN		STAND COUNTS (max 20) at 10d and 17d						
		Aliette	Ridomil	Dimethomorph	Rizolex	Thiram	Nil	LSD(P=0.05)
1 *Aphanomyces cochlioides*	10d	11.5	5.5	8.0	4.0	13.5	4.7	
	17d	0.2	0	0	0	**9.5**	0.2	5.1
2 *Pythium* spp.	10d	5.2	11.7	0	0.2	4.0	0	
	17d	3.2	**13.5**	0	0.2	4.0	0	2.2
3 *Rhizoctonia solani*	10d	3.5	0	0	13.7	0	0	
	17d	2.5	0	0	**16.0**	0	0	1.3
4 Nil	10d	16	8.5	12.5	12.2	11.2	14.5	
	17d	17.2	10.5	13.7	12.7	12.7	16.0	4.9

DISCUSSION. Once again, metalaxyl and tolclofos methyl were by far the most effective for *Pythium* and *Rhizoctonia* respectively. It is evident that thiram has an effect on Aphanomyces but requires high rates of application. In a lower disease situation it may be a useful treatment.

CHRONOLOGICAL DATA:

Experiment initiated 9 May 1995
Stand counts 19 May 1995
26 May 1995

2.14 General Discussion — Seed dressings and drenches

In this series of three experiments, metalaxyl and tolclofos-methyl showed specific activity against *Pythium* sp. and *Rhizoctonia solani* respectively. Even as seed dressings at low rates of application, they allowed seedling establishment. No fungicide was effective against *A. cochlioides* as a seed dressing, although thiram as a drench showed some activity.

The highly specific activity of metalaxyl and tolclofos methyl towards Pythium and Rhizoctonia suggest they could be used commercially to control these pathogens.

2.2 USING SOIL DISEASE INDEXING TO PREDICT FIELD DISEASE INCIDENCE

As well as being able to relate test results to subsequent field disease severity, a disease indexing test must also be consistent, i.e. give similar results from the same soil sample in repeated tests.

In this section we conducted experiments which

- examined the in-field variability of root rot to determine whether intensive field sampling is essential
- determined whether the indexing test gives consistent results
- correlated the results of the glasshouse indexing test with the disease losses in fields.

2.21 Variability in disease potential within fields

2.211 Experiment 4: An estimate of the variability of black root rot in two beetroot soils of the Lockyer Valley

SUMMARY. Eight sites were sampled within two beetroot fields and a soil index test performed on each sample. The test result was hindered by poor germination of the monogerm seed.

INTRODUCTION. If disease is uniform within a field, it is not essential to take several samples. In this test, an attempt was made to quantify the variability of root disease due to *Aphanomyces cochlioides*.

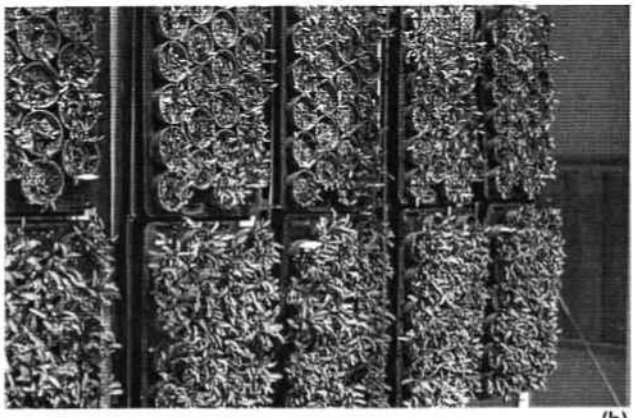
PROCEDURE. Two fields (EL farm and RH farm) were selected and eight 2 L soil samples taken from each. A standard test (10 pots natural/2 pots sterile soil) was carried out on each sample. Five seed of cv. Monolith were sown in each pot and an emergence count made two weeks later. Plants were rated for disease (0-5) four weeks after sowing.

RESULTS. The germination of cv. Monolith was very poor and erratic. Only an average of 60% germination was achieved in sterile soil with great variability between pots. Disease severity ranged from 2.3 - 4.5 at the EL site and 1.5 - 3.7 at the RH site.

Using the Soil Indexing Test - Beetroot

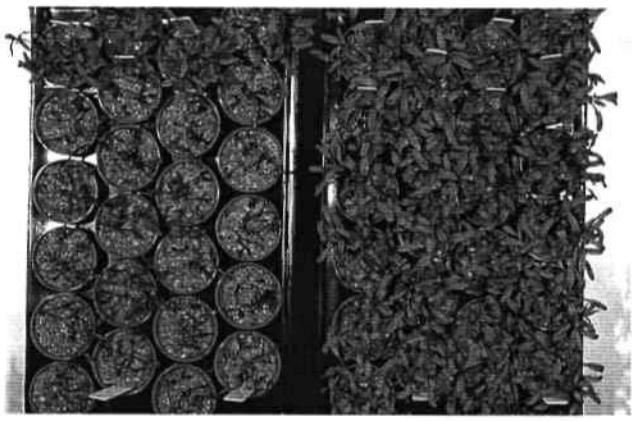
Patchy stands indicate the probability of high levels of soil pathogens

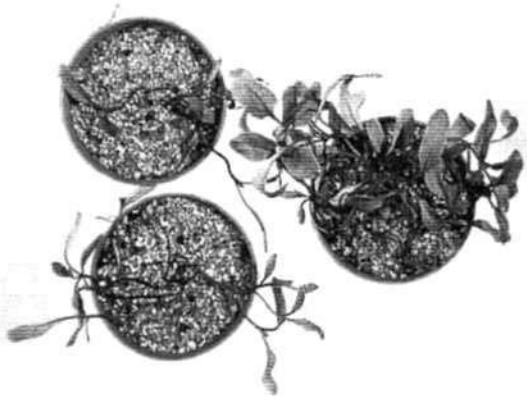
(a)



(b)

Tests can be set up in a glasshouse (a) or controlled environment cabinet (b)





Differences in soil disease potential between sites can be dramatic

Table 4

The disease severity in two beetroot fields (eight sites each).

Site	Disease severity (0-5)	
	EL Farm	RH Farm
1	2.3	1.5
2	2.6	2.0
3	2.7	2.1
4	2.7	2.1
5	3.3	2.2
6	3.6	2.5
7	4.0	3.3
8	4.5	3.7
Mean	3.24	2.4

DISCUSSION. The figures in Table 4 indicate there is a large range in disease severity within fields and several samples would be required to obtain an accurate mean. It is thought however, that some of the variability in this experiment was due to experimental factors which can be modified.

The experiment should be repeated using high quality seed. Since this will be polyembryonic, ratings of disease in whole pots rather than individual plants should be done. Seed need not be counted as long as 10-12 are sown in each pot.

CHRONOLOGICAL DATA:

Experiment sown 19 January 1996
Establishment count 2 February 1996
Final disease rating 16 February 1996

2.212 Experiment 5: Variation in disease severity between sampling sites in two beetroot fields

SUMMARY. *The RH site showed low disease with minimal variability between sampling sites. The E.L. field with higher disease potential showed three sites (0-2), four sites (2-3) and one site (3-4). Pre-emergence rots at both sites were controlled by Thiram seed dressing.*

PROCEDURE. Two sites were selected. The RH field was sown to a rotation crop while the EL field was prepared for a beetroot crop. The previous crop was beetroot.

Soil samples were taken from 8 points in each field and processed in the usual way.

RESULTS. Untreated seed was affected by pre-emergence damping-off in all samples. This was controlled by Thiram as well as A + T + R (Table 5).

The RH samples were all low in disease.
There was some variability between samples from the EL field (0.8-3.3).

DISCUSSION. This test suffered due to glasshouse roof leaks with the possibility of soil splash. This could explain the presence of Aphanomyces in the sterile plots. Losses in the EL field were due to both Aphanomyces and Pythium.

Table 5

Beetroot soil indexing — replicated sampling at RH and ELsites
Test sown 19 April, rated 8 May 1996

Site		Treatment			
		Field soil			Sterile soil
		Untreated	Thiram	A+T+R	A+T+R
RH	1	0.3 **	1.0	0.5	0.3
	2	0 **	0.7	0	0
	3	1.0 **	1.0	1.0	0.3
	4	0 **	0	0	0
	5	0.3 **	0	0.3	0.6
	6	0 **	0	0	0
	7	0 **	0	1.3	0.6
	8	0 **	0	0.3	0.3
	Mean	0.2	0.3	0.4	0.2
	Std Dev.	0.32	0.44	0.46	0.23
EL	1	2.2 ***	3.3	1.8	0
	2	1.0 ***	1.0	0.2	0
	3	1.3 ***	1.7	1.5	0.5
	4	0.5 ***	2.2	0.8	0
	5	1.8 ***	2.7	0	0
	6	2.2 ***	0.8	1.2	1.0
	7	2.5 ***	2.0	2.2	2.0
	8	3.0 ***	2.5	1.2	2.0
	Mean	1.8	2.0	1.1	0.7
	Std Dev.	0.78	0.79	0.71	0.83

* = population less than in sterile soil; ** = pop. 25% less; *** pop. >50% less

CHRONOLOGICAL DATA:

Trial planted 19 April 1996
Trial rated 8 May 1996

2.22 Consistency of results with the indexing test

2.221 Experiment 6: Reproducibility of results using the beetroot disease indexing test — 1997

SUMMARY. In 1997, soil samples were collected from nine beetroot sites. These were each subdivided into five sub-samples and a standard test performed on each. The variability between results of the five tests is an indication of the ability of the test to give reproducible results. For the thiram treated seed, 95% of tests were in the acceptable range while for A+T+R treated seed, 98% were considered to give acceptable results.

INTRODUCTION. A standard disease indexing test to determine the disease potential for a beetroot soil involves collecting a representative soil sample, then calculating disease losses in six pots of sterile soil, six pots of thiram treated seed and 12 pots sown with seed treated with Apron and Rizolex as well as thiram. Disease indices are calculated, based on the number of dead seedlings per pot after 18-21 days.

In order to have confidence in this test, it should give similar results when used to test sub-samples of a soil.

In the work reported below, soil samples were collected from nine field sites and standard tests performed on five sub-samples of each soil to determine the ability of the test to give reproducible results.

METHODS. Soil samples (20 L) were collected from nine fields in the Lockyer Valley due to be sown to beetroot crops. These were collected in a W pattern from the top 10 cm of soil at approximately 50 points.

The soils were air-dried, if necessary, then passed through a 6 mm sieve to remove large stones and organic trash. Each soil sample was thoroughly mixed before and after sieving.

A 4 L sub-sample was autoclaved to provide a sterile control. The remaining soil was used to fill 90 test pots.

In each pot a 20 mL layer of large vermiculite was covered with a 100 mL soil sample. After wetting up, 10 beetroot seed were sown and covered with 30 mL fine vermiculite.

The test seed was Derwent Globe which was either treated with the standard fungicide thiram or additionally treated with Rizolex and Apron, both applied as slurries at the rate of 1.5 g/kg seed.

For each of the nine soils, there were five standard tests. Each standard test consisted of

(i) 6 pots of sterile soil sown to thiram treated seed
(ii) 6 pots of natural soil sown to thiram treated seed
(iii) 12 pots of natural soil sown to thiram + Rizolex + Apron treated seed (A+R+T).

After sowing, pots were covered for three days then monitored every 2-3 days when dead seedlings were recorded and removed. The test was completed three weeks after sowing.

Since beetroot seed is polyembryonic, variable numbers of seedlings emerged in each pot. Disease severity was determined as

0 — no dead seedlings
1 — 1-3 dead seedlings
2 — 4-8 dead seedlings
3 — 9-12 dead seedlings
4 — >12 dead seedlings but some seedlings still healthy
5 — all seedlings dead

Each time dead plants were removed, 15 were selected at random and isolations made to determine causal organisms. A total of 60 seedlings from each site were examined.

RESULTS. Table 6 shows the mean indices for each site and the range in results from the five tests. Full results are in Table 7.

Thiram treated seed: The range in test results was less than 1.5 severity units for seven of the nine sites. Large ranges in disease severity were recorded for sites 2 and 6 with 2.3 and 3.5 respectively.

A+T+R treated seed: The range in test results was less than 1.5 severity units for all except three sites. For sites 3 & 7 the difference between lowest and highest disease indices was 1.6 severity units, while for site 6 it was 2.2.

DISCUSSION. In any biological test, it must be expected that there will be a degree of variability between duplicate tests due to experimental error (e.g. slight differences in watering) and the complex nature of biological systems. For the purposes of disease forecasting, there has to be confidence that a test is capable of predicting what will be the field situation if conditions are favourable for disease.

Table 6

Disease severity indices (mean and range) derived from five tests on each of nine beetroot sites

Site No.	Disease severity 0-5				Pathogens		
	Thiram treated seed		A+T+R treated seed		% recovered		
	Mean	Range[A]	Mean	Range	Rhiz	Aph	Pyth
1	1.9	1.2 - 2.7	0.9	0.7 - 1.2	58	0	0
2	3.5	2.7 - 5.0	1.3	0.6 - 2.0	78	0	0
3	3.1	2.5 - 3.8	3.2	2.5 - 4.1	3	67	0
4	3.7	3.2 - 4.3	3.8	3.2 - 4.6	2	78	0
5	1.5	1.2 - 2.1	1.0	0.7 - 1.4	50	0	0
6	2.0	0.5 - 4.0	2.0	0.9 - 3.1	4	85	0
7	4.3	3.3 - 4.8	4.0	3.1 - 4.7	11	74	0
8	4.3	3.3 - 4.8	4.1	3.3 - 4.6	12	67	0
9	3.1	2.7 - 3.7	2.4	1.5 - 2.9	16	78	0

[A] Range of disease severities in the five replicate tests conducted on each field sample. Full results in Table 7.

[B] % recovery (from 60 seedlings) of the pathogens Rhizoctonia, Aphanomyces and Pythium.

The purpose of the current study is to ensure that the test for the disease index of beetroot fields is reliable, i.e. it consistently gives a result which indicates low, medium or high disease risk.

Based on a 0-5 scale of severity, a rating of

(a) 0-1 should indicate very low disease risk
(b) 1.1-2 should indicate low disease risk
(c) 2.1-3 should indicate low-moderate disease risk
(d) 3.1-4 should indicate moderate-high disease risk
(e) 4.1-5 should indicate high disease risk

If the mean of the five tests is taken as the best indication of disease potential, each of the five test results should also indicate approximately the same disease risk and should not vary either side of the mean by one severity unit.

Using this criterion, for thiram treated seed, 95% of the tests conformed and for A+T+R treated seed 98% conformed.

While it would be desirable to have greater uniformity between replicate tests, the results obtained indicate that the tests can be relied upon to separate fields into low, medium and high risk with an accuracy of >90%.

The tests also showed the effects of different organisms. In the three soils where Rhizoctonia predominated, the use of Rizolex as a seed dressing gave lower disease indices due to the control of Rhizoctonia. For the other sites where Aphanomyces predominated, the results with both seed dressings (thiram and T+R+A) were similar.

It is concluded the beetroot soil indexing test has >90% reliability for predicting whether soils are low, moderate or high risk. It also enables predictions to be made on the probability of Rhizoctonia or Aphanomyces being the major pathogen.

Table 7

Disease indices from the five replicate tests carried out on each of nine soil samples

Disease Indices

Site No.	Thiram Seed					A+T+R seed				
	I	II	III	IV	V	I	II	III	IV	V
1	1.5	1.5	2.7	1.2	2.7	0.7	0.8	1.2	0.7	0.9
2	3.2	2.8	5.0	4.0	2.7	2.0	1.2	0.6	1.2	1.5
3	2.7	3.2	3.8	2.5	3.3	4.1	3.2	3.2	3.1	2.5
4	3.5	4.3	3.2	3.3	4.3	3.2	3.2	4.6	3.2	4.6
5	1.7	1.2	1.5	1.2	2.2	0.7	0.9	0.8	1.4	1.3
6	4.0	1.5	2.5	0.5	0.8	3.1	2.2	2.0	1.7	0.9
7	3.3	4.8	4.0	4.5	4.7	3.1	3.8	4.1	4.2	4.7
8	3.3	4.8	4.5	4.0	4.8	3.3	4.1	4.6	4.1	4.6
9	3.2	3.7	3.2	3.0	2.7	1.5	2.7	2.2	2.7	2.9

CHRONOLOGICAL DATA:

Glasshouse test sown	6/2/97
1st rating	13/2/97
2nd rating	14/2/97
3rd rating	17/2/97
4th rating	21/2/97
5th rating	26/2/97

2.23 Correlation of the results from the glasshouse indexing test with field disease severity

In this section we firstly tried to produce a range of field disease severity by fumigating plots with different concentrations of methyl bromide gas and, secondly, we established observation plots on district farms where disease progress was monitored.

2.231 Experiment 7: Using a beetroot bioassay to predict disease levels in field plots treated with different rates of methyl bromide

SUMMARY. *A field experiment was established in which plots were treated with methyl bromide at rates of 0 g/m^2, 0 g/m^2 + plastic sheeting, 200 g/m^2, 100 g/m^2, 67 g/m^2 and 50 g/m^2. A bioassay performed using soil from the 24 field plots showed a response to treatment with a survival of 81% in the plots receiving the highest rate of fumigation and 55% in unfumigated soil. There were no significant differences in the field plots in either number of seedlings emerging or deaths. Isolations showed* A. cochlioides *caused 77% of deaths in the field but only 8% in the bioassay while* R. solani *was frequently (37%) isolated from diseased plants in the bioassay but was not isolated from field plants. These results indicate that when conditions do not favour disease in the field, there is a poor correlation between a bioassay and field results.*

PROCEDURE. A field trial was established on a site at Gatton where beetroot had been grown for several years. Plots were fumigated with different rates of methyl bromide immediately after hilling on 13 March 1995. Plastic sheeting was removed two days later and the experimental area sown the same day as part of the whole field.

The trial was laid out as a 6 treatments x 4 replications randomised block experiment. Plots were of unequal size to give different areas treated by one 680 g canister of methyl bromide. In each plot, 5 rows were treated but plot lengths varied from 1.2 m to 4.8 m. For plant counts, the datum area was a 40cm length of the 3 central rows.

A 5 L sample of soil was collected from each plot for a glasshouse bioassay.

Bioassay. Six 12.5 cm diam. pots were filled with 800 mL of soil from each sample. Three pots were sown with 20 untreated seed of cv. Monolith and 3 pots with Apron (350 g/kg metalaxyl) treated seed (2 g/kg seed). Seed was covered with a 1 cm layer of vermiculite and dead plants noted and removed over a four week period.

Isolations. Diseased plants were collected from the field and bioassay and isolations carried out using the tea diffuser method. Seventy isolations were made from the field-collected plants and 72 from the bioassay plants.

RESULTS. Field Experiment: Plant populations in the field experiment were high (>100 plants/m) and there were no significant differences between treatments. The occurrence of diseased plants was spasmodic with small groups of plants being affected rather than evenly distributed individuals. Although there were no recorded deaths in the highest rate of methyl bromide and about 4% loss in the untreated plots, differences were not significant (Table 8).

Bioassay: The bioassay showed a response to treatment with a survival of 81% in the highest rate of methyl bromide use and only 55% in the untreated. Significantly higher survival rates were recorded for methyl bromide treatments of 200, 100 and 67 g/m^2 compared with the untreated (Table 9) There was also a significant response to the Apron seed dressing (Table 10).

Isolations: There were big differences in the frequency of isolation of pathogens between the field and bioassay. *Aphanomyces cochlioides* was predominantly isolated from field grown seedlings while *Rhizoctonia solani* (37%) predominated over this pathogen (8%) in the

bioassay (Table 11). A higher recovery of *A. euteiches* in the second field assessment showed this pathogen has a post-emergence phase.

DISCUSSION. Losses due to disease in the field experiment were low and unevenly distributed. Field conditions were dry but it is thought uneven distribution of irrigation may have led to the spasmodic disease recordings.

The bioassay showed that *Pythium* was active as a cause of pre-emergence loss since there was a significant increases in emergence due to Apron seed dressing. Both *R. solani* and *A. euteiches* caused losses but conditions in the bioassay favoured *R. solani*. The bioassay followed the expected trend of fewer diseased plants at the higher rates of use of methyl bromide. Examination of individual plots showed no consistent pattern of correlation between bioassay and field result probably due to the irregularities in the field occurrence.

Recent glasshouse experiments have shown that seed dressings of Apron and Rizolex are highly effective against losses due to *Pythium* and *R. solani*. If these were used commercially it would be only necessary to determine the disease potential of *A. euteiches* by bioassay. This aspect will be concentrated on in future tests.

Table 8

The effect of different rates of methyl bromide fumigation on the establishment of beetroot seedlings in field plots

Treatment	Total plants/ 1.2 m of row	Deaths/1.2 m of row
Methyl bromide fumigation 200 g/m^2	133	0
Methyl bromide fumigation 100 g/m^2	142	1.08
Methyl bromide fumigation 67 g/m^2	142	3.08
Methyl bromide fumigation 50 g/m^2	141	0.58
Untreated soil + plastic sheeting	128	6.75
Untreated soil	127	5.50
	NS	NS

Table 9

Bioassay: Survival (%) of beetroot seedlings grown in soil collected from the 1995 field experiment

Field soil treatment	% Survival
Methyl bromide 200 g/m^2	81.2
Methyl bromide 100 g/m^2	74.0
Methyl bromide 67 g/m^2	71.7
Methyl bromide 50 g/m^2	63.7
Untreated + plastic	61.0
Untreated	55.4
LSD (P= 0.05)	14.9

Table 10

Effect of seed treatment with Apron® on the survival of beetroot seedlings in a bioassay of field soil.

	%Survival
Seed treated with Apron 2 g/kg	74.0
Seed untreated	61.7
LSD (P= 0.01)	8.6

Table 11

Cause of death in beetroot seedlings collected from the field trial and in the glasshouse bioassay

	Field site		
	29/3/95	5/4/95	Bioassay
Total isolations	72	70	72
+ ve *Aphanomyces cochlioides*	27	54	6
+ ve *Rhizoctonia solani*	4	0	27
+ ve *Pythium* spp.	0	1	5
- Sterile white fungus	20	0	
Other	8	2	3

CHRONOLOGICAL DATA:

Fumigation applied	13 - 15 March 1995
Experiment sown	
Stand counts	5 April 1995
Isolations ex field	5 April 1995
Bioassay sown	20 March 1995
Bioassay final rating	18 April 1995
Isolations ex bioassay	3 April 1995

2.232 Experiment 8: Correlation of disease index results with field performance at 16 beetroot sites in 1996

SUMMARY. Using a soil bioassay which detects Aphanomyces cochlioides, 10 fields were rated as low risk, 5 as moderate and 4 as high risk sites. Plant populations varied from 18 to 76 per metre of row based on a sowing rate adjusted to 1 x 10^6 seeds/ha. There was no correlation between the Aphanomyces disease index and emergence figures,(as expected). There was a correlation between high disease indices from the glasshouse test and post-emergence deaths.

INTRODUCTION. A test has been developed to indicate the likely severity of loss to beetroot seedlings due to *A. cochliobolus*. It does not detect problems due to *Pythium* spp. Or *Rhizoctonia solani*. In this experiment, glasshouse obtained disease indices were correlated with actual field stands.

PROCEDURE.

(i) **DISEASE INDEX TEST**. Nineteen fields were sampled. Each composite sample of 3-4 litres soil was composed of 15-20 small subsamples taken from within each field. A small sample (250 mL) was autoclaved.

Pots (7.5 cm diameter) were filled as follows:

1 20 mL coarse vermiculite grade 4 in bottom of pot
2 100 mL soil
3 Wet up
4 10-12 seed of beetroot cv. Detroit Globe treated with Apron Rizolex & Thiram sown in each pot
5 30 mL fine vermiculite G2, water added to field capacity

For each test, two control (sterilized soil) pots were included with 10 pots filled with natural soil. Pots were covered until the first signs of germination and then watered every day.

The first disease rating was made 8 d and the second 17 d after sowing. Each pot was examined and rated 0-5 on the following scale:

0 — no disease, similar to control
1 — slight reddening of cotyledons, no dead plants/black roots
2 — 1-3 plants dead (<25%)
3 — 3-5 dead plants (25-50%)
4 — plants dead apart from 1 or 2 (>50-90%)
5 — all plants dead or with black roots (100%)

(II) DISEASE LOSSES IN FIELDS. *Establishment:* At 3-4 weeks post-planting, sites were visited and stand counts made by counting emerged plants (dead or alive) iin 10-20 1 m lengths of row. Since growers sowed different rates of seed for various reasons (baby beet/slicing beet; high rates to offset expected disease losses etc), this data was also obtained. The number of dead or dying seedlings was counted.

At maturity: During the growing season, heavy rainfall was received in the Lockyer Valley and many crops were adversely affected. Crops were inspected and a general observation made based on crop density and severity of ground rots. Isolations were made from the black lesions affecting many beet.

RESULTS. Seed generally was completely germinated within 3-4 days. Deaths, in high risk soils were plentiful at the first rating, 8 days after sowing (Table 12). Four samples appeared to be high risk for beetroot, i.e. index >4.0: JJ a &b, KH a, MN b. Several were intermediate (>2.0 >4.0) and most were low risk (<2.0) (Table 13).

1. Disease index/emergence/post-emergence death:

Table 12

Relationship between Aphanomyces Index, and emergence and seedling death.

Aphanomyces Index (0 -5)		*Plants/metre	% deaths
Br	0.4	28	19
Br	0.6	not obtained	0.3
DV	0.9	30	13.8
RS	1.1	35	16.8
JH	1.3	76	11.7
KW	1.7	30	6.1
EL(a)	1.9	40	2.1
KH (b)	2.4	not obtained	4.1
DV (a)	2.8	42	8.5
DV (b)	2.8	74	18.3
MN (a)	2.9	22	66.6
EL (b)	3.5	34	5.4
KH (a)	4.2	not obtained	6.7
JJ (b)	4.9	74	62.7
JJ (a)	5.0	35	83.4
MN (b)	5.0	18	76.3

* Adjusted to sowing rate of 1 X 10^6 seed/ha

There is no correlation between the Aphanomyces Index and emergence. The relationship between the AI and % post-emergence deaths is also irregular, but there is a good correlation with most soils considered high risk.

2. Disease Index / field observations at maturity

Table 13

The relationship between Aphanomyces index and the mature crop.

Aphanomyces index	Field rating*
0.4	?
0.6	?
0.9	+++
1.1	+
1.3	+
1.7	+
1.9	++++
2.4	+
2.8	+++
2.8	+++
2.9	++++
3.5	++++
4.2	+++++
4.9	+++++
5.0	+++++
5.0	++++

*
+ good crop, low disease
++ low incidence of rots
+++ patchy stand / moderate severity of rots
++++ poor crop
+++++ not harvested
? – mature crop not observed

There is a trend for sites with a high disease index to have been susceptible to crop loss following the heavy rains. Aphanomyces was isolated rarely from the black lesions. The most commonly recovered fungi were *Fusarium* op.

DISCUSSION. This test was carried out to predict the probability of Aphanomyces losses only. It was expected that seed dressings to overcome Pythium and Rhizoctonia losses would be available for growers thus making the prediction of these disease losses unnecessary. It now appears that tolclofos methyl (Rizolex) will not be registered for grower use. Apron is currently registered for use on beetroot seed.

The results of this test show that apart from fields where there are high post-emergence losses due to *A. cochlioides*, an Aphanomyces index is of little value in the absence of seed dressings to control pre-emergence rots due to Pythium and Rhizoctonia. The variability in

emergence figures could of course be due to many factors eg; planting depth, soil tilth, soil moisture, insect activity, but pre-emergence fungal rots would also be important. Future soil indices will therefore attempt to determine the probability of losses due to Pythium and Rhizoctonia as well as Aphanomyces.

The wet weather in May caused severe losses in some fields. Low areas were most affected but high frequencies of beet affected with blemishes occurred generally in some fields. The association of high losses with sites where high Aphanomyces indices were obtained suggests *A cochlioides* is involved. Isolations from affected beet gave only one recovery of *A cochlioides* from 112 samples. The majority of fungi recovered were *Fusarium* sp.

2.233 Experiment 9. Correlation of glasshouse predictions and field results for nine beetroot sites in 1997

SUMMARY. *Glasshouse disease indices were carried out on soil samples from nine beetroot sites. Field observations were made on eight of these. The index test showed which organisms were present, detected differences on probable disease severity between sites and, in a dry year, gave a fair indication of actual field losses. A closer correlation would be expected in a season with normal rainfall.*

INTRODUCTION. Disease organisms such as *Aphanomyces cochlioides, Rhizoctonia solani* and *Pythium* spp. can contribute to field losses during the early stages of beetroot crops establishment.

A bioassay has been devised which indicates the probable severity of losses and shows which of the organisms are involved. In 1997, nine sites were chosen to determine whether the glasshouse test accurately predicted the field outcome.

METHODS. Soil samples were collected from nine sites in the Lockyer Valley and five soil index tests conducted on each. The treatments in the tests were:-

(1) sterile soil sown to thiram seed
(2) natural soil sown to thiram treated seed
(3) natural soil sown to A+T+R treated seed (1)
(4) natural soil sown to A+T+R treated soil (2)

Each index test was set up so there were six replicate pots of each of the four treatments. Twelve seed were sown in each pot. Dead seedlings were counted and removed every 2-3 days over a period of 20 days from sowing. Disease severity ratings were allocated as

0 — no dead seedlings per pot
1 — 1-3 dead seedlings per pot
2 — 4-8 dead seedlings per pot
3 — 9-12 dead seedlings per pot
4 — >12 dead seedlings per pot but some still alive
5 — all seedlings dead

An analysis of variance was conducted on the 4 treatments x 5 replicates of each soil sample.

Differences between treatments could be due to the presence of Pythium or Rhizoctonia as pathogens since these are not well controlled by thiram but are controlled by Apron and Rizolex seed dressings. Comparison of the duplicate A+T+R treatments gives a measure of the consistency of this treatment.

Field sites. At each field site, a small field trial was established using the following treatments:-

(1) thiram treated seed
(2) thiram + Apron treated seed
(3) thiram + Apron + Rizolex treated seed
(4) untreated seed

Plots were single rows x 3 m long. There were six replicates laid out in a randomized blocks design. A hand planter was used.

Field trials were established within one day of the grower sowing his field. Six x 3 m lengths of rows adjacent to the trial were counted in a similar way to the experimental plots.

Field sites were visited weekly for a period of 5-6 weeks from sowing. The central 1 m of each plot was used as datum for observations. A count of seedling population was made when germination and seedling emergence was judged to be complete, usually 2-3 weeks after sowing. A final count was made at the end of the observation period (5-6 weeks) when seedling losses to Aphanomyces were apparent. The difference in populations was calculated as percent loss.

RESULTS AND DISCUSSION.

Site 1 — Glasshouse test

Treatment	Disease severity (0-5)	*Pathogens isolated
Sterile soil	0.14 a	Rhizoctonia 58%
Thiram seed	1.92 c	Pythium 0%
A+T+R seed (1)	0.90 b	Aphanomyces 0%
A+T+R seed (2)	0.84 b	
LSD (P = 0.05)	0.61	

*The result of isolating from 60 dead seedlings. Not related to treatment.

Assessment. The higher disease severity in the thiram treatment is due to Rhizoctonia. Absence of Aphanomyces and the low disease severity figures indicates low disease risk.

Field test *Sowing date:* 10 March 1997
1st count: 18 March 1997
2nd count: 16 April 1997

Treatment	% lost
Thiram seed	17
T + Apron seed	10
T+A+R seed	14
Untreated	15
LSD (P = 0.05)	N.S.
Commercial planting	9

Assessment: Generally low stand losses which could be due to factors other than disease.

Correlation: Good.

Site 2 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.62 a	Rhizoctonia 78%
Thiram seed	3.54 b	Pythium 0%
A+T+R seed (1)	1.38 b	Aphanomyces 0%
A+T+R seed (2)	1.18 a	
LSD (P = 0.05)	1.03	

Assessment: The higher disease severity in thiram treatment reflects the activity of Rhizoctonia. Rhizoctonia may or may not be active in the field. A low disease risk is predicted.

Field test *Sowing date:* 13 March 1997
1st count: 24 March 1997
2nd count: 16 April 1997

Treatment	% lost
Thiram seed	26
T + Apron seed	17
T+A+R seed	40
Untreated	27
LSD (P = 0.05)	N.S.
Commercial planting	32

Assessment: There was a high degree of variability between replicates of the same treatment which led to treatment averages being not significantly different from one another. Variability also occurred in the commercial planting with losses varying from 0-100%. It is suspected factors other than disease were involved.

Correlation: Fair

Site 3 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.22 a	Rhizoctonia 3%
Thiram seed	3.10 b	Pythium 0%
A+T+R seed (1)	3.04 b	Aphanomyces 67%
A+T+R seed (2)	3.40 b	
LSD (P = 0.05)	0.80	

Assessment: The moderate-high disease index, regardless of seed treatment, accurately reflects the activity of Aphanomyces. A moderate-high field loss is indicated if wet weather occurs during the first 4-6 weeks after sowing.

Field test	*Sowing date:*	5 March 1997
	1st count:	18 March 1997
	2nd count:	8 April 1997

Treatment	**% lost**
Thiram seed	17
T + Apron seed	20
T+A+R seed	22
Untreated	25
LSD (P = 0.05)	N.S.
Commercial planting	44

Assessment: As in the glasshouse test, there were no differences due to seed treatment. Losses in the field trial were low-moderate while losses in the commercial crop were high. Differences between the trial sowing and commercial crop may have been due to differences in depth of sowing or similar factor.

Correlation: Poor for trial planting, good for commercial field.

Site 4 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.24 a	Rhizoctonia 0%
Thiram seed	3.72 b	Pythium 2%
A+T+R seed (1)	4.15 b	Aphanomyces 78%
A+T+R seed (2)	3.54 b	
LSD (P = 0.05)	0.81	

Assessment: With all treatments in natural soil having high disease severity indices, high field losses are predicted if weather conditions are wet during the firs 4-6 weeks of growth. Aphanomyces is the major pathogen.

Field test: Could not be established.

Site 5 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.28 a	Pythium 3%
Thiram seed	1.56 c	Rhizoctonia 50%
T+A+R seed (1)	0.80 b	Aphanomyces 0%
T+A+R seed (2)	1.10 b	
LSD (P = 0.05)	0.80	

Assessment: High levels of organic matter in the soil at sampling time have led to Rhizoctonia as the major pathogen. The Rizolex treatment has reduced disease severity significantly. Rhizoctonia may also be active in the field following sowing but usually does not cause severe losses. A low-moderate field loss is indicated.

Field test *Sowing date:* 5 March 1997
1st count: 18 March 1997
2nd count: 8 April 1997

Treatment	**% lost**
Thiram seed	17
T + Apron seed	20
T+A+R seed	24
Untreated	26
LSD (P = 0.05)	N.S.
Commercial planting	26

Assessment: There were no significant differences due to treatment indicating low Rhizoctonia activity in the field. All treatments and the commercial field showed low-moderate loss.

Correlation: Good.

Site 6 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.04 a	Pythium 0%
Thiram seed	1.86 b	Rhizoctonia 4%
T+A+R seed (1)	1.94 b	Aphanomyces 85%
T+A+R seed (2)	2.06 b	Fusarium 5%
LSD (P = 0.05)	1.12	

Assessment: Aphanomyces is the dominant pathogen but not present in numbers which will cause high losses. Field losses will depend on weather conditions — low if dry; moderate if wet.

Field test *Sowing date:* 24 February 1997
1st count: 14 March 1997
2nd count: 2 April 1997

Treatment	**% lost**	
Thiram seed	38	
T + Apron seed	47	
T+A+R seed	29	
Untreated	—	(did not germinate)
LSD (P = 0.05)	N.S.	
Commercial field	23	

Assessment: There was a high degree of variability between replicates of a treatment due to herbicide spray damage causing some seedling losses. Losses in the trial were higher than in the commercial crop since some rows sown with the hand seeder were off-line and had more herbicide damage.

Correlation: Good correlation between prediction and commercial field.

Site 7 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.32 a	Pythium 0%
Thiram seed	4.26 b	Rhizoctonia 11%
A+T+R seed (1)	4.14 b	Aphanomyces 74%
A+T+R seed (2)	3.86 b	
LSD (P = 0.05)	0.59	

Assessment: High degree severity in all treatments and Aphanomyces as the major pathogen indicates high risk, especially under wet conditions.

Field test *Sowing date:* 4 March 1997
1st count: 18 March 1997
2nd count: 8 April 1997

Treatment	**% lost**
Thiram seed	76
T + Apron seed	83
T+A+R seed	74
Untreated	80
LSD (P = 0.05)	N.S.
Commercial field	82

Assessment: Uniform high losses in all treatments shows activity of Aphanomyces. Commercial field suffered similar losses.

Correlation: Good.

Site 8 — Glasshouse test

Treatment	**Disease severity (0-5)**	**Pathogens**
Sterile soil	0.14 a	Pythium 0%
Thiram seed	4.28 b	Rhizoctonia 12%
T+A+R seed (1)	3.98 b	Aphanomyces 67%
T+A+R seed (2)	4.00 b	
LSD (P = 0.05)	0.61	

Assessment: Uniformly high disease severity in all treatments and Aphanomyces as the major pathogen indicates moderate-high losses, depending on weather conditions.

Field test *Sowing date:* 24 February 1997
1st count: 10 March 1997
2nd count: 2 April 1997

Treatment	**% lost**	
Thiram seed	28	
T + Apron seed	33	
T+A+R seed	37	
Untreated	—	(did not germinate)
LSD (P = 0.05)	N.S.	
Commercial planting	23	

Assessment: Field losses were variable. In the experimental area they were moderate and in the commercial field low-moderate.

Correlation: For field trial — fair.
For commercial field — poor.

Site 9 — Glasshouse test

Treatment	Disease severity (0-5)	Pathogens
Sterile soil	0.18 a	Pythium 0%
Thiram seed	3.16 c	Rhizoctonia 16%
T+A+R seed (1)	2.30 b	Aphanomyces 78%
T+A+R seed (2)	2.60 bc	
LSD (P = 0.05)	0.66	

Assessment: With the standard thiram treatment, disease severity is moderate. It is due to Aphanomyces as the major pathogen but Rhizoctonia activity is appreciable at 16%. Control of Rhizoctonia with Rizolex seed dressing shows Aphanomyces disease potential is low-moderate.

Field test *Sowing date:* 17 March 1997
1st count: 24 March 1997
2nd count: 24 April 1997

Treatment	**% lost**
Thiram seed	26
T + Apron seed	20
T+A+R seed	30
Untreated	28
LSD (P = 0.05)	N.S.
Commercial planting	15

Assessment: Field trial losses are low-moderate while the commercial field showed low losses. There was great variability between plots of the same treatment.

Correlation: Poor for the commercial field, fair for the field test. It was expected slightly higher losses would occur in the field.

WEATHER CONDITIONS

The observations were made during a generally dry season with rainfall in February, March and April well below the 98 year mean. The figures show below cover the period from the earliest date of sowing (24/2) to the last field inspection (24/4/97).

	Rainfall (mm)	Wet days
24-28 February 1997	17.6	3
1-31 March 1997	14.6	5
1-24 April 1997	16.4	4

Total rainfall for those three months was 101 mm compared with the 98 year average of 230 mm.

2.3 DISCUSSION- INDEXING BEETROOT SOILS

The glasshouse test gave useful, accurate information regarding the pathogens present in the soil sample. Clear differences in disease potential between sites were indicated and the field observations generally supported the trends in the glasshouse.

Correlation of results between glasshouse and field observations was difficult due to several factors:-

- the polyembryonic nature of beetroot seed may lead to the emergence of a proportion of weak seedlings which do not survive.

- there are losses due to ploughing, insects, herbicide sprays which are not related to the disease severity index.

These background losses are thought to account for at least 10% of stand losses in most farms.

In comparing the glasshouse and field results, in many cases, field losses were lower than expected. Much of this discrepancy could be due to the dry seasonal conditions which did not favour *Aphanomyces cochlioides* or *Pythium* spp. If the test is used as an indicator of disease severity under average or above rainfall, the correlation should be much closer for these farms.

In summary, the soil index test showed what organisms were present, it detected differences in probable disease severity between sites, and in a dry season, gave a fair indication of field losses.

3 PEA

3.1 PATHOGENS ASSOCIATED WITH PEA DECLINE

A wide range of soil borne organisms can be associated with pea roots when plants show symptoms of decline .While some will be pathogens, others may be only secondary invaders and not capable of causing disease to healthy plants.

3.11 Experiment 1: Pathogens associated with pea decline

SUMMARY. Isolations were made from pea plants collected from six properties in the Lockyer Valley in 1994. Pathogenicity tests showed Aphanomyces euteiches, Fusarium solani, Ascochyta pinodella, Pythium sp. Fusarium oxysporum *and* Rhizoctonia solani *could all cause severe disease. Non-pathogenic isolates included* Macrophomina sp., *several* Pythium sp. *and* Fusarium sp.

INTRODUCTION. Pea plants were sampled from fields included in the soil indexing survey. These were rated for disease severity then isolations were carried out which resulted in 27 cultures. To determine which of these were liable to be the important pathogens, pathogenicity tests were conducted.

PROCEDURE. Pea seed (cv. Bounty) was surface sterilised in chlorine solution (100 ppm available chlorine 5min then rinsed) and sown in vermiculite in a CEC 22^{0}C until emergence. Nutrient solution was applied weekly. When plants had established two nodes, they were rinsed free of vermiculite and a cube (5mm) of inoculum placed on the stem near the seed. Plants were replanted in vermiculite individually in plastic drinking cups and returned to the CEC for two weeks.

Plants were examined for signs of disease on stem and roots and severity rated on a 0-4 scale where 0, no disease; 1, slight discolouration; 2, distinct lesion or discolouration but small in extent; 3, large lesion; 4, large lesion or extensive root rot, plant dead or almost dead.

RESULTS. The fungi isolated were: *Pythium species* (8) *Fusarium sp.* (4) *Fusarium solani* (3*) Fusarium oxysporum* (2), *Aphanomyces euteiches* (2) *Ascochyta pinodella* (2) *Rhizoctonia solani* (1) and *Macrophomina phaseolina* (1*).*

The most virulent of theses were *A. euteiches, A. pinodella, Fusarium solani, F. oxysporum,* some isolates of *Pythium* and *R. solani* (Table 1). Several P*ythium* isolates ,*Fusarium* sp., and *M. phaseolina* were practically non-pathogenic.

DISCUSSION. The highly pathogenic *A. euteiches* and *A. pinodella* were found on 2 sites but it is probable *A. euteiches* may have been present but not recovered from other sites since it is often difficult to recover from plants with advanced root rot symptoms. *Fusaria* seem important in the decline problem since they were widely distributed and some isolates, particularly *F. solani,* were pathogenic. Although few *Pythium* isolates were pathogenic in the test, they may be important as pre-emergence pathogens. Their widespread distribution indicates the need for seed dressings to prevent seed rot.

Table 1

Pathogenicity test — disease severity and symptoms on seedlings caused by 27 fungal isolates ex. field peas

Field site and field severity (0-5)	Isolate	Species	Severity (0-4)	Symptoms
F. Bros. 3.4	4198 a-1	*Fusarium solani*	3	Black lesion
	4198 a-2	*Macrophomina* sp.	0	-
	4198 b-1	*F. oxysporum*	2	Dark crown lesion
	4198 b-2	*Fusarium* sp.	2	Dark lesion
G.G. 0.04	4194-1	Pythium sp.	1	Small brown lesions
	4194-2	Pythium sp.	2	Dark brown stem lesion
J.F. 1.5	4199-1	Mixed	0	-
	4199-2	*Pythium* sp.	3	Root browning
	4199-3	*Rhizoctonia* sp.	3	Rot above seed
	4196-a	*Pythium* sp.	1	Small brown lesion
	4196-b	*Asochyta pinodella*	4	Black root rot
GEH. 1.61	4192 a-1	Fusarium sp.	0	-
	4192 a-2	Sterile black fungus	1	Small brown lesion
	4192 a-3	Fusarium sp.	1	Small tan lesion
	4192 b-1	Pythium sp.	0	-
	4192 b-2	Pythium sp.	2	Light brown root lesion
	4192 b-3	Pythium sp.	1	Light brown root lesion
ZIS. 3.2	4197 a-1	Aphanomyces	4	Extensive brown rot
	4197 a-2	*F. solani*	3	Black root lesion
	4197 b	*Ascochyta pinodella*	3	Black root lesion
ROB. 0.96	4193 a-1	Aphanomyces	0	-
	4193 a-2	*Fusarium solani*	3	Black stem lesion
	4193 a-3	*Fusarium oxysporum*	3	Dark brown lesion
	4193 b-1	Sterile white fungus	1	Light brown root lesion
	4193 b-2	*Pythium* sp.	1	Small brown lesion
	4193 c-1	*Fusarium* sp.	2	Light brown lesion
	4193 c-2		0	-

3.2 USING SOIL DISEASE INDEX TO PREDICT FIELD DISEASE INCIDENCE

In this section we developed the glasshouse indexing test and used it to compare the disease potential at different field sites. In 3 seasons (1995, 96, 97) the glasshouse disease index was correlated with the disease severity in crops which were later sown on those sites. As a starting point, the "within field" variability of disease potential was determined at two sites.

3.21 Variability in disease potential within fields

3.211 Experiment 2: Variability of the pea disease index between sampling sites in two pea fields

SUMMARY. *A disease index was derived for each of eight sampling sites in two pea fields. These were compared with the results of a standard test. For the field with a high disease risk, sampling sites ranged from 2.09 - 5.0 with a mean of 4.29. This compared well with results of a standard test - 4.78. For the low disease risk field, the sampling site range was 1.0 - 2.13 with a mean of 1.78. This correlated well with the standard test rating of 1.82.*

PROCEDURE. Two fields at Harrisville (A & B) were used for this experiment. The object was to determine how much variability in disease potential exists within a field and whether eight sub samples of soil is sufficient to give a reasonable average.

Soil samples (about 5 L) were taken from each of 8 locations in each of the two fields. Standard tests were conducted in the CEC at 24°C.

Standard test: 10 small pots filled with 100 ml soil sown with 10 fungicide treated seed (Apron, Rizolex, Thiram) grown for 22 days in CEC and each plant rated 0 - 5 for root rot severity.

In addition, the two fields were randomly sampled and the composite samples subjected to a standard test.

RESULTS. At site A, six samples gave high indices while two were significantly lower (Table 2). At site B five samples were not significantly different from one another. The mean of the eight samples were - Site A - 4.29, Site B - 1.78. The values for the composite samples were 4.78 and 1.82.

Table 2

Mean disease indices for 8 soil sampling sites in 2 fields (Harrisville A & B) compared with a normal composite sample

Sample	Disease index (0-5)	
	H'ville A	H'ville B
1	4.98	2.0
2	4.54	1.0
3	2.09	2.3
4	4.99	1.3
5	4.71	1.1
6	5.00	2.0
7	4.99	2.0
8	3.04	2.6
Mean	4.29	1.78
LSD (P=0.05)	0.59	0.47
Composite sample	4.78	1.82

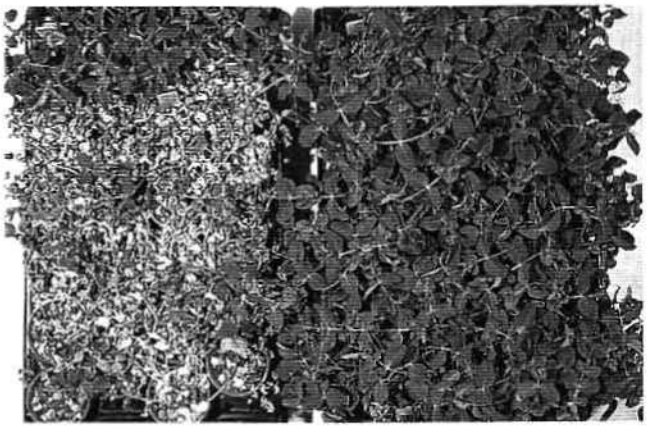
DISCUSSION. At both fields, there was some variability between sampling sites although the majority were closely grouped.

There was a good correlation between the mean of the eight sites and the standard test done on the composite sample. In view of the fact that there is some variability within fields, higher sample numbers would give a more accurate measure of the disease potential.

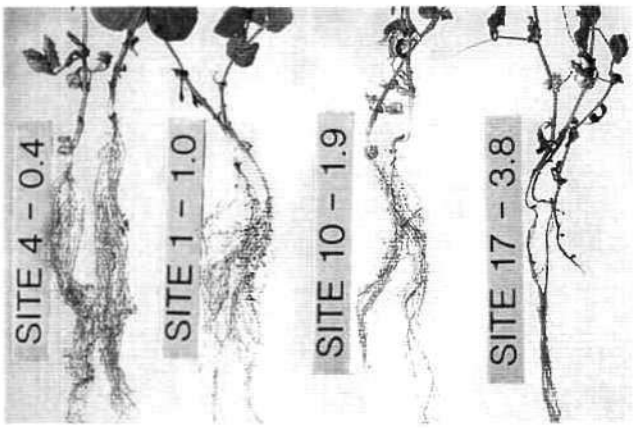
It is suggested a minimum of 10 sub-samples be taken but 20 would be better.

The Disease Indexing Test - Peas

Several tests set up in the glasshouse. Each 24 pot tray is used to index a different soil sample.



Differences in disease potential between soil samples can sometimes be dramatic.



The disease potential of different fields can be recognized by differences in root rot severity of test plants.

CHRONOLOGICAL DATA.

Soils set up in CEC 22/12/95 } } 22 days.
Experiment ended 15/01/96 }

3.22 Correlation of results from glasshouse indexing test with field disease severity

3.221 Experiment 3: Methyl bromide field trial

SUMMARY. Four different rates of application of methyl bromide were used in a replicated field trial to try to give a range in soil root rot potential. The season was dry and there were no significant differences in disease development in the field plots. Glasshouse disease indexing of soils showed all rates of application of methyl bromide as well as plastic tarping alone significantly reduced the soil disease index.

INTRODUCTION. Root rot in processing peas can greatly reduce productivity. In other countries, various soil indexing systems have been developed to identify high risk fields and quantify potential losses. Indexing is a bioassay whereby soil samples in pots are sown to peas, grown in conditions favourable for disease development and given a figure based on the severity of root rot which develops. This experiment was designed to induce a range of disease potential which could be quantified both by field disease ratings and a glasshouse bioassay .

PROCEDURE. A field site was selected on the Ford property near Gatton. Treatments were applied after seed bed preparation and pre-sowing irrigation. Treatments consisted of 4 rates of application of methyl bromide applied under plastic sheeting; plastic sheeting alone and no treatment. The experiment was a 6 x 4 randomised blocks design. The different rates of methyl bromide were obtained by applying one 680g can of methyl bromide to each plot but having different sized plots for each treatment (3.4, 6.8 , 9.0 and 13.6m^2). These compared with a standard rate of use of methyl bromide of 1 kg/m^2 = 680g/6.8m^2. Plots which were covered with plastic but did not receive methyl bromide were 3.4m^2.

Plastic fumigation sheets were removed after two days and soil samples collected from each plot for disease indexing. The location of plots was marked and sowing was carried out as part of the whole field.

Glasshouse indexing. Approximately 10L of soil were collected from each plot, thoroughly mixed, and ground to pass through a 5mm screen. Three 15cm diameter pots were filled with soil and 10 seed of cv. Small Sieve Freezer sown at a depth of 2cm. Pots were watered daily (without pot saucers). When at the 11-12 node stage, roots were washed, examined and rated for disease severity (0-5). The severity of lesions at the cotyledon site and stem were also rated (0-3).

Root rot severity – 0, no disease, roots fibrous and white; 1, slight, some small roots discoloured, no general loss of root volume; 2, diseased roots obvious, loss of root or diseased roots up to 25% of total; 3, moderate disease, up to 50%; 4 severe, loss>50-75%; 5, very severe >75-100%.

Cotyledon and stem lesions were rated as 0, no symptoms; 1, small lesion not encircling; 2, stem encircled, lesion <1cm long; 3, stem encircled, lesion >1cm long.

Field indexing. Five plants were dug from each plot, washed free of soil and rated for root rot using the above 0-5 scale. Plants were at the early flowering stage of growth.

Field plot yields. From each plot the plants within 2 x 0.25m^2 quadrants were removed and passed through a stationary pea viner. Yields of shelled green peas were measured.

RESULTS.

Glasshouse indexing. There were no differences in root rot between any of the treatments where methyl bromide or plastic sheeting was used. All these treatments showed lower indices than the control treatment (Table 3).

There were significant differences between treatment in the severity of crown rot with less disease occurring with the higher rates of methyl bromide application.

Combining the three ratings using a weighted formula of 70% to root index, 15% to each of crown and stem indices (0.7 x root rot index x 20) + (0.15 x crown rot index x 33.3) + 0.15 x stem index 33.3) gave a spread of disease indices from 23.4 to 73.1. The higher rates of methyl bromide treatment generally had a lower index. The treatment which was not covered by plastic had a significantly higher rating than all others.

Table 3

A comparison between disease severity in pea plants grown in treated field plots with glasshouse disease indexing

Treatment	Root rot (0-5)		Crown rot (0-3)	Stem rot (0-3)	Weighted DSI (0-100)	Green pea yield g/m^2
Methyl bromide –	*Field*	*Index*				
1kg/5m^2 + plastic	1.5	1.06	0.45	1.26	23.4a	557
1kg/10m^2 + plastic	1.45	1.19	1.62	0.86	29.1ab	714
1kg/13.m^2 + plastic	1.3	1.49	1.63	1.09	43.1b	657
1kg/20m^2 + plastic	1.15	1.47	2.35	1.35	39.1ab	555
0 + plastic	1.65	1.96	2.15	0.83	42.3b	687
0 - plastic	1.5	3.34	2.92	2.35	73.1	544
LSD P = 0.05	NS	1.04	1.02	NS	16.9	NS
P = 0.01	NS	1.44	1.42	NS	23.4	NS

The most common disease symptom in all treatments was a black crown lesion which extended to both roots and stem. Isolations showed *Fusarium solani* was the causal organism.

Field indexing. There were no significant differences in root rot severity between treatment.

Field plot yields. There were no significant differences between treatments.

DISCUSSION. A very dry season led to very low disease levels in the field plots and non-significant differences between treatments for both disease and yield. The soil indexing

showed that at this site, *Fusarium solani* was the most common pathogen and the crown rot and stem rot ratings were important in determining the Disease Severity Index of treatments. This organism was also important as a root invading pathogen, particularly of shallow roots.

Varying the application rate of methyl bromide did create some differences in DSI between treatments but plastic sheeting alone also reduced the disease severity. The reason for this is unknown by may be a soil solarisation effect.

In general, this experiment has shown that glasshouse derived DSI is of little significance in seasons when weather conditions do not favour soil borne diseases.

CHRONOLOGICAL DATA.

Methyl bromide applied	6 June 1994
Plastic sheeting removal	8 June 1994
Plots sown	11 June 1994
Field plots rated	18 August 1994
Field plots harvested	15 September 1994

3.222 Experiment 4: Indexing seven pea soil samples for damping off and root rot potential

SUMMARY. *In seven soils from the Lockyer Valley, damping off potential was high (10-48% survival) but could be greatly reduced by a thiram/metalaxyl/tolclofos methyl seed dressing provided* Aphanomyces euteiches *was not present. Two soils showed a high root disease potential due to* A. euteiches, *the remainder were low.*

INTRODUCTION. Soil indexing is a way of predicting the severity of damping off and root rot of peas. In this experiment, seven soil samples were tested in the glasshouse and field grown plants rated to provide a comparison of predicted severity with actual severity.

PROCEDURE. Soil samples were collected from seven sites, mixed and a one litre sub-sample autoclaved to eliminate pathogens. Pea seed cv. Patea was used with the commercial thiram dressing or with an additional dressing of Apron + Rizolex (1.5 + 1.5 g/kg seed). For each soil sample treatments were:

(a) One pot (12.5 cm diam.) *sterile soil* sown with 10 thiram treated seed to test germination of seed.

(b) Four pots (12.5 cm) *natural soil* sown with 10 thiram treated seed to test the efficacy of the standard seed treatment on emergence and root rot severity.

(c) Four pots (12.5 cm) *natural soil* sown with 10 seed treated with Apron and Rizolex as well as Thiram to test emergence and root rot severity when pathogens such as *Pythium* and *Rhizoctonia* are effectively controlled.

Plants were grown for five weeks, flooded for two days and washed free of soil at six weeks after sowing. The number of survivors (%) and severity of root rot (0-5) were rated.

* 20-25 plants from the sites were rated for root rot severity at the flowering stage of growth.

Table 4

The effect of seed dressings on the survival and root disease severity of peas grown in seven different soil samples from the Lockyer Valley. The results of this pot test can be compared with disease severity in field grown plants from the same sites

Site	Soil treatment	Seed treatment	% Survival (0-100)	Root rot (0-5)	
				pot	field
Pit. 1	Sterile	Thiram	90	0	
	Natural	Thiram	20	4.2	2.1
	Natural	T + Ap + Riz.	15	4.3	
Pit. 2	Sterile	Thiram	60	0.7	
	Natural	Thiram	27	5.0	1.8
	Natural	T + Ap + Riz.	33	5.0	
LFM	Sterile	Thiram	80	0	
	Natural	Thiram	27	2.0	1.3
	Natural	T + Ap + Riz.	75	0.1	
J.H.	Sterile	Thiram	100	0	
	Natural	Thiram	10	1.7	0
	Natural	T + Ap + Riz.	73	0	
E.L.	Sterile	Thiram	90	0	
	Natural	Thiram	38	1.7	Not sown
	Natural	T + Ap + Riz.	90	0.2	
W.Z.	Sterile	Thiram	80	0	
	Natural	Thiram	48	1.1	2.3
	Natural	T + Ap + Riz.	90	0.1	
D.S.	Sterile	Thiram	90	0	
	Natural	Thiram	45	1.0	0.4
	Natural	T + Ap + Riz.	82	0.3	

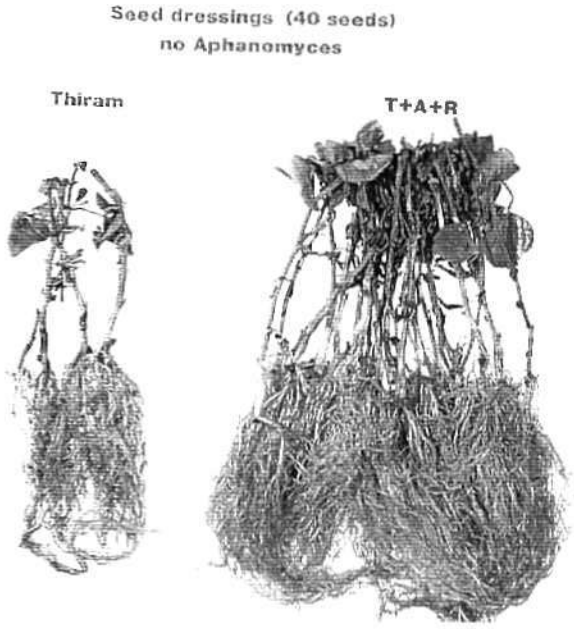
RESULTS. The results in Table 4 show six samples had a plant survival of 80-100% in sterile soil. Site Pit.2 was lower at 60%. With thiram seed dressing, survival rates were between 20 and 48%. This was restored to 73-90% by the more effective seed treatment except at the Pit. sites where survival was still 15-30%.

Root rot severity was low except at the two Pit. sites (4.3 and 5.0).

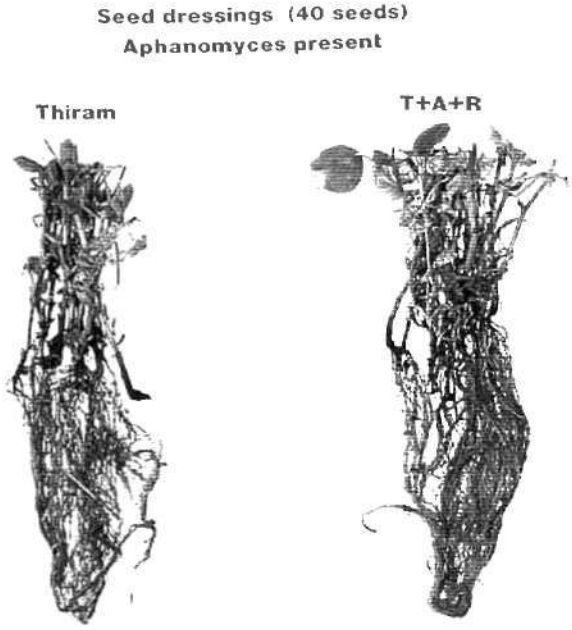
Field pea samples showed generally low root rot severities with highest ratings at the W.Z. and Pit. 1 sites (2.3 and 2.1).

DISCUSSION. The difference in survival due to the T + A + R seed treatment was out standing and led to lower root disease ratings except at the Pit. sites. The low emergence and high root disease at these two sites was due to *Aphanomyces euteiches* which is not controlled by the seed dressings. Field disease at the Pit. sites was low due to low soil moisture which is not favourable for *Aphanomyces* root rot development. Correlation between the pot test and field samples was generally good except for a higher than expected field disease rating at the W.Z. site.

The Effect of Fungicide Seed Dressings on Plant Establishment



By controlling *Pythium* and *Rhizoctonia* with Apron® and Rizolex® (right), seedlings develop large, healthy root systems



Seed dressings of Thiram®, Apron® and Rizolex® will not control *Aphanomyces* sp.

CONCLUSIONS. Further development of the T+A+R. seed dressing could lead to improved emergence and lower root disease. The soil indexing test could then be directed solely at *Aphanomyces* potential.

CHRONOLOGICAL DATA.

Soil collected	17th August, 1995
Test commenced	18th August, 1995
Test concluded	2nd October, 1995

3.223 Experiment 5: Correlation of soil disease index with field disease ratings and yield in the 1995 pea season (17 farms)

SUMMARY. *During the 1995 pea season, 17 sites were indexed for root rot severity and crops rated for disease severity at flowering. Yields were obtained from the harvesting contractor. There was excellent correlation between the index and actual field disease for 7 sites, good correlation for 6 sites and poor correlations for 4 sites. Dry conditions and water shortages probably led to lower than predicted disease severity on some sites.*

PROCEDURE. Soil samples were collected, mixed and large clods broken up. Pea seed cv. Patea was treated with Thiram 80, Apron 350 and Rizolex 500 at 1.5g/kg seed for each fungicide. Soil was used to fill four of five pots and 10 seed sown on the soil surface and covered with vermiculite. Plants were rated for disease (0-5) after 5/6 weeks.

Field plant samples were collected at the early-mid flowering stage and 20-25 root systems rated for disease severity from each site.

Yield figures were obtained from the harvesting contractor, Vecon, at the completion of harvesting.

RESULTS. The results in Table 5 show that there was a close correlation between the predictive test and the actual field severity of root rot for seven sites and reasonably accurate predictions for six. In the remaining four tests, predictions of root disease severity were higher than actually occurred.

There was little correlation between the disease severity and yield.

Table 5

Relationship between yield of peas (t/ha), field disease severity and soil index of disease severity for sites in 1995.

Site*	Yield t/ha (Shelled peas)	Field severity (0-5)	Soil index (0-5)		Correlation index/field**	Remarks
			1*	2*		
Vecon	3.0	0.5	1.8		++	Water shortage
J.F.	4.5	0.6	0.9		+++	Water shortage
C.D.	5.1	3.0	4.3	1.8	++	
M.R.	5.3	2.3	2.4		+++	
J.P.2	5.4	1.8	5.0		+	Water shortage
J.P. 1	5.7	2.1	4.2		+	Water shortage
M.G.	5.8	1.5	0.0	1.0	++	
W.Z.	5.9	2.3	0.1		++	
L.F.M.	6.4	1.3	0.1		+++	
N.G. 1	6.4	3.0	4.7	3.4	++	
J..H.	6.5	0.0	0.0		+++	Out of a good rotation
J.R.	6.6	1.1	0.6	0.4	+++	
N.G. 2	6.9	2.4	4.9	0.9	+	
D.S.	7.0	0.4	0.3		+++	
R.K.	7.2	4.0	4.9	3.2	+++	
A.M.	7.3	1.2	3.8		+	
K.H.	7.8	1.1	2.5		++	

* A seedling test conducted over 3 weeks

** + poor correlation between Soil Index and Field Severity
++ good correlation
+++ excellent correlation

DISCUSSION. In this abnormally dry season the area sown to peas was very small. In some cases growers applied irrigation sufficient for their crops to reach full potential while for others water was in short supply. Many of the high yielding crops were very well grown and were on land coming out of a non-pea rotation.

The severity of root rot in field crops depends on many factors including drainage, inoculum present and frequency of saturation. In the soil indexing test we detect root rot problems due to *Aphanomyces, Fusarium* and *Ascochyta* but not *Pythium* or *Rhizoctonia* due to the fungicide seed treatment. The major root rot organism is *Aphanomyces euteiches* which

causes root death but generally not plant death. Disease severity depends on soil moisture availability since the organism spreads by motile zoospores. In view of this, it could be expected that in a dry season, field disease levels, may not be as high as that indicated by the soil index. In most cases where there is poor correlation between the Soil Index and Field Severity, it is due to the Field Severity being much lower than predicted according to the Soil Index.

Further refinement and testing of the Soil Indexing system will continue in 1996.

3.224 Experiment 6: Correlation of soil disease index with field disease ratings in the 1996 pea season (15 farms)

SUMMARY. Fifteen pea soils were indexed for disease severity (0-5). Seven were very low (a rating < 1.0); four were low-moderate (1-3.5) and four were very high (> 4.5). When rated for root rot severity at late flowering, one field was classed as very low and 14 as low-moderate severity. There was a poor correlation between the prediction and actual field results, possibly due to dry field conditions and low disease development.

INTRODUCTION. This work continues to examine the probability of being able to accurately predict field disease severity in processing pea crops from a glasshouse indexing test.

PROCEDURE.

Glasshouse Indexing. Soil samples were collected from 15 fields where the next crop was to be processing green peas. Soils were ground and sieved to remove stones, hard clods and large organic detritus.

Small (150mL) pots were prepared with layers of 20ml coarse vermiculite; 100ml soil; three pea seed treated with Apron + Rizolex + Thiram and 30ml fine vermiculite. In this test, 24 pots were used for each soil including four pots containing a sub sample of sterilised soil. Pots were saturated and covered with plastic until germination. Pots were watered to saturation each day and fertilised with slow release Osmocote pellets at the commencement of the experiment.

After four weeks, roots were washed free of soil and rated for disease severity on a 0-5 scale.

Field Severity. Pea farms were visited at fortnightly intervals to monitor the first appearance of disease symptoms and to be aware of crop growth. As each crop reached late flowering, approximately 20 plants were dug and rated for root rot severity (0-5). A mean field rating was obtained.

RESULTS. The glasshouse test (Table 6) indicated there were large differences in disease severity between some sites. Seven sites showed low disease indices (< 1.0) while 4 suggested high (> 3.5) disease potential.

None of the 15 field disease ratings showed high levels of root rot. Most were in the low-moderate severity range. There was no correlation between the two tests.

Table 6

Comparison of the soil disease index and field severity of 15 pea sites in 1996

Site	Disease index (0-5)	Field severity (0-5)
K.G.	0	2.58
G.G.	0.12	2.64
K.G.	0.17	2.11
D.R.	0.29	1.15
I.G.	0.63	0.30
W.Z.	1.00	1.17
M.R.	2.09	1.28
E.Z.	2.71	1.71
M.R.	3.04	2.30
K.Bros.	3.09	1.29
W.Z.	4.54	2.00
N.S.	4.75	1.42
A.M.	4.83	1.44
R.Bros.	4.83	1.81

DISCUSSION. Although there were clear differences between soils in the glasshouse tests, they were not displayed in the field ratings. It can only be suggested that while disease is encouraged by daily saturation of pots, this situation does not occur in the field. Dry field conditions do not allow disease expression to reach its potential. This is a short coming of disease prediction techniques of this sort- conditions can be standardised for the glasshouse test, but all aspects of the field side of crop and disease development are variable.

3.225 Experiment 7: Correlation of soil disease index with field disease ratings in the 1997 pea season (6 farms)

SUMMARY. Root rot ratings (0-5) varied from 0.93 – 4.0 in the eight fields sampled at early pod set. There was a good correlation between the soil index test and field severity.

PROCEDURE. Twenty pea plants were examined for root rot severity in each of eight crops when they were at the late flowering – early pod set stage. Roots were rated on a 0-5 scale of severity as previously.

Soil tests had previously been conducted on samples from six of these fields. Correlations were made between these and field ratings.

RESULTS AND DISCUSSION. Only one crop (Table 7) was classed as having a high disease severity (G.G.; 4.0). This high rating was associated with a root rot caused by *Chalara elegans*, a first record of this pathogen in peas in Qld. Two other crops were moderate (J.F., 3.2 and W.Z., 2.3). The remainder were low (0.9 - 1.5). The three crops showing the highest field ratings were also ranked highest in the soil index test (G.G., 2.5; J.F., 0.9 and W.Z.,0.9). The fields showing low disease were classed as low risk in the indexing test with indices of 0.5 – 0.6.

Table 7

Correlation of soil indices with field severity in six pea fields – 1997

Grower	Disease index	Fungi isolated	Field severity (0-5)
J.F.	0.85	PFA	3.2
M.R.	0.46	P	1.0
N.G.	0.47	-	0.9
Vecon (Granthan)	0.55	PFA	1.2
W.Z.	0.92	PF	2.3
G.G.	2.45	PFC	4.0

P = Pythium sp; F = Fusarium sp; A = Aphanomyces euteiches; C = Chalara elegans

3.23 Variation in root rot potential at two sites over a two-year period in the absence of peas

SUMMARY. Five soil disease indexing tests were carried out on each of two fields over a two year period. The major pathogen present was *Aphanomyces euteiches.* There was no decline in disease potential during the observation period.

INTRODUCTION. During the field survey in 1994, a field at Harrisville showed vastly different disease severities in sections which had different land use histories. One half of the field (site B) had carried two pea crops in the preceeding five years and had a high disease incidence. The other half, site A, had not been sown to peas previously and had a very low root rot incidence. Over the next two years soil samples were taken and assessed to follow changes in the disease severity indices at these two sites.

PROCEDURE. A disease indexing test was carried out at 6 monthly intervals on each of the two sites, commencing in June 1994. The first sample was taken from within the immature 1994 pea crop. The second sample (12/94) was taken after crop residues had been mulched into the soil. No further pea crops were sown. Land use for the remainder of the observation period was production of forage sorghum.

RESULTS. The disease index at Site B increased (doubled) after the pea crop had been mulched. and thereafter remained high (Table 8). At site A, the disease potential also increased following the 1994 pea crop but remained low and became 0 at the final assessment.

Table 8

Soil disease indices at two field sites over a two-year period

Sampling date	Disease severity 0-5		Land use
	Site B	Site A	
June 1994	2.5	0.9	Pea Crop
Jan 1995	5.0	1.8	Fallow
July 1995	5.0	0.3	Sorghum
Dec 1995	4.8	1.8	Sorghum
July 1996	4.2	0	Sorghum

DISCUSSION. When this field at Harrisville was inspected in June 1994, the pea crop was young. The soil samples which were taken from the two sides of the field clearly showed the effect of the different land use histories. Site B with two previous crops in five years showed moderate disease potential (2.5) while Site A with no previous pea production showed low disease potential (0.9).

By the end of the season, the disease potential had increased sharply at both sites. This reflects the multiplication of inoculum during the season.

In the next 18 months, there was a slight drop in disease potential at Site B (5.0 to 4.2) and an appreciable drop at Site A (1.8 to 0). This occurred under a land use regime of fallow and forage sorghum. It seems that for fields with a low disease potential, a rotation of one pea crop in three years will probably maintain a low disease potential. Once high potentials are reached, it will take a long absence from pea and other susceptible crops for the disease potential to reach a low level.

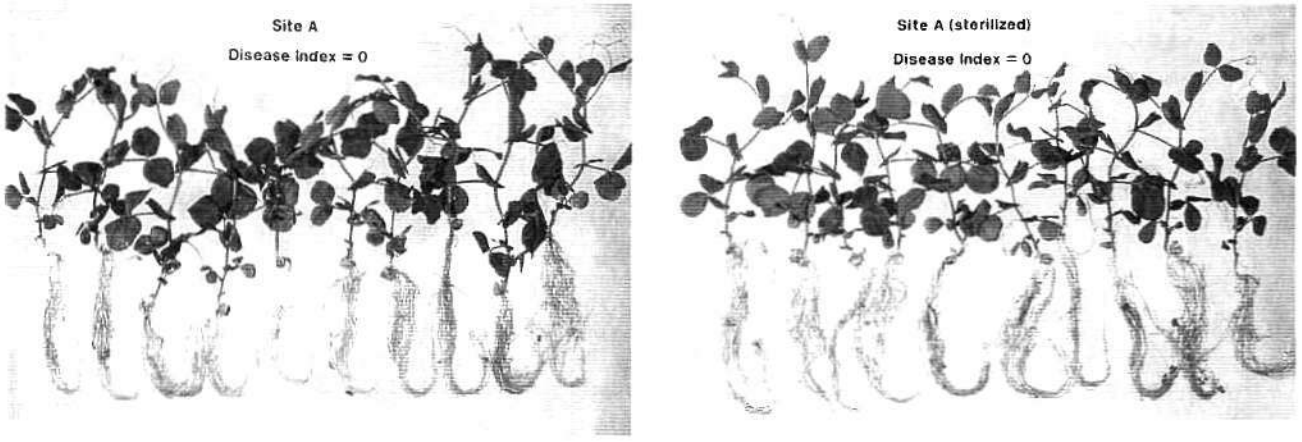
4.0 DISCUSSION – INDEXING PEA SOILS

Peas are affected by a wide range of pathogens. Isolations from many plants from many sites in the Lockyer Valley indicate that *Aphanomyces euteiches* is probably the most common source of root rot although it is often difficult to isolate from plants with advanced root rot symptoms. *Pythium* sp. often caused pre-emergence damping off in our tests and could be detremental to good field establishment under wet conditions. *Fusarium solani, F. oxysporum, Ascochyta pinodella* and *Chalara elegans* are also associated with root rot in south-east Qld pea crops. *Rhizoctonia solani* is usually associated with a crown rot in fields with undecomposed plant trash.

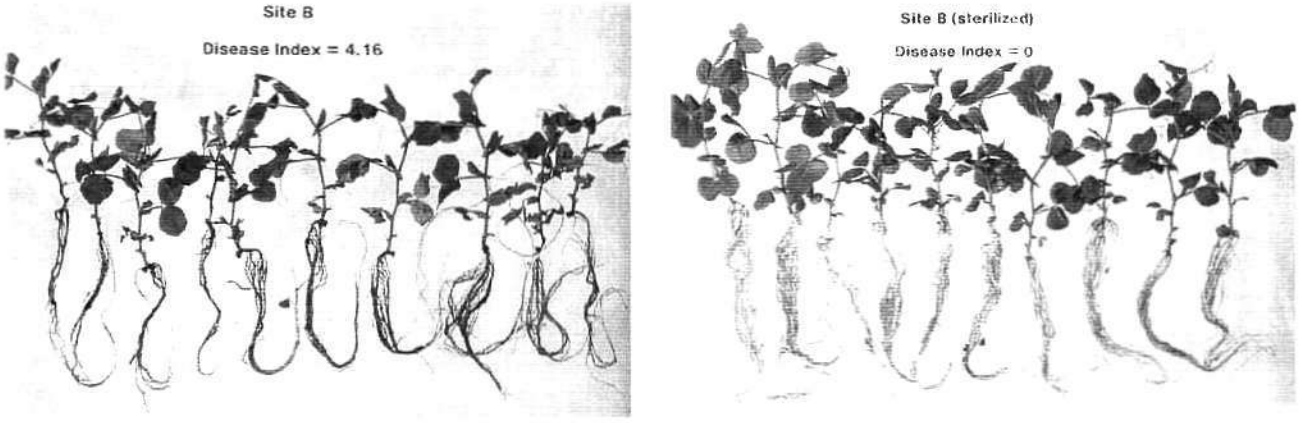
While seed dressings are capable of reducing losses due to *Pythium* and seed-borne *Ascochyta* sp., their zone of protection does not extend into the soil to be effective against organisms which roots encounter as they grow. The purpose of developing an indexing test is to gauge the probable severity of root rot.

For Aphanomyces, a short indexing test (4 weeks) is suitable. For other pathogens, a longer test (6 weeks) will allow better symptom development. The short test gives a more reliable indication of soil disease potential due to *Aphanomyces* since it limits the time available for secondary disease spread from plant to plant within the pot. This is particularly important for

The Effect of Different Land Use Histories on Disease Potential in Two Parts of the Same Field



Site A - one pea crop in 5 years. There is no difference in root rot severity between natural soil (left) and a sterilized soil sample (right).



Site B - 3 pea crops in 5 years. Although the sterilized soil sample (right) from this site has no disease, the natural soil sample (left) shows a high disease potential.

pathogens such as *Aphanomyces* and *Pythium* which reproduce quickly and have motile spores.

The soil indexing test was capable of consistently differentiating between soils with low and high disease potential eg. Harrisville A & B sites. In the two fields which were investigated, there also seemed to be a high degree of uniformity in disease indices from different sites within each field. This consistency of disease potential for pea root rot is supported by our observations in rating pea fields for disease severity. Usually there are no noticeable 'hot spots'. Uniformity of disease symptoms through a field is the norm.

The prediction of field disease severity from a soil indexing test is difficult. While it is possible to accurately compare soil samples under uniform conditions in the glasshouse, the conditions which determine field disease severity vary from field to field. The indexing test should accurately predict disease severity when conditions favour high disease severity but when field conditions are unfavourable, there is usually a poor correlation. It was unfortunate that in 1994-96 the Lockyer and Fassifern Valleys experienced drought conditions. Perhaps the most important way the test can be used is to identify 'at risk' fields which can then be used for other purposes. It should be remembered, however, that lucerne and beans are also hosts of *A. euteiches*. For soils with low disease potential, a rotation of one pea crop every three years should ensure a long period with few root rot problems. The lower acreages now sown to peas in south-east Qld. will enable longer rotations to be practised.

5.0 *GENERAL DISCUSSION*

Extension/adoption by Industry of research findings. The decision to adopt the soil indexing test will depend on the attitude of the processing companies. In Qld., the main processing company is Golden Circle Ltd which processes both beetroot and peas. The field production of the pea crop is managed by Vecon Ltd. Beetroot production is managed directly by Golden Circle. Edgells will no longer process either peas or beetroot due to closure of their Manly (Brisbane) plant in December 1998.

This project has been conducted in close co-operation with field officers of both companies and there is general concern at the incidence of soil-borne diseases. At the conclusion of the project, an address was given to beetroot growers, field officers and management of Golden Circle A proposal to continue soil testing was made and it is anticipated the company will support disease indexing in 1999 on a fee for service basis.

The reduction in the size of the local pea processing industry suggests there will be little interest for the extension of the service for pea crops. Interest has been expressed by Edgells, Tas. that it may be useful since soil-borne disease problems are of concern.

A major benefit of the project has been the attention it has drawn to the soil-borne disease problem due to the large number of on-farm trial sites we established. At every opportunity we encouraged growers to use improved land use practices.

Directions for future research and/or activities supported by HRDC. Tasmanian researchers may wish to trial the methods we have established for indexing pea root rot severity. This could be done in a one year period.

Financial/commercial benefits of adoption of research findings. The changes in the vegetable processing industry in south-east Qld. in recent years demonstrate it is an industry competing on world markets. Efficiency in all stages of product development must be high to successfully compete.

The increasing incidence of soil-borne diseases has been one impediment to efficient field production of both peas and beetroot contributing to the supply problems. The project has developed tests to identify high risk fields which can then be removed from production. Of equal importance is the growing adoption in the district of improved farming practices such as including gramineous crops in the rotation. In time these will improve soil structure and increase the diversity of soil micro-organisms. During the final year of the project, we were seeing lower disease indices on the farms of early adoptors.

The main commercial benefit of the project will be a beetroot industry with a declining soil disease problem able to compete and survive with competing products on an open market.

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