HDC FINAL REPORT

Project Number:	**SF 10c**
Project Title:	**Chemical control of Raspberry Root Rot**
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Key words:	**raspberry, root disease, *Phytophthora*, fungicides, control**

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Practical section for growers

Application:
The principal objective of the work was to find alternatives to existing fungicides for raspberry root rot that would give better and more consistent control of the disease. The fungicide 'Recoil' (a mixture of mancozeb and oxadixyl) applied at a rate of 12 kg per treated hectare has been identified as effective and practical and has received an 'Off-label' recommendation for raspberry root rot.

Summary

Brief description

Raspberry root rot is a serious threat to raspberry producers in all parts of the United Kingdom. From its first appearance in the early 1980's, it has spread to all important areas of production often causing complete loss of previously productive fields. In the long term the disease will best be controlled by combining various aspects of cultural control with fungicides and resistant cultivars but the development of such a strategy will take time, a commodity that is in scarce supply for hard-pressed growers who have to deal with the disease now! There is therefore an urgent need for effective fungicides that will allow growers to cope with the problem until new control strategies emerge.

Early work, which was also supported by HDC, resulted in the release of the fungicides Ridomil Plus and later Fubol 58 WP for control of raspberry root rot caused by *Phytophthora fragariae* var. *rubi*. Fubol 58 WP became the standard material for control of the disease, but while many growers have expressed satisfaction with its effectiveness, a number have complained that in situations where disease pressure is high, control is often patchy.

Present project

The present project was really aimed at overcoming such complaints by identifying other effective materials that were competitively priced and which would be likely to be available for a long period. To this end, we concentrated, as in earlier trials, on materials that were available for control of potato late blight. Both the late blight fungus and the raspberry root rot fungus are *Phytophthora* spp. and they are susceptible to more or less the same fungicides. Unlike N.America, root rot caused by *Phytophthora* are generally not a major market for fungicides in Europe. Many soil-borne diseases like raspberry root rot do not affect crops of large enough acreage to justify the cost of developing materials specifically for their use. By contrast many promising materials have been developed for foliage diseases like potato late blight or downy mildew of grapevine. Because of this, we consider that the best way to get effective materials registered for use on such a crop as raspberry is through 'off-label' approvals. An advantage of using potato fungicides is that the price of the material is largely set by its main use, in this case control of potato late blight. Potatoes are not just less valuable per acre than raspberries, but there is considerable competition in the late blight fungicide market. We reasoned that using late blight fungicides for root rot might make control cheaper to the grower. Modern potato fungicides are usually mixtures of several materials and this has another potential advantage, namely a reduction in the likelihood that resistant strains of the fungus will emerge to shorten the useful life of the fungicide.

Glasshouse experiments quickly revealed that the number of materials with activity against root rot was rather limited. As a result of this and later glasshouse and field experiments, further field trials were set up with the support of HDC in 1989. Four were established in collaboration with the Scottish Agricultural College (SAC) as two pairs of trials, one member of each pair being supervised by SCRI staff and the other by SAC staff. The first pair were small-scale trials designed to test out a number of materials that had not yet been trialled extensively in the field The second set consisted of large scale trials of three fungicides each of which had looked promising in other work. In these latter trials, the rates of application were the same for each material.

Although the trials in each pair were very similar, there was an important difference in each case between the SCRI and SAC trials. The SCRI trials were designed to see how effective the materials would be at 'resuscitating' existing, established plantations that had been badly affected by root rot. The large SAC trial was newly planted onto a site where there had been bad outbreaks in the previous year and the plantation had been 'grubbed'. In the small SAC trial, many of the stools in the established plantation had died and it was into these areas that the trial was planted. It was hoped that this would help us to decide on one aspect of a control strategy, i.e. whether it was better to start afresh on a badly diseased or to attempt to revive badly affected plantations.

The only other differences between the trials related to slight differences in methods of recording the results and in one unnamed fungicide which SAC was able to include in their small trial but which was not available to staff at SCRI at the time of starting their trials.

Small-scale trials

Only materials containing phenylamide components were effective and of those Recoil and, to a lesser extent, Fubol 58 WP were the best. Differences were generally more marked in both SAC trials than in the SCRI ones.

Although Aliette was very effective in glasshouse trials and it is a useful fungicide for controlling many *Phytophthora* diseases including strawberry red core, it was ineffective in these and other field trials.

Large-scale trials

In these trials only the Recoil and the Fubol 58 WP had any significant effect on the disease. There were important differences in the results from the SAC and SCRI trials. On replanted sites (SAC trial), Recoil had a greater beneficial effect than Fubol in both years. In 1991, the highest level of Fubol gave slightly better results than the lower rates but disease was evident in all Fubol treatments. By 1992, however, Fubol was not effective at all in this trial and all three treatments were badly diseased. In contrast, Recoil was very effective at all three dose rates in 1991 and was still effective in 1992, although the level of disease in the treatment with the lowest dose rate rose considerably by the second year and it was much less effective than the other two rates. There is a slight suggestion that the intermediate rate also may have been less effective than the highest rate but this was not supported statistically.

The results of applying the materials to an established site were less clear cut than above, mainly because it took so long to 'iron out' patchiness in the site. The differences between treatments in 1991 were not great but by 1992 a pattern had emerged in which both Fubol and Recoil were having beneficial effects. The best results were obtained with the highest rate of Recoil but the differences were not great among all three rates of both

At the time the trials ended, Recoil was also cheaper than Fubol and tests on behalf of SAC revealed no residues in the fruit. SAC therefore with SCRI support applied for and got an 'Off-label' approval for this material.

Action Points for Growers

1. Recoil is marketed by Sandoz Crop Protection Ltd under MAFF No. 04039.

2. Its active ingredients are 56% mancozeb, 10% w/w oxadixyl

3. The Off-label approval was sought by the Scottish Agricultural College and issued on 7 December 1992. It expires on 31 December 1995 subject to continuing approval.

4. The material cannot be applied more than twice a season.

The following guidelines have the support of Scottish Agricultural College, The Scottish Soft Fruit Growers Association and the Scottish Crop Research Institute

5. Although higher rates have been approved, 12 kg/ha gives effective control in nearly all situations except where disease pressure is exceptionally high. In order to protect the working life of this useful material it is essential that it is not used at unnecessarily high rates. Therefore, do not use rates higher than 12 kg/ha without discussing the situation with your agrochemical specialist and/or Sandoz Crop Protection.

6. It is important to avoid applying high rates of the material even when you might think that you are using 12 kg/ha. Please remember that the material is applied in a 50 cm band spray on either side of the centre of the raspberry row and not to the remainder of the alleyways between the rows. The rate of 12 kg/ha applies to a 'treated' hectare and as growers plant raspberries at different row widths, a 'treated' hectare could represent anywhere between 2-3 actual hectares in a plantation. It may be useful to remember that a 'treated' hectare is equivalent to 10,000 linear meters of raspberry rows regardless of the spacing between the rows.

7. The raspberry recommendations do not appear on the label, but please read it carefully and ensure that all precautions are followed.

Science section

Introduction

Raspberry root rot is a serious threat to raspberry producers in all parts of the United Kingdom. From its first appearance in the early 1980's, it has spread to all important areas of production often causing complete loss of previously productive fields. In the long term the disease will best be controlled by combining various aspects of cultural control with fungicides and resistant cultivars but the development of such a strategy will take time, a commodity that is in scarce supply for hard-pressed growers who have to deal with the disease now! There is therefore an urgent need for effective fungicides that will allow growers to cope with the problem until new control strategies emerge.

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The present project was really aimed at overcoming such complaints by identifying other effective materials that were competitively priced and which would be likely to be available for a long period. To this end, we concentrated, as in earlier trials, on materials that were available for control of potato late blight. Both the late blight fungus and the raspberry root rot fungus are *Phytophthora* spp. and they are susceptible to more or less the same fungicides. Unlike N.America, root rot caused by *Phytophthora* are generally not a major market for fungicides in Europe. Many soil-borne diseases like raspberry root rot do not affect crops of large enough acreage to justify the cost of developing materials specifically for their use. By contrast many promising materials have been developed for foliage diseases like potato late blight or downy mildew of grapevine. Because of this, we consider that the best way to get effective materials registered for use on such a crop as raspberry is through 'off-label' approvals. An advantage of using potato fungicides is that the price of the material is largely set by its main use, in this case control of potato late blight. Potatoes are not just less valuable per acre than raspberries, but there is considerable competition in the late blight fungicide market. We reasoned that using late blight fungicides for root rot might make control cheaper to the grower. Modern potato fungicides are usually mixtures of several materials and this has another potential advantage, namely a reduction in the likelihood that resistant strains of the fungus will emerge to shorten the useful life of the fungicide.

Materials and Methods

Glasshouse experiments

These were carried out on a number of materials with potential activity against root rot (Table 1). With the exception of the foliar application of Aliette, the fungicides (for rates see Table 1) were applied to the plants as soil drenches. All rates were equivalent to those recommended for the products in the field or those by which the level of the phenylamide component of mixtures were equalised across treatments. The fungicides were applied to plants of cv. Glen Moy growing in University of California soilless compost in 125 mm diam plastic pots three days before inoculation with 100 ml drench of zoospore suspensions (1000 zoospores ml^{-1}) of the fungus.

Field Experiments

Field experiments were established as a result of the glasshouse experiments. Four were set up in 1989 with the support of HDC in collaboration with the Scottish Agricultural College (SAC). The trials were in two pairs, one member of each pair being supervised by SCRI staff and the other by SAC staff.

The first pair of trials were small-scale and designed to test out a number of materials that had not yet been trialled extensively in the field (Tables 2 & 3). They were laid out as randomised block designs with four replicates per treatment. In 1991 the following records were taken: total numbers of fruiting and primocanes; number of fruiting canes still alive mid-summer and their heights; number of primocane taller than 30 and 50 cm in height;

The second set of trials consisted of large scale trials of three fungicides (see Tables 4 & 5) each of which had looked promising in other work. In these latter trials, the rates of application were the same for each material, namely 12 24 and 36 kg of product per treated hectare. In the SAC trial they were applied to whole rows in plants freshly planted into a badly diseased site that had been grubbed that year. In the SCRI trial the plots were sections of rows with 25 stools per plot.

There was another important difference in each case between the SCRI and SAC trials. The SCRI trials were designed to see how effective the materials would be at 'resuscitating' existing, established plantations that had been badly affected by root rot. The large SAC trial was newly planted onto a site where there had been bad outbreaks in the previous year and the plantation had been 'grubbed'. In the small SAC trial, many of the stools in the established plantation had died and it was into these areas that the trial was planted. It was hoped that this would help us to decide on one aspect of a control strategy, i.e. whether it was better to start afresh on a badly diseased or to attempt to revive badly affected plantations.

The only other differences between the trials related to slight differences in methods of recording the results: in the SAC trials a composite measure of the health of the plots (Sum of disease index) was used and the numbers of healthy primocane were counted; in the SCRI trials various measurements were taken (see Table 2 & 3). Also, SAC was able to include one unnamed fungicide in their small trial which was not available to staff at SCRI at the time of starting their small trial.

Results

Glasshouse experiments & Small-scale trials

The results of glasshouse trials are given in Table 1. A number of materials gave complete control of root rot: Recoil, Oxadixyl, Aaterra and Aliette both as a drench and foliar application. Ridomil Plus, Patafol Plus and Stanza gave substantial control but Bravo and Fytospore were relatively ineffective.

Small-scale trials

Although Aliette was very effective in glasshouse trials it had little effect in the field. Only Recoil was highly effective in both years in both trials, although other phenylamide fungicides performed well in either year in either trial. Differences were generally more marked in both SAC trials than in the SCRI ones (Tables 2 & 3).

Large-scale trials

There was little to record during the first year of the trials (1990) and the results in all cases start in 1991. In the case of the SAC trials this was because the first year was an establishment year and the primocane was removed by mowing, while in the SCRI trial it was due to unevenness in disease levels resulting from trying to establish the trial on an existing plantation where disease was not distributed evenly.

The results of both trials can be seen in Tables 4 & 5. In this case only the Recoil and the Fubol 58 WP had any significant effect on the disease. The related material Galben M had no effect in either trial.

There were important differences in the results from the SAC and SCRI trials. On replanted sites (SAC trial), Recoil had a greater beneficial effect than Fubol in both years. In 1991, the highest level of Fubol gave slightly better results than the lower rates but disease was evident in all Fubol treatments. By 1992, however, Fubol was not effective at all rates in this trial and all three treatments were badly diseased. In contrast, Recoil was very effective at all three dose rates in 1991 and was still effective in 1992, although the level of disease in the treatment with the lowest dose rate rose considerably by the second year and it was much less effective than the other two rates. There is a slight suggestion that the intermediate rate also may have been less effective than the highest rate but this was not supported statistically.

The results of applying the materials to an established site were less clear cut than above, mainly because it took so long to 'iron' out patchiness in the site. The differences between treatments in 1991 were not great but by 1992 a pattern had emerged in which both Fubol and Recoil were having beneficial effects. The best results were obtained with the highest rate of Recoil but the differences were not great among all three rates of both products.

Conclusions

The greater effectiveness of Recoil over Fubol may be due to any or all of the following three possibilities: Synergism between the components of Recoil but not in Fubol (this has been recorded in laboratory studies; higher retention rates in soil for one active component of Recoil; Lower rates of degradation in soil. Whatever the reason, there is no doubt that Recoil was the most effective fungicide tested, more than existing treatments. At the time of the trial, it was also cheaper than Fubol and tests on behalf of SAC revealed no residues in the fruit. **SAC therefore with SCRI support applied for and got an 'Off-label' approval for this material.**

Resuscitating plantations through fungicides was less effective in general than the more expensive option of planting again and applying fungicides. However, growers may not find it feasible to bear the capital costs of completely replacing plantations especially young ones that have yet to give them a return on their money. In such cases, if the disease pressure is not great i.e. the disease is not spreading very quickly or having too severe an effect, they may wish to consider the resuscitation approach or to grub and replant the worst-affected parts of a plantation.

To extend the life of Recoil, and all other useful agrochemicals, all recommendations must be followed carefully to avoid unnecessarily high rates of application. This is especially important in a perennial crop such as raspberries where the material is being applied twice a year, perhaps for several years. It is important therefore to develop new more 'integrated' control strategies in which the amount of fungicide is reduced, perhaps by combining it with the use of ridges and partially resistant cultivars.

Table 1. **Results of Pot experiments with candidate fungicides for the control of phytophthora root rot of raspberry.**

Product	Product per plant (g)	Product per treated hectare (kg)	% Increase height	% Leaves Wilted	% Roots Rotted
Uninoculated	-	-	61	31	0
Inoculated Control	-	-	45	68	98
Ridomil Plus	2.67	8.0	54	23	6
Bravo	4.17	12.5	57	41	90
Fytospore	7.67	23.0	50	23	42
Patafol Plus	7.0	21.0	61	25	11
Stanza	10.0	30.0	57	21	10
Aaterra	4.17	12.5	57	24	0
Oxadixyl (25%)	1.6	4.8	61	34	0
Recoil	4.0	12.0	60	29	0
Aliette (drench)	1.25	3.75	64	35	0
Aliette (foliar)	1.25	3.75	65	31	0

Table 2. SAC small-scale trial for the control of raspberry root rot.

Treatment	(kg ha^{-1})	1991				1992	
		Disease Index	Number of new canes	Disease Index (corrected for row effect)	Number of new canes	Disease Index	Number of new canes
Untreated control		10.8	4.6	10.8	4.6	12.0	0.0
Ridomil Plus		6.7	26.0	7.8	22.8	9.3	24.8
Fubol 58 WP	(24)	6.7	22.5	5.7	26.7	7.8	23.0
" " "	(36)	4.5	57.0	3.6	61.0	7.0	32.2
Recoil	(24)	1.0	44.2	1.8	41.3	2.8	42.0
"	(36)	0.0	73.7	0.1	71.3	0.3	72.5
Dithane		12.0	0.3	12.0	2.5	12.0	0.3
Aliette		11.0	4.5	10.6	2.8	12.0	0.3
ICI/Fubol	(36)	5.5	34.5	5.7	35.7	10.3	21.8
ICI/Fubol	(36)	4.5	41.2	4.1	41.4	10.3	18.3
ESCA coded		1.0	40.7	1.4	39.0	1.0	61.7
L.S.D. (tr v. untr.)		3.3	19.2	3.6	19.7	1.7	10.9
L.S.D. (tr. v. tr.)		4.0	22.9	4.1	22.0	1.4	9.1

Disease Index: 0 = healthy and 12 = dead

Table 3. SCRI small-scale trial for the control of raspberry root rot in an established plantation.

Treatment	(kg ha^{-1})	1991						1992					
		Living Primocanes			Fruiting Canes			Living Primocanes			Fruiting Canes		
		Number per stool	Over 30 cm number	%	Mean height	No. Alive per stool	% Healthy	Number per stool	Over 30 cm number	%	Mean height	No. Alive per stool	% Healthy
Untreated control	-	6.3	5.6	83	54	3.2	65	2.5	1.9	48	31	1.8	50
Ridomil Plus	(8.25)	6.6	6.0	91	60	3.2	64	2.8	2.2	78*	42	2.3	65
Fubol 58WP	(24)	10.1	10.0	98	65	5.0	84	4.9	4.0	61	48	3.6*	66
" " "	(36)	8.9	8.6	96	65	4.9	84	4.9	4.2	82*	55*	3.5*	74*
Recoil	(24)	9.0	8.6	97	71	5.1	89	5.6*	4.9*	87*	68*	4.7*	90*
"	(36)	9.5	9.5	100	84	4.7	94	6.8*	5.8*	81*	61*	4.2*	84*
Dithane	(23)	6.0	5.9	98	67	3.0	70	2.9	2.7	92*	43	2.5	70
Aliette	(10)	6.6	6.5	97	58	3.7	69	3.0	2.4	78*	39	2.1	56
L.S.D. (P = 0.05)		ns.	ns.	10.3	ns.	ns.	ns.	2.8	2.4	23	2.0	1.4	22

Table 4. SAC Large-scale trial for the control of raspberry root rot in a new plantation - (Rattray, Perthshire).

Treatment	(kg ha^{-1})	1991 Number of canes >1 metre	1991 Number of canes Living	1991 Disease Index	1992 Number of canes >1 metre	1992 Number of canes Living	1992 Disease Index
Untreated control	-	0.4	1.9	9.3	0	0	12.0
Fubol 58WP	(12)	2.5	7.8	5.1	0.5	4.0	11.3
Fubol 58WP	(24)	3.0	8.6	5.9	0.9	4.7	11.0
Fubol 58WP	(36)	4.3	10.1	5.6	0.5	3.4	11.6
Recoil	(12)	6.8	15.7	0.5	6.7	21.1	3.2
Recoil	(24)	11.0	17.1	0.9	19.6	40.2	1.6
Recoil	(36)	7.6	12.4	0.2	20.5	37.1	1.1
Galben M	(12)	3.4	8.1	4.4	1.8	6.2	11.1
Galben M	(24)	0.4	1.7	7.2	0.0	0.3	12.0
Galben M	(36)	1.0	3.0	7.6	0.1	0.5	11.9
L.S.D. (tr v. tr)		1.4	2.2	1.2	1.8	2.3	0.6
L.S.D. (tr v. untr)		1.1	1.8	1.0	1.5	1.8	0.5

Table 5. SCRI Large-scale trial for the control of raspberry root rot in an established plantation - (Cranslea, Perthshire)

Treatment		1991					1992						
		Primocane		Fruiting Cane			Primocane				Fruiting Cane		
				Alive			Alive				Alive		
		Plot Vigour	Mean Height (cm)	number	%	Mean Height (cm)	number	>0.5m	Vigour	Mean Height (cm)	number	%	Mean Height (cm)
Untreated control	-	3.3	46	4.7	33	108	4	3	0.6	25	0.5	16	96
Fubol 58WP	(12)	4.2	65	5.8	55	124	14*	12*	2.3*	68*	3.0*	68*	137*
Fubol 58WP	(24)	3.5	48	3.2	34	99	10	7	1.4	50	2.0*	52*	119
Fubol 58WP	(36)	4.5	66	7.3	65	136	18*	17*	2.9*	77*	2.5*	66*	137*
Recoil	(12)	3.7	46	2.9	28	102	14*	11	1.9*	64*	2.4*	59*	115
Recoil	(24)	3.8	52	4.6	47	105	17*	16*	2.5*	72*	3.3*	73*	124*
Recoil	(36)	4.6	67	5.6	53	119	22*	21*	3.3*	85*	3.3*	80*	137*
Galben	(12)	3.4	46	4.1	33	109	4	3	0.6	28	0.8	31	96
Galben	(24)	2.5	30	1.7	5	59	1	0.5	0.2	14	0.4	16	63
Galben	(36)	3.0	42	3.9	27	83	3	3	0.4	18	0.9	21	84
LSD (5%)		1.0	19	ns	ns	ns tr. v. untr.	7.5	7.8	1.2	32	1.2	30	36
						tr. v. tr.	9.3	9.7	1.5	40	1.5	37	45

Plot vigour in 1991 was assessed visually on a 0-5 scale with 0 = no primocanes and 5 = numerous healthy primocanes