

Project title: HDC contribution to the Scottish Raspberry Development Programme R & D initiatives - "Field trials of integrated control of raspberry root rot"

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EXECUTIVE SUMMARY

Various measures that could be used as part of a strategy for lessening the impact of raspberry root rot are discussed. Research has been carried out on these measures with the support of the Scottish Soft Fruit Growers Ltd.

Covered in detail are two field trials on integrated disease management established on East Loan, SCRI (Trial 1) and on an adjacent farm, Star Inn (Trial 2). Trial 1 includes two cultivars, Glen Moy and Malling Admiral; which differed slightly in their resistance in pot trials; two rates of Recoil fungicide (6 and 12 kg per treated hectare; applied twice yearly); ridged v non-ridged; and mulched v non-mulched. Trial 2 only had Glen Moy; three rates of Recoil (4, 8 and 12 kg per ha); ridged v non-ridged; and mulched v non-mulched.

Numbers of young cane, height of young cane and various assessments of disease were recorded from 1994-1996 inclusive. Disease was much higher in Trial 1 than in Trial 2 but it worsened at both sites throughout the trials. In Trial 1, many control plots were almost completely destroyed.

In general, the best results in terms of disease control were obtained with the higher rates of Recoil fungicide in combination with cv. Malling Admiral, thus confirming the effectiveness of Recoil. The importance of breeding new cultivars with even modest levels of resistance similar to those found in Malling Admiral was demonstrated. These levels should not be difficult to obtain within the existing breeding programme.

Although less marked than the effects of fungicide and host resistance, ridging gave some modest improvements in plant health. There were no obvious benefits from mulching and it cannot be recommended for disease control. One problem in incorporating ridging in management regimes might be a need for a unique regime for each cultivar since interactions between ridging and cultivar were observed. There might be site and seasonal effects to consider also. Nevertheless, growers should strongly consider incorporating ridges into their disease management, especially if they have irrigation available during the summer. They will have to remake the ridges each year but that can be done relatively easily if mulching is omitted.

A new field trial was established in 1995/96 to test the suitability of ridging and fungicides for control of root rot in nine new cultivars some released from the SCRI breeding programme. First results are due in 1997.

Similarly, new blight fungicides released since the off-label approval for Recoil were tested in the glasshouse for their efficacy against root rot. As a result a new field trial was established in the Brechin area in Autumn 1996. These will test rates of the fungicides equivalent to those for Recoil against root rot with the materials applied in the standard two applications or in four (half-rate) applications. First results are due in 1997.

INTRODUCTION

Raspberry root rot is a serious soil-borne disease caused by infection of raspberry roots and crowns and the bases of young and old canes by *Phytophthora*. A number of species have been implicated in this disease but in Scotland the most serious is undoubtedly *P. fragariae* variety *rubi*, which is very closely related to the fungus causing strawberry red core. Raspberry root rot only became apparent as a problem for Scottish raspberry producers in the mid-1980's, but with its rapid spread and severity, it was soon the major disease problem facing the industry. Initial efforts at control were two-fold: firstly, to stem the flood of new outbreaks which were clearly due to the use of infected planting material, and secondly, to develop palliative measures for affected growers through the development of good fungicide control.

Clean stock: Close collaboration among SCRI, SASA and the Horticultural Health Inspectorate of SOAEFD soon slowed the number of new outbreaks arising from infected Scottish stocks. An effective bait test was quickly devised for all stocks entered for certification, which was itself made compulsory for all raspberry stocks from 1991 onwards. Consequently, the number of new outbreaks reported to staff at SCRI has declined considerably, although they have not completely stopped and in 1995/96 there were more than in previous years.

Sensitive PCR primers have recently been developed for *P. fragariae* thus making possible its rapid and sensitive detection by molecular methods. This technique has only been tested on a small scale with field material but the results were promising (see below).

Fungicides: The development of effective fungicides took longer than the bait test and in a sense continues to this day (see later in report). Ridomil Plus (metalaxyl and copper oxychloride) was released first, only to be superseded by Fubol 58WP (metalaxyl and mancozeb) which was clearly more effective; off-label approval for these fungicides arose from work at SCRI and SAC.

Some growers however were still unhappy with the level of control achieved with the latter and further trials in collaboration with SAC resulted in the release of Recoil (oxadixyl and mancozeb) in 1993. Recoil gave even better results than Fubol, especially under high disease pressure. Unfortunately, in some situations, the efficacy of year-after-year applications was only maintained at the higher levels of fungicide and there was pressure from Sandoz, the makers of Recoil, to reduce amounts of the material used on raspberries to the absolute minimum. There was therefore a need for further work to develop new management techniques in raspberry that would help control disease with reduced rates of fungicide applications.

Ridging & Mulching: While the work on fungicides was progressing at SCRI, we became aware of the work of Wayne Wilcox at Geneva Experimental Station of Cornell University in upper New York State, and later that of Nina Heiberg in Norway, who were both attempting to control raspberry root rot using ridges. Moisture is essential for infection by any *Phytophthora* spp and the longer root systems can be kept free of periods of soil saturation then the healthier they are likely to be. Ridges keep root systems above the water

table for longer than culture on the flat and hence offer the prospect of some control. Mulching was another treatment that had given some promising results in their preliminary trials, probably by shedding water from ridges into the troughs between the rows.

Host Resistance: At SCRI we were also interested in exploiting our own knowledge on the resistance of raspberry cultivars to root rot. Many cultivars have been rated for their resistance, and although most had little or any, a number had moderate levels of resistance. We were interested in how much this resistance could contribute to growing systems designed to lessen the impact of root rot.

Integrated disease management (IDM): There was therefore a number of potentially useful but unconnected measures each of which might give some degree of control. It seemed that if these (ridging, mulching, host resistance and fungicides) were incorporated into an IDM package for raspberry root rot, there might be a real opportunity of controlling the disease on infested sites and thereby improving the viability of growers on holdings affected by it. An additional advantage might be a reduction in the amounts of fungicides being used to control the disease. As well as reducing costs, this would lengthen the life of materials such as Recoil and help prevent the emergence of fungicide-resistant strains.

Each of the above elements has been progressed through various programmes of work, some funded by the SSFG Ltd initiative and others by joint SOAEFD/HDC funding or through the core programmes of SCRI.

EXPERIMENTAL WORK

Elimination of Diseased Planting stocks rapid Diagnostics (SOAEFD + HDC funded)

A rapid test for detecting *P. fragariae* v *rubi* and other *Phytophthora* species in the roots of raspberry plants has been developed. This test, which is based on the DNA fingerprint of the fungus and can give results within a day, was compared in 1995 with a conventional bait test run by SASA, East Craigs. The test performed as well as the official test, detecting root rot in a number of 'spiked' samples. Similar molecular diagnostics detected infection by more minor *Phytophthora* species that were not detected by the conventional test. Repeat tests are due shortly in 1997.

Field experiments with ridging, fungicides and varieties differing in resistance to root rot (SSFG funded).

Two trials were established in 1994, one on SCRI land and one on adjacent private land. Both sites had been infested naturally with *P. fragariae* v *rubi* several years prior to the establishment of the trials. In the case of the SCRI trial, infected plant material collected from the site prior to planting was chopped finely and ploughed back into the soil in two directions to ensure even infection in the trial. The following treatments in all combinations were included in each trial:

MATERIALS AND METHODS

Trial 1: East Loan, SCRI (four blocks, randomised block design)

Cultivars: Glen Moy, Malling Admiral.

Glen Moy has no resistance to raspberry root rot but is a popular cultivar of some importance to the industry. Malling Admiral has little agronomically to recommend it but had shown moderate levels of resistance to the disease in pot trials and provided that element for the trial.

Fungicides: None, 6 and 12 kg per treated ha (\approx 10,000 metres of row) Recoil

Ridging: Ridging v normal cultivation on the flat (non-ridged)

Mulching: Plastic mulch v bare soil (non-mulched)

Trial 2: Star Inn (four blocks, randomised block design)

Cultivar: Glen Moy

Fungicides: None, 4, 8 and 12 kg per treated ha (\approx 10,000 metres of row) Recoil

Ridging: Ridging v bare soil on the flat (non-ridged)

Mulching: Plastic mulch v bare soil (non-mulched)

The sites were chosen because they could be closely supervised from SCRI and they represented high (East Loan) and low (Star Inn) disease pressure. Irrigation lines were included in all the plots in case the plants came under too much stress from water deficiency during the Summer.

RESULTS

In descriptions of treatments carried out on trial plot ie cultivar, fungicide etc, if there is a significance level for this treatment, this has been stated.

If there is no significance level the description of a treatment will only represent a trend that is present for the differing treatments.

Another point of note is the complex interactions that exist between certain treatments eg genotype (cultivar), mulch (cultivation) and the varying levels of significance. All the data that exists for this can be found in the full statistical appendices.

EAST LOAN, SCRI

1994 - ESTABLISHMENT YEAR:

Number of primocanes per stool (Table 1)

Table 1.

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1.41	1.72	1.31	2.15	1.46	2.17	2.02	1.94	1.92	1.88	1.75	1.98
Mulched	0.85	1.27	1.44	1.38	1.91	1.56	1.56	1.54	1.71	1.77	1.77	1.90

As could be expected, numbers of new cane were small in this first year as were treatment differences.

Cultivar: The greatest number of canes were produced by Malling Admiral (to a 99.9% significance level)

Fungicide: The greatest number of canes (to a 99% significance level) were obtained from applying 12 kg/ha of Recoil.

Height of primocane (cm) (Table 2)

Table 2

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	58.7	64.7	47.6	63.5	67.8	64.4	79.9	86.0	82.4	63.8	89.9	88.2
Mulched	41.3	49.7	42.5	59.3	55.1	61.6	62.6	65.7	90.7	82.8	90.7	82.7

Cultivar: Canes of Admiral were much taller (to a 99.9% significance level) than canes of Moy but this was more a reflection of innate differences between the genotypes than anything related to root rot severity or its control (80.4 (Malling Admiral) v 56.4 (Glen Moy)).

Fungicide: The tallest canes (to a 99% significance level) for either cultivar (but there is no significance here due to an interaction between fungicide and cultivar) were obtained with 12 kg treated ha⁻¹ of Recoil {to a 99% significance level (63.6(0) → 66.6 (6) → 75.0(12))}.

Ridging: Ridging had little effect on cane height (69.4 (ridged) v 67.4 (non-ridged))

Mulching: Canes were taller (to a 99% significance level) without mulching (71.4 (non-mulched) v 65.4 (mulched))

Worst and Best treatments: The worst treatment was Glen Moy/no fungicide /non-ridged/mulched; the best was Malling Admiral/6 or 12 kg Recoil/non-ridged/mulched.

Health Score (Table 3)

The following system for scoring disease was only used in this establishment year; it was changed radically in subsequent years. Scores were awarded as follows: stools that were dead were scored - 1; obviously diseased but alive - 2; apparently healthy - 3. Thus in this case higher scores means healthier plants, *i.e.* less disease.

Table 3

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	2.27	2.42	2.10	2.67	2.35	2.56	2.50	2.63	2.63	2.44	2.60	2.73
Mulched	1.71	2.00	2.19	2.25	2.38	2.41	2.23	2.27	2.56	2.73	2.65	2.67

Cultivar: Malling Admiral was healthier (to a 99.9% significance level) than Glen Moy (2.55 (Malling Admiral) v 2.28 (Glen Moy))

Fungicides: Fungicides gave healthier plants (to a 99.9% significance level) (2.25(0) → 2.45(6) → 2.54(12)).

Ridging: Ridging had little effect on health (2.48 (ridged) v 2.35 (non-ridged)).

Mulching: Mulching had little effect on health (2.49 (non-mulched) v 2.34 (mulched)).

Worst and Best treatments: The worst treatment was Glen Moy/no fungicide/non-ridged/mulched (1.71); the best were Malling Admiral/6 kg Recoil/ridges/mulched (2.73) and Malling Admiral/12 kg Recoil/ridges/non-mulched (2.73).

SUMMARY FOR 1994: The greatest effects observed in Year 1 were cultivar and then fungicide. Any effects of ridging and mulching were very small.

1995 - SECOND YEAR

Number of primocanes per stool (Table 4)

Table 4

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	9.1	12.1	6.3	12.2	8.8	12.4	8.2	5.1	9.1	5.0	7.3	3.3
Mulched	2.6	5.1	4.3	4.7	5.8	6.2	3.8	5.1	6.2	6.2	4.8	7.3

Cultivar: Moy produced more young cane (to a 99.9% significance level) than Admiral (7.45 (Glen Moy) v 5.94 (Malling Admiral))

Fungicides: Recoil increased numbers of young cane slightly (6.39(0) → 6.73(6) → 6.98(12))

Ridging: Ridging increased numbers of young cane slightly (7.06 (ridged) v 6.35 (non-ridged))

Mulching: Mulching reduced numbers of young cane numbers (to a 99% significance level) (5.18 (mulched) v 8.24 (non-mulched))

Treatment interactions: These were very strong (to a 99.9% significance level in the majority of cases) especially between the genotypes. Thus ridges greatly increased young cane numbers in Glen Moy (to a 99.9% significance level) but reduced them in Admiral.

Worst and Best treatments: Worst treatment, Glen Moy/no fungicide/non-ridged/mulched (2.6); the best, Glen Moy/12 kg Recoil/ridges/non-mulched (12.4)

Height of primocane (cm) (Table 5)

Table 5

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	90	108	85	101	108	110	149	140	153	113	158	135
Mulched	76	93	82	86	94	110	130	136	148	159	160	154

Cultivar: The difference in cane height (to a 99.9% significance level) between Admiral and Moy was again considerable (to a 99.9% significance level (144.5 (Malling Admiral)) v 95.3 (Glen Moy))

Fungicide: Fungicide increased the height of primocanes (to a 99% significance level) (115.25(0) → 115.88(6) → 128.63(12))

Ridging: Ridging had little or no effect on cane height (119.4 (non-ridged) v 120.4 (ridged))

Mulching: Mulching had little or no effect on cane height (119 (mulched) v 120.8 (non-mulched))

Worst and Best treatments: The worst treatment was Glen Moy/no fungicide/non-ridged/mulched; the best was Malling Admiral/12 kg Recoil/mulched/non-ridged.

Whole Plot Disease Assessments (Table 6)

Disease was assessed in two ways in 1995 - for each plot as a whole plant and for individual stools. Whole plots were assessed using the following scores: 0 - all stools apparently healthy; 1 - less than 50% stools dead; 2 - more than 50% stools dead. Note this is opposite to the system used in 1994. For stool scores see next section below.

Table 6

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1.50	0.75	1.00	0.50	0.75	1.00	0.50	0	0.25	0.25	0.25	0

Mulched	1.00	1.25	1.00	0.50	1.00	0.25	0	0.50	0.25	0	0	0
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Cultivar: Malling Admiral was less diseased (to a 99.9% significance level) than Moy (0.17 (Malling Admiral) v 0.88 Glen Moy))

Fungicides: Fungicides gave healthier plants (to a 99% significance level) (0.68(0) → 0.47(6) → 0.41(12))

Ridging: Ridging reduced disease (0.41 (ridged) v 0.63 (non-ridged))

Mulching: Mulching reduced disease slightly (0.48 (mulched) v 0.56 (non-mulched))

Worst and Best treatments: The worst treatment was Glen Moy/no fungicide/non-ridged/non-mulched (1.50); a number of treatments were apparently completely healthy. All were mulched; 4/6 were ridged; 4/6 were Admiral; 3/6 were 12 kg, 1/6 was 6kg and 1/6 was no Recoil.

Stool Disease Assessments (Table 7)

Three stools were selected at random and assessed using the following scores: 0 - all canes apparently healthy; 1 - < than 50% canes dead or dying; 2 - > than 50% canes dead or dying.

Table 7

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	0.50	0.25	0.33	0.17	0.25	0	0	0	0.08	0.17	0	0
Mulched	0.83	0.67	0.42	0.50	0.25	0.25	0.42	0.17	0.08	0	0	0

Cultivar: Malling Admiral was less diseased (to a 99.9% significance level) than Moy (0.08 (Malling Admiral) v 0.37 (Glen Moy))

Fungicides: Fungicides gave healthier stools (to a 99% significance level) (0.35(0) → 0.22(6) → 0.09(12))

Ridging: Ridging reduced disease slightly (0.18 (ridged) v 0.26 (non-ridged))

Mulching: Mulching increased stool disease slightly (to a 99% significance level) (0.3 (mulched) v 0.15 (non-mulched))

Worst and Best treatments: The worst treatment was Glen Moy/no fungicide/non-

ridged/mulched. Many treatments had zero scores but especially Admiral treated with fungicide.

SUMMARY FOR 1995: Although the plants grew considerably in 1995 the disease become more severe. On non-mulched ridges it was noticeable that Moy produced lots of primocane but it was usually small. Clear differences in the performance of the cultivars had emerged. Moy was suffering much more damage than Admiral. The benefits of fungicide were obvious and ridging had a small but clear benefit, whereas the effects of mulching were less obvious.

1996 - THIRD YEAR

Number of primocanes per stool (Table 8)

Table 8

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	3.42	3.25	5.33	5.75	5.87	6.50	9.08	7.25	9.25	6.75	8.33	6.33
Mulched	4.34	2.54	9.16	4.92	6.75	9.17	6.83	11.8	10.4	11.3	10.9	13.4

Cultivar: Admiral produced many more young cane (to a 99.9% significance level) than Moy (9.3 (Malling Admiral) v 5.58 (Glen Moy))

Fungicides: Increasing fungicide dosages increased cane number (to a 99.9% significance level) (6.06(0) → 7.85(6) → 8.41(12))

Ridging: Had no effect on cane number (7.48 (non-ridged) v 7.41 (ridged))

Mulching: Mulching reduced cane numbers (to a 99% significance level) (6.43 (non-mulched) v 8.45 (mulched))

Worst and Best treatments: The worst treatment was Glen Moy/ridges/mulched/no fungicide; the best Malling Admiral/ridges/mulched/12 kg Recoil/ha.

Height of primocane (cm) (Table 9)

Table 9

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	57	67	87	110	104	116	187	203	189	179	191	190
Mulched	106	51	123	94	121	141	177	177	181	183	212	178

Cultivar: Canes of Admiral were much taller (to a 99.9% significance level) than those of Moy (187.4 (Malling Admiral) v 97.9 (Glen Moy))

Fungicide: Again fungicide increased cane height (to a 99.9% significance level) (128(0) → 143.3(6) → 156.6(12))

Ridging: Ridging had little effect on cane height (140.7 (ridged) v 144.6 non-ridged))

Mulching: Mulching had little effect on cane height (145.3 (mulched) v 140 non-mulched))

Worst and Best treatments: The best treatment was Admiral grown on non-ridged plots with mulch and with the highest rate of fungicide; the worst was Moy grown on ridged/mulched plots and with no fungicide.

Whole Plot Disease Assessments (Table 10)

Disease was assessed in four ways in 1996- for plots as whole, overall stool scores based on three stools per plot, and diseases on primocane and fruiting cane (twelve stools each). Whole plots were assessed using the following scores: 0 - all stools apparently healthy; 1 - less than 50% stools dead; 2 - more than 50% stools dead. For the other scores see next two sections.

Table 10

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	2.00	1.75	1.75	1.25	1.75	1.00	1.00	0.25	0.25	0	0	0
Mulched	1.75	2.00	1.00	2.00	1.50	1.00	0.75	0.75	0.50	0	0	0

Cultivar: Admiral was much less affected by disease (to 99.9% significance level) than Moy (0.29 (Malling Admiral) v 1.56 (Glen Moy))

Fungicides: Fungicide decreased disease (to a 99.9% significance level) (1.28(0) → 0.84(6) → 0.66(12))

Ridging: Ridging decreased disease slightly (0.83 (ridged) v 1.02 (non-ridged))

Mulching: Mulching had little effect on disease (0.94 (mulched) v 0.92 (non-mulched))

Worst and Best treatments: Several treatments with Moy scored 2; no disease was recorded on any treatment involving Admiral and fungicides;

Stool Disease Assessments (Table 11)

Three stools were selected at random and assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead or dying; 2 - more than 50% canes dead or dying.

Table 11

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1.58	1.25	1.08	0.50	0.92	0.50	0.08	0	0	0	0	0
Mulched	0.99	1.92	0.22	1.25	0.75	0.75	0.75	0.33	0.29	0	0	0

Cultivar: Admiral was much less affected by disease (to a 99.9% significance level) than Moy (0.12 (Malling Admiral v 0.97 (Glen Moy))

Fungicides: Fungicides decreased disease (to a 99.9% significance level) (0.86(0) → 0.42(6) → 0.36(12))

Ridging: Ridging had little effect on disease (0.54 (ridged) v 0.55 (non-ridged))

Mulching: Mulching increased disease slightly (0.49 (non-mulched) v 0.60 (mulched))

Worst and Best treatments: Very little disease was recorded on any treatment involving Admiral and fungicides; the worst treatment was Moy grown without ridging with mulch and no fungicide.

Young cane Disease Assessments (Table 12)

Disease on young canes in twelve stools per plot was assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead, dying or likely to die; 2 - more than 50% canes dead or dying.

Table 12

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1.14	0.91	0.94	0.55	0.70	0.24	0.04	0	0	0	0	0
Mulched	0.51	0.70	0.52	0.50	0.45	0.23	0.06	0	0	0	0	0

Cultivar: Admiral was much less affected by disease (to a 99.9% significance level) than Moy (0.01 (Malling Admiral) v 0.62 (Glen Moy))

Fungicides: Fungicides decreased disease (to a 95% significance level) (0.42(0) → 0.31(6) → 0.20(12))

Ridging: Ridging decreased disease slightly (0.26 (ridged) v 0.36 (non-ridged))

Mulching: Mulching decreased disease slightly (to a 95% significance level) (0.25 (mulched) v 0.38 (non-mulched))

Worst and Best treatments: The worst treatment was Glen Moy/non-ridged/non-mulched/no fungicide; very little disease was recorded on any treatment involving Malling Admiral.

Fruiting cane Disease Assessments (Table 13)

Disease of fruiting canes in twelve stools per plot was assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead, dying or likely to die; 2 - more than 50% canes dead or dying.

Table 13

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1.70	1.35	1.62	0.81	1.15	0.44	0.45	0.10	0.04	0.02	0	0
Mulched	1.08	1.62	0.90	1.11	0.99	0.44	0.92	0.72	0.28	0.04	0	0

Cultivar: Admiral was much less affected by disease (to a 99.9% significance level) than Moy (0.21 (Malling Admiral) v 1.10 (Glen Moy))

Fungicides: Fungicides decreased disease (to a 99.9% significance level) (0.99(0) → 0.60(6) → 0.38(12))

Ridging: Ridging decreased disease slightly (0.55 (ridged) v 0.76 (non-ridged))

Mulching: Mulching had little effect on disease (0.67 (mulched) v 0.64 (non-mulched))

Worst and Best treatments: The worst treatment was Moy grown on non-ridged/non-mulched plots and no fungicide; very little disease was recorded on any treatment involving Admiral and fungicide.

Mean Yield per plot (Table 14)

Four picks were made with the mechanical harvester in 1996. Some caution should be attached to the data as the pickings were not made comprehensively from the start to the end of the season. Consequently, yields are merely indicative and not definitive of performance. Moreover, treatments such as mulching may well have affected the timing of fruiting in relation to picking.

Table 14

Cultivar	Glen Moy						Malling Admiral					
	0		6		12		0		6		12	
Fungicide (kg ha ⁻¹)												
Ridges	-	+	-	+	-	+	-	+	-	+	-	+
Non-mulched	1038	1706	506	4575	3294	4319	5188	7613	6931	5463	7256	6063
Mulched	1900	2156	3838	2694	4844	4575	3488	4956	7338	7763	8369	8150

Cultivar: Admiral yielded more than twice Moy (to a 99.9% significance level) (6548 (Malling Admiral) v 2954 (Glen Moy))

Fungicides: Increasing fungicide application rate, increased yield (to a 99.9% significance level) (3505(0)→ 4889(6) → 5859(12))

Ridging: Ridging increased yield slightly (5003 (ridged) v 4499 (non-ridged))

Mulching: Mulching increased yield slightly (5006 (mulched) v 4496 (non-mulched))

Worst and Best treatments: The worst yield was Glen Moy/non-ridged/non-mulched/6 kg Recoil; the best yield was Admiral/non-ridged/mulched/12 kg Recoil.

Yields are also shown below in Table 15a and 15b in slightly different format

Table 15 a

Non-ridged cultivation

Recoil (kg/ha)	Mulched		Non-Mulched		Totals
	Glen Moy	Admiral	Glen Moy	Admiral	
0	7600	13950	4150	20750	46450
6	15350	29350	4725	27725	77150
12	19375*	33475*	13175	29025	95050
Totals	42325	76775	22050	77500	

* highest yields for each cultivar in any treatment

Table 15 b**Ridged Cultivation**

Recoil (kg/ha)	Mulched		Non-Mulched		Totals
	Glen Moy	Admiral	Glen Moy	Admiral	
0	6825	19825	6825	30450	63925
6	10775	31050	18300*	21850	81975
12	18300*	32600*	17275	24250	92425
Totals	35900	83475	42400	76550	

SUMMARY FOR 1996: Disease was noticeably more severe in 1996 than in previous years. Nevertheless, Admiral continued to perform well although it also benefited from applications of fungicide. Generally, Moy performed badly.

OVERALL SUMMARY

Most measurements indicated that growing Moy on ridges was moderately beneficial and growers should continue to consider this in their management regimes. Mulching had little effect on control of raspberry root and should NOT be regarded as a suitable treatment if disease moderation is the sole objective.

An important lesson to be learned from this experiment was the importance of cultivar selection. Even a cultivar such as Malling Admiral, which has relatively modest levels of resistance in glasshouse trials can be very worthwhile growing in the field in conjunction with ridging and fungicides. It should be noted that we are not recommending Malling Admiral as a cultivar since it has several other serious deficiencies. With existing rates of fungicides, or even lower, it will be possible to grow a cultivar with similar resistance even in quite badly infected sites and still obtain satisfactory yields. With Glen Moy and other similar types it will be difficult to establish a management regime that will keep badly infested plantations yielding satisfactorily for long, even with the highest rates of fungicide used in this trial.

STAR INN

1994 - ESTABLISHMENT YEAR.

Number of primocanes per stool (Table 16)

Table 16

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	1.81	1.85	1.81	2.07	1.90	2.00	1.73	2.35
Mulched	1.40	1.69	2.00	1.81	1.63	1.67	1.90	1.54

Numbers of new cane as could be expected were small in this first year and there was little to note.

Mulching: Cane number was greater (to a 99% significance level) without mulching.

Height of primocane (cm) (Table 17)

Table 17

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	79.6	94.7	73.6	103.5	86.4	104.8	91.4	102.7
Mulched	53.8	84.4	72.7	82.7	76.7	88.4	70.3	91.0

Fungicide: Fungicide increased cane height (to a 99.9% significance level) but there was no difference between 8.0 and 12.0 kg Recoil treated ha⁻¹ of Recoil (78.1 (0) → 83.1 (4) → 89.1 (8) → 88.9 (12) the same form of recording is used hereafter).

Ridging: Canes were taller (to a 99% significance level) on ridges than on the flat (94.0 (ridged) v 75.6 (non-ridged))

Mulching: Canes were taller (to a 99% significance level) without mulching (77.5 (mulched) v 92.1(non-mulched))

Worst and Best treatments: The worst treatment was No fungicide/non-ridged/mulched (53.8); the best was 8 kg Recoil/ridged/mulched.

Stool Health Score (Table 18)

The following system for scoring disease was only used in this establishment year; it was changed radically in subsequent years. Scores were awarded as follows: stools that were dead were scored - 1; obviously diseased but alive - 2; apparently healthy - 3. Thus in this case higher scores means healthier plants, *i.e.* less disease.

Table 18

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Non-mulched	2.81	2.71	2.65	2.98	2.80	2.94	2.81	2.96
Mulched	2.27	2.83	2.69	2.79	2.67	2.87	2.56	2.92

Fungicides: Fungicides gave healthier plants (to a 95% significance level) (2.66(0) → 2.78(4) → 2.82(8) → 2.81(12)).

Ridging: Ridging improved health (to a 99% significance level) (2.90 (ridged) v 2.66 (non-ridged)).

Mulching: Mulching resulted in slightly poorer health (to a 95% significance level) (2.70 (mulched) v 2.83 (non-mulched)).

Worst and Best treatments: The worst treatment was No fungicide/non-ridged/mulched; the best was 4 kg Recoil/ridged/non-mulched.

SUMMARY FOR 1994: The disease pressure in this site was lower than on the SCRI and this is reflected in fewer and smaller differences in levels of disease in the establishment year. Nevertheless fungicides and ridging improved plant health.

1995 - SECOND YEAR

Number of primocanes per stool (Table 19)

Table 19

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	9.50	16.92	10.17	20.92	9.50	23.67	11.33	22.00
Mulched	3.17	5.01	5.92	4.75	7.08	5.33	4.58	4.83

Fungicides: Recoil at any level increased young cane numbers (8.65(0) → 10.44(4) → 11.40(8) → 10.69(12))

Ridging: Ridging increased young cane numbers considerably (to a 95% significance level) (12.93 (ridged) v 7.66 (non-ridged))

Mulching: Mulching reduced young cane numbers considerably (to a 99.9% significance level) (5.08 (mulched) v 15.0 (non-mulched))

Worst and Best treatments: Worst treatment was No fungicide/non-ridged/mulched; the best, 8 kg Recoil/ridged/non-mulched.

Height of primocane (cm) (Table 20)

Table 20

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	120.9	95.7	119.7	119.8	116.0	117.7	125.4	124.0
Mulched	110.4	126.7	113.8	129.0	132.1	134.4	105.0	133.2

The following trends were noted:

Fungicide: Fungicide increased the height of primocanes but differences were quite small among different levels of fungicide (113.4(0) → 120.6(4) → 125.1(8) → 121.9(12))

Ridging: Ridging had little effect on cane height (122.5 (ridged) v 117.9 (non-ridged))

Mulching: Mulching had little effect on cane height (123.1 (mulched) v 117.4 (non-mulched))

Worst and Best treatments: The worst treatment was No fungicide/ridged/non-mulched; the best was 8 kg Recoil/ridged/mulched.

Whole Plot Disease Assessments (Table 21)

Disease was assessed in two ways in 1995 - for each plot as a whole and for individual stools. Whole plots were assessed using the following scores: 0 - all stools apparently healthy; 1 - less than 50% stools dead; 2 - more than 50% stools dead. Note this is opposite of system used in 1994. For stool scores see next section below.

Table 21

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Non-mulched	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25
Mulched	0.25	0.75	0.50	0	0	0.25	0	0

The following trends were noted.

Fungicides: Fungicides reduced disease (0.44(0) → 0.25(4) → 0.19(8) → 0.13(12))

Ridging: Ridging increased disease (0.28 (ridged) v 0.22 (non-ridged))

Mulching: Mulching reduced disease (0.22 (mulched) v 0.28 (non-mulched))

Worst and Best treatments: The worst treatment was No fungicide/ridged/mulched; a number of treatments were very healthy, most were mulched and all had received fungicide.

Stool Disease Assessments (Table 22)

Three stools were selected at random and assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead or dying; 2 - more than 50% canes dead or dying.

Table 22

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Non-mulched	0	0.33	0	0	0.08	0	0	0
Mulched	0.25	0.25	0.33	0.17	0.08	0.08	0.25	0.08

Fungicides: Fungicides gave healthier stools (0.21(0) → 0.13(4) → 0.06(8) → 0.08(12))

Ridging: Ridging had little effect on disease (0.11 (ridged) v 0.13 (non-ridged))

Mulching: Mulching increased disease (to a 95% significance level) (0.19 (mulched) v 0.05 (non-mulched))

Worst and Best treatments: The worst treatments were No fungicide/ridged/non-mulched and 4kg of Recoil/non-ridged/mulched. Many treatments had zero scores .

SUMMARY FOR 1995: There was some increase in disease but not much in 1995 on this moderately infested, consequently non-treatment had great effects although fungicide improved health. The effects of ridging were not great but usually beneficial; any slight effect of mulching was probably deleterious.

1996 - THIRD YEAR

Number of primocanes per stool (Table 23)

Table 23

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	3.79	4.92	5.46	7.50	7.42	8.25	8.75	6.37
Mulched	6.21	4.42	6.50	5.58	6.25	6.17	7.33	7.42

Fungicides: Increasing fungicide application rate, increased cane number (to 99% significance level) 4.83(0) → 6.26(4) → 7.02(8) → 7.47(12))

Ridging: Ridging had no effect on cane number (6.33 (ridged) v 6.46 (non-ridged))

Mulching: Mulching had no effect on cane number (6.24 (mulched) v 6.56 non-mulched))

Worst and Best treatments: The worst treatment was no fungicide/non-ridged/non-mulched; the best was 12 kg Recoil/non-ridged/non-mulched.

Height of primocane (cm) (Table 24)

Table 24

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	139.7	133.4	163.7	149.1	159.2	165.1	184.8	143.9
Mulched	178.0	145.4	149.7	173.3	168.1	168.9	177.7	158.6

The following trends were noted.

Fungicide: Fungicide increased cane height (149.1(0) → 159.0(4) → 165.3(8) → 166.2(12))

Ridging: Ridging reduced cane height (154.7 (ridged) v 165.1 (non-ridged))

Mulching: Mulching increased cane height (165.0 (mulched) v 154.9 (non-mulched))

Worst and Best treatments: The worst treatment was No fungicide/ridged/non-mulched and the best 12 Kg Recoil/non-ridged/non-mulched.

Whole Plot Disease Assessments (Table 25)

Disease was assessed in four ways in 1996- for plots as a whole, overall stool scores based on three stools per plot, and diseases on primocane and fruiting cane (twelve stools each). Whole plots were assessed using the following scores: 0 - all stools apparently healthy; 1 - less than 50% stools dead; 2 - more than 50% stools dead. For the other scores see next two sections.

Table 25

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	1.25	1.00	1.00	0.75	0.75	0.50	0.50	1.00
Mulched	1.00	1.50	1.25	1.25	0.75	0.75	1.25	1.00

The following trends were noted.

Fungicides: Fungicides decreased disease (1.19(0) → 1.06(4) → 0.69(8) → 0.94(12))

Ridging: Ridging had no effect on disease (0.97 (ridged) v 0.97 (non-ridged))

Mulching: Mulching increased disease (1.09 (mulched) v 0.84 (non-mulched))

Worst and Best treatments: The worst treatment was no fungicide/ridged and mulched. Several treatments with Recoil were equally good.

Stool Disease Assessments (Table 26)

Three stools were selected at random and assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead or dying; 2 - more than 50% canes dead or dying.

Table 26

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Non-mulched	1.17	0.92	0.84	0.50	0.42	0.25	0.17	0.46
Mulched	0.42	0.92	0.67	0.50	0.50	0.25	0.92	0.42

The following trends were noted.

Fungicides: Fungicide decreased disease (0.85(0) → 0.63(4) → 0.35(8) → 0.49(12))

Ridging: Ridging decreased disease slightly (0.53 (ridged) v 0.64 (non-ridged))

Mulching: Mulching had little effect on disease (0.58 (mulched) v 0.59 (non-mulched))

Worst and Best treatments: The worst treatment was no fungicide/non-ridged/non-mulched; the best 12 Kg Recoil/non-ridged/non-mulched.

Young cane Disease Assessments (Table 27)

The health of young canes in twelve stools per plot was assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead, dying or likely to die; 2 - more than 50% canes dead or dying.

Table 27

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Ridges								
Non-mulched	0.80	0.42	0.66	0.38	0.19	0.24	0.13	0.06
Mulched	0.47	0.89	0.40	0.25	0.34	0	0.19	0.11

Fungicides: Fungicides decreased disease (to a 99.9% significance level) (0.65(0) → 0.42(4) → 0.19(8) → 0.12(12))

Ridging: Ridging decreased disease slightly (0.29 (ridged) v 0.40 (non-ridged))

Mulching: Mulching had no effect on disease (0.33 (mulched) v 0.36 (non-mulched))

Worst and Best treatments: The worst treatment was no fungicide/non-ridged/non-mulched; the best 8 kg Recoil/ridged/mulched.

Fruiting cane Disease Assessments (Table 28)

The health of fruiting canes in twelve stools per plot was assessed using the following scores: 0 - all canes apparently healthy; 1 - less than 50% canes dead, dying or likely to die; 2 - more than 50% canes dead or dying.

Table 28

Fungicide (kg ha ⁻¹)	0		4		8		12	
	-	+	-	+	-	+	-	+
Ridges								
Non-mulched	0.81	0.97	0.78	0.38	0.32	0.40	0.17	0.10
Mulched	0.84	1.19	0.88	0.31	0.58	0.13	0.69	0.15

Fungicides: Fungicides decreased disease (to a 99% significance level) (0.95(0) → 0.59(4))

→ 0.36(8) → 0.28(12))

Ridging: Ridging decreased disease (0.45 (ridged) v 0.63 (non-ridged))

Mulching: Mulching increased disease slightly (0.60 (mulched) v 0.49 (non-mulched))

Worst and Best treatments: The worst treatment was no fungicide/ridged/mulched; the best 12 kg. Recoil/ridged/non-mulched.

Mean Yield per plot (Table 29)

Four picks were made with the mechanical harvester in 1996. Some caution should be attached to the data as the pickings were not made comprehensively from the start to the end of the season. Consequently, yields are merely indicative and not definitive of performance. Moreover, treatments such as mulching may well have affected the timing of fruiting in relation to picking

Table 29

Fungicide (kg ha ⁻¹)	0		4		8		12	
Ridges	-	+	-	+	-	+	-	+
Non-mulched	6258	5925	6806	7225	9419	7769	11741	8544
Mulched	5700	4406	8523	9169	9869	10694	9125	11013

Fungicides: Increasing fungicide application rate, increased yields (to a 99% significance level) (5572(0) → 7931(4) → 9438(8) → 10106(12))

Ridging: Ridging had a lesser effect on yield (8093 (ridged) v 8430 (non-ridged))

Mulching: Mulching increased yield slightly (8562 (mulched) v 7961 (non-mulched))

Worst and Best treatments: The worst treatment was no Fungicide/ridged/mulched and the best yielding 12 kg Recoil/non-ridged/mulched

Yields are also shown below in Table 30a and 30b in slightly different format

Table 30a

Non-ridged			
Recoil (kg/ha)	Mulched	Non-mulched	Totals
0	22800	25030	47830
4	34090	27225	61315
8	39475	37675	77150
12	36500	46955	83455
Totals	132865	136885	

Table 30b

Ridged			
Recoil (kg/ha)	Mulched	Non-mulched	Totals
0	17625	23700	41325
4	36675	28900	65575
8	42775	31075	73850
12	44050	34175	78225
Totals	114125	117850	

SUMMARY FOR 1996: Disease increased again in 1996 over 1995 but generally this site was still much less affected than the East Loan site. Fungicides had the greatest effect on disease but again ridging gave a small improvement over the flat. Mulching may have been slightly beneficial but it is doubtful if it would have justified its cost in this trial.

CONCLUSIONS

- 1. Recoil is an effective fungicide treatment for raspberry root rot but rates much lower than the present recommendation of 12 kg per treated hectare cannot be contemplated for Glen Moy. Once the resistance of commercial cultivars is improved to or above the levels observed in Malling Admiral in this trial then fungicides levels can be reduced.**
- 2. Achieving levels of resistance in new raspberry selections equivalent to that found in Malling Admiral would go a long way to greatly lessening the impact of root rot on raspberry growing in Tayside and elsewhere.**
- 3. Ridging alone would have little economic impact on disease but it is generally beneficial and it is recommended that growers include it in their management systems where root rot is a problem. Larger ridges than those used in this trial may be even more beneficial and growers can and should take steps each year to ensure that ridges are not eroded away.**
- 4. Mulching with polythene had mixed effects in the trials and cannot be recommended to commercial growers on grounds of contributing to root rot control. It is expensive and prevents re-building of ridges which gradually slump over several years. It may, however, have a role in management of weeds and suckers thus assisting in stool management.**

CULTIVAR TRIALS

Trial 3

In light of the importance of cultivar resistance to root rot control and the release of a number of new cultivars, whose performance against root rot in the field is unknown, a new trial was established at SCRI in Autumn 1995. It incorporates nine cultivars: Glen Clova, Glen Prosen, Glen Magna, Glen Ample, Glen Rosa, Glen Shee, Meeker, Gaia, Julia. The first six were planted in Autumn 1995 and other three in Spring 1996. Establishment was generally good but where plants had not grown they were replaced in Spring 1996. The trial incorporated Recoil at 0 and 6 kg treated ha⁻¹, and ridging and non-ridging, with the aim of developing a suitable growing regime for each of the above cultivars. The first useful data from this trial will be available in late 1997.

GLASSHOUSE AND FIELD TRIALS OF NEW FUNGICIDES

Recoil is still very effective against root rot and should remain so, provided the ban on its use in spawn beds is maintained. Indeed at the recent North British Crop Protection Conference, staff from the Pesticide Safety Division of MAFF examined the data on Recoil produced at SCRI and suggested that there might be enough information to go for a full label recommendation for raspberries. Nevertheless, Recoil may not be available to growers indefinitely. Sandoz have moved to recommending Ripost, a three-way mixture of fungicides for control of potato late blight, and they are keen to see if this same material will control raspberry root rot. Recoil is principally sold for late blight control and its replacement with Ripost could present difficulties for raspberry growers as Riposte is not approved for root rot control.

In addition, new classes of fungicides with activity against *Phytophthora* have been developed since the release of Recoil, namely dimethomorph (Cyanamid) and fluazinam (Zeneca). These materials appear to have a completely different action from the phenylamides, metalaxyl and oxadixyl, and could be interesting alternatives should the latter ever be withdrawn or the fungus develops resistance to them. Fluazinam has already proved effective against powdery scab of potatoes, an intractable soil-borne disease, and could be useful against soil-borne *Phytophthora*.

A glasshouse screen of new fungicide materials involving 32 different combinations of fungicides, their rates of and timing of application (before or after inoculation with the fungus), was therefore undertaken in 1996. The new materials were applied to pot plants of Glen Moy at rates equivalent to half and full rates of Recoil (6 and 12 kg product/treated ha) and before and several days after inoculation with the fungus. Results from this experiment are given below in Table 31. Although the trial gave good results, these could have been even more clear-cut than shown; the watering control system failed and plants received amounts of water which probably favoured the fungus and flushed the fungicides from the pots.

A number of materials in this trial, including Invader, Ripost and Shirlan (ai fluazinam), gave at least as good control of root rot as Recoil and were therefore included in further trials established in a commercial plantation in the Brechin area in late 1996. Management and application schedules generally match those used commercially but to see if timing of application could improve efficacy, a regime of four half-doses instead of two full doses per season is also being tested. First results will be available in late 1997.

Table 31. Pot trials of fungicides active against raspberry root rot. Effect of fungicides on root rot as measured as % increase in height of plants and % leaves wilted after inoculation, and root rot score

Table 31

Fungicide rate (kg ha ⁻¹)*	6		12		6		12		6		12	
	% Height Increase				% Leaves Wilted				Root Rot Score			
Treatment	before	after	before	after	before	after	before	after	before	after	before	after
Control-Uninoc.	50.2				5.6				1.25			
Control-Inoc.	19.9				16.9				4.25			
Recoil	33.9	31.0	29.2	18.6	9.8	13.8	5.3	15.5	3.5	4.5	2.30	4.00
Ripost	33.0	35.2	27.6	19.0	13.8	15.3	7.3	15.3	3.75	4.25	3.00	4.50
Tattoo	30.4	17.0	39.4	18.2	14.5	15.0	11	14.3	3.00	4.75	2.75	4.25
Curzate M	18.5	22.9	30.1	31.0	10.5	14.8	8.5	14.0	4.00	4.25	2.50	4.25
Invader	28.6	25.1	35.4	25.9	12.3	15.8	5.5	14.8	3.25	4.25	1.50	4.25
Shirlan	42.3	31.1	16.5	19.2	8.5	15.3	6.5	12.5	2.25	4.25	2.00	4.25
Aliette	15.2	12.9	32.7	23.4	15.5	12.8	15.0	13.3	4.00	4.75	3.75	4.25
Fubol	27.9	15.8	46.5	24.1	9.0	14.3	8.8	16.8	3.25	4.25	2.75	4.00

* Arbitrary rates of application had to be developed for each fungicide as they had different active ingredients and some were powders while others were liquids. The only common reference point was the recommended rates used to control late blight of potatoes. Rates were calculated from these to give a rate of the main active ingredient for each fungicide roughly equivalent to the rates of active ingredient found in 6 or 12 kg Recoil as used in raspberry root rot control.

Fungicides: Fungicides generally reduced disease (to a 99.9% significance level)

Root rot (0 - no disease; 5 - 100% roots rooted)

Uninoculated control 1.25 → Fungicide 3.64 → Inoculated control 4.25)

Worst and Best treatments: The worst fungicide treatment was Aliette applied at a rate equivalent to 6 kg Recoil per hectare after inoculation; the best was Invader applied at a rate equivalent to 12 kg per hectare before inoculation. A number of others gave results similar to Invader.

Figure 1 - April 1994, 1st year. Establishment of trial showing ridges and mulching.



Figure 1

Figure 2 - October 1994, 1st year. Mulched ridge row with no fungicides

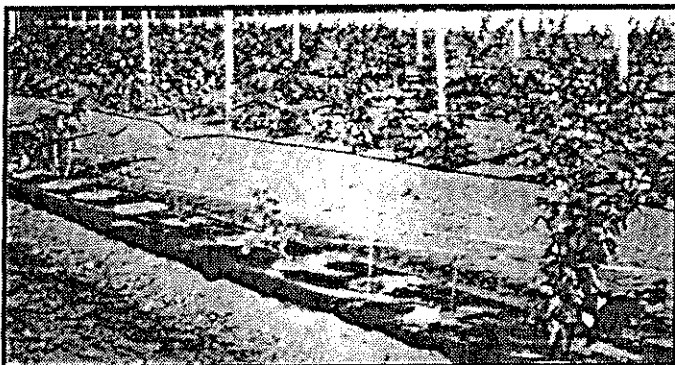


Figure 2

Figure 3 - October 1994, 1st year. Establishment of trial showing ridges and mulching.

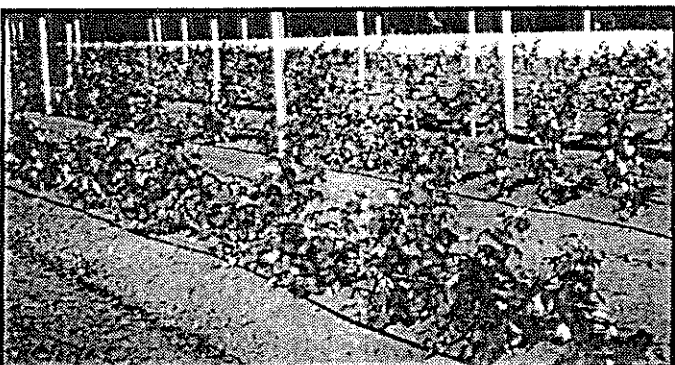


Figure 3

Figure 4 - July 1995 2nd year. Overview of trial showing mulching/ridging, irrigation and death of canes following certain treatments



Figure 4

Figure 5 - July 1996 3rd year. Glen Moy, mulched on flat with 4kg ha^{-1} Recoil showing extensive cane death.



Figure 5

Figure 6 - July 1996 3rd year. Brown lesions at base of Glen Moy canes.



Figure 6