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Pruned stub infection trial - March 2009 assessments

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Client Report No. 44326

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Date: May 2009
Clients: Nectria Focus Group
MAF - FIDA
Contract No: 44326

CLIENT REPORT No: 44326

EXECUTIVE SUMMARY

Objective

The original objective of the trial was to determine the effect of season of pruning on Nectria disease development; to determine the effect of stub treatment with a protective fungicide, and also to determine how long freshly pruned stubs are susceptible to infection, in both summer and winter. After several years, it became apparent that stub size was an important factor. Since 2005, the objective of the trial was broadened to examine the effect of stub size on fluting and to monitor the development of cankers or flutes over time with the final outcome of estimating the effect on log grade.

Key Results

1. Nectria flute canker may not cause as much damage as first thought.
2. After the first lift pruning operation, incidence of fluting increased for about one year, then decreased over three years and then stabilised.
3. Nearly all flutes initially recorded on first lift pruning stubs smaller than 60 mm are now no longer apparent.
4. After the second pruning operation, incidence of fluting has followed a similar trend to that seen after the first lift.
5. It is likely that disease assessments carried out 1-3 years after pruning will overestimate disease incidence.
6. *Neonectria fuckeliana* plays a role in canker development
7. Pruning operations should not be undertaken in winter
8. Fungicidal treatment of small stubs will not reduce overall disease incidence and is not necessary.

Application of Results

Disease incidence should be reduced significantly by pruning in summer and by avoiding large branch stubs.

Further Work

The next assessment should be done in March 2010.

TABLE OF CONTENTS

Contract number	
Client Report No.	44326
Products investigated	Garrison fungicide
Wood species worked on	Pinus radiata
Other materials used	Neonectria fuckeliana
Location	Otago

INTRODUCTION

A trial to determine the effect of pruning and stub treatment was established in February 2003. The aims of the trial were to:

- Develop a management strategy to reduce the incidence of defect associated with pruned stubs by:
    - Examining the effect of season of pruning on disease development
    - Examining the effect of stub treatment with a protective fungicide on disease development
    - Determining how long freshly pruned stubs are susceptible to infection, in both summer and winter.

The trial was assessed every three months after establishment until June 2005. At that time it was decided to assess whorls from the first lift pruning every 6 months and continue 3-monthly assessments for the second lift whorls only. In August 2006 it was decided to discontinue 3-month assessments of the second lift stubs. The next assessment of first and second lift whorls took place from 3 to 8 January 2007 and then again from 27 March to 1 April 2009. Results from the 2009 assessments are described.

METHODS

Site selection and design

In January 2003, plots were established in two unpruned *Pinus radiata* stands situated in Tokoiti Forest, which had a known disease history. The Hetherington Rd stand was established in July 1996 and the Poverty Hill Rd in July 1997. Pruning took place in February 2003 (summer prune, first lift to 2.0 m), August 2003 (winter prune, first lift to 2.0 m), March 2005 (summer prune, second lift to 4.0 m), and September 2005 (winter prune, second lift to 4.0 m).

The trial followed a randomised block design where 2 treatment blocks were replicated on 2 sites with 12-tree plots. Treatments were randomly allocated within blocks giving a total of 672 trees. Plots were 20 m square and sufficiently large to ensure that 12 trees were contained in each plot with an adequate buffer between plots.

Treatments and assessment

The treatments were: fungicide applied immediately after summer and winter pruning, delayed fungicide application, immediate inoculation after pruning and delayed inoculation. All fungicide and inoculum applications were integrated with summer and winter pruning treatments. There was also pruning in summer and winter with no additional treatment, an unpruned control, and a coat-hanger treatment where a branch length of about 30 mm was left on the stem after pruning.

Treatments are summarised below:

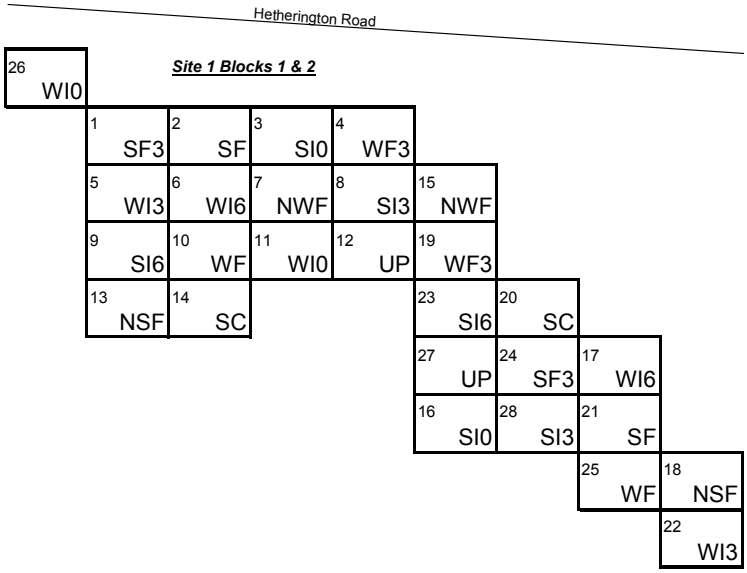
Two sites	Site one and site two (13 treatments replicated in 2 blocks at each site)
Four stub treatments:	Fungicide applied immediately, 3 months, and 6 months after pruning, no fungicide.
Two pruning times:	Summer and winter, plus an unpruned control, and a summer prune treatment where “coathangers” were left on the stem.
Three inoculation times:	Immediately, 3 months, and 6 months after pruning

Assessments were undertaken on a stub-by-stub basis, with individual stubs on three whorls marked to ensure that assessments over time related to the same stub. Flute categories were: fluting not present, low, medium, and severe. Flute severity was based on the length and depth of the flute, as below:

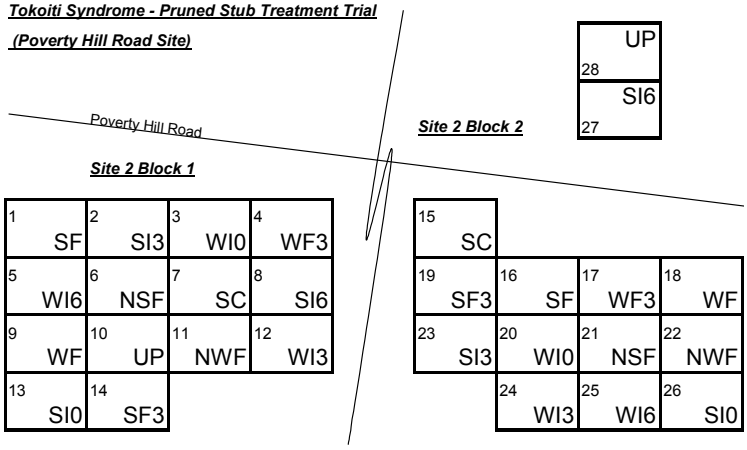
0	No flute	
1	Low flute	Shallow flute less than 100 mm long
2	Medium flute	Shallow flute 100-200 mm long, or Deep flute less than 100 mm (~finger length) long
3	Severe flute	Shallow flute over 200 mm long, or Deep flute over 100 mm (~finger length) long

The trial layout is shown below.

Tokoiti Syndrome - Pruned Stub Treatment Trial (Hetherington Road Site)



Tokoiti Syndrome - Pruned Stub Treatment Trial
(Poverty Hill Road Site)



Codes (W above refers to winter treatment)

NSF	No summer fungicide
SF	Summer fungicide
SF3	Summer fungicide 3 months after pruning
SI0	Summer inoculation immediately after pruning
SI3	Summer inoculation 3 months after pruning
SI6	Summer inoculation 6 months after pruning
SC	Summer "coathanger"
UP	Unpruned

RESULTS AND DISCUSSION

Incidence of trees with flutes

Incidence of trees with flutes has stabilised. On the first lift whorls, disease incidence was 15%. Incidence has decreased from a peak of 66% in November 2003 to 15% almost six years later. Almost 3 years ago 14% of the trees were affected with flutes on the first lift whorls. Just over 47% of plot trees had some degree of fluting in the second lift whorls, compared with 69% at the 2007 assessment.

Figure 1 shows the incidence of trees with flutes and how that has changed over time. A few interesting points are apparent.

Firstly, flutes were present when the trees were assessed immediately after pruning. About 30% of trees had flutes present immediately after first lift pruning, and immediately after second lift pruning over 40% of trees had flutes present on the second lift whorls assessed. Flutes were therefore associated with unpruned whorls.

Secondly, the incidence of trees affected appears to have peaked at just under 70%, both for first and second lift whorls. For the first lift pruning, the incidence of trees affected declined after the peak 9 months after pruning. The decline lasted almost 3 years, after which time incidence remained stable. For the second lift, incidence increased over a period of 2 years and now appears to be declining.

In effect, just under half the trial trees have at least one flute in either first or second lift whorls, with the decline in flutes from first lift whorls being countered by the large number of trees with fluted second lift whorls. The economic consequences of this are as yet unknown.

Trees pruned in winter had a higher incidence of fluting than trees pruned in summer. Forty percent of trees pruned in summer had flutes, compared with 52% of those pruned in winter. After inoculation, incidence was 38% and 94%, respectively.

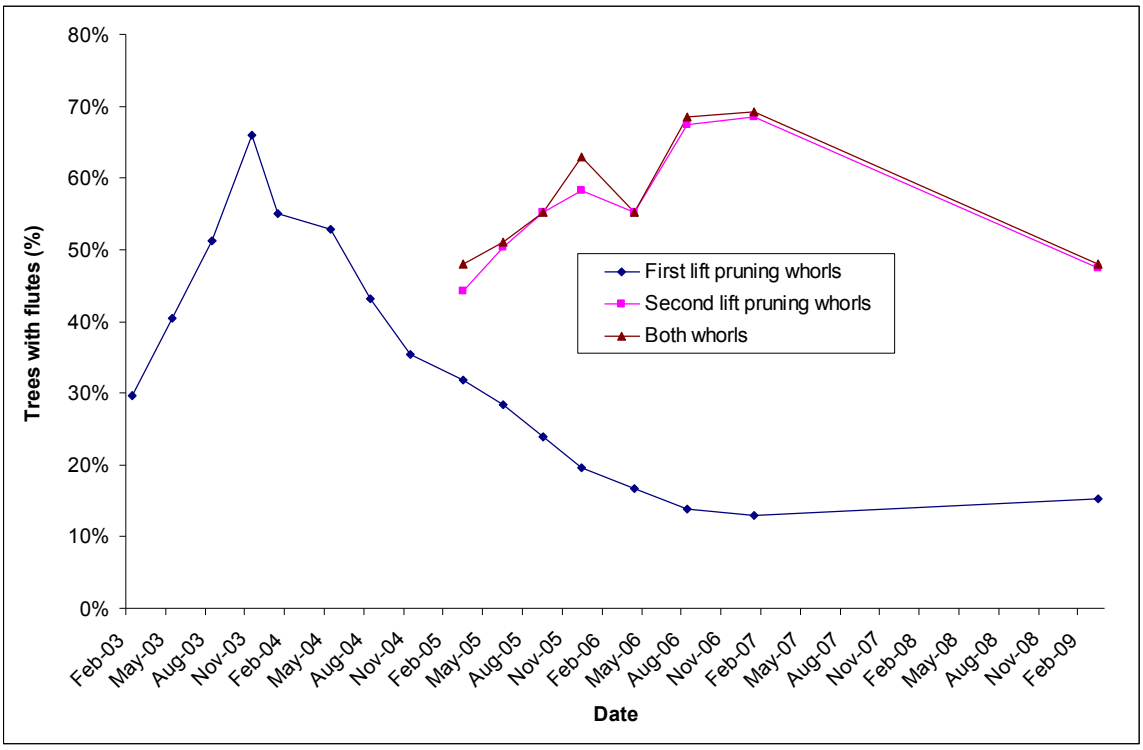


Figure 1: Percentage of trees with flutes (first and second lift whorls, all treatments)

Incidence of stubs with flutes

Inoculation immediately after pruning in winter was the only treatment statistically significant from the others, for both first and second lifts (Tables 1 and 2).

Time of pruning

Overall fluting incidence in first lift whorls was 2.1%, almost the same as that recorded during the August 2006 and January 2007 assessments (1.9%). In second lift whorls, overall incidence was 9.6%, down from the 15.5% recorded in August 2006 and January 2007. The incidence of fluting was higher in trees that were pruned in winter. Winter pruning, without inoculation or fungicide, resulted in 2.1% infection compared with 0.6% for the summer pruned treatment in first lift whorls, and similar but weaker response was seen in the second lift whorls where percentage of stubs with flutes was 9.7% after winter pruning and 8.5% after summer pruning.

Inoculation

For the first lift whorls, 12.3% of stubs inoculated immediately after winter pruning had flutes, statistically significantly different from the 4.5% of those inoculated immediately after summer pruning. The rate of fluting was reduced when inoculation was delayed by 3 or 6 months. For the second lift whorls, winter inoculation immediately after pruning resulted in 32.4% incidence compared with the average 9.6%. This treatment was significantly different from all others. Inoculation of second lift whorls during summer had no effect.

Fungicide

Summer fungicide applied immediately after first lift pruning resulted in 0.5% fluting, almost the same as the corresponding winter fungicide treatment (0.4%). However, these levels were not significantly different from other treatments, with the exception of immediate inoculation in winter. The same trend was apparent in the second lift whorls.

Table 1 - Percentage of fluted stubs by treatment (first lift whorls)

Treatment	Feb 2003	May 2003	Aug 2003	Nov 2003	Feb 2004	May 2004	Aug 2004	Nov 2004	Mar 2005	Dec 2005	Aug 2006	Jan 2007	Mar 2009
No SF	2.9	3.8	6.9	10.2	6.2	6.7	4.5	2.8	1.7	1.1b	0.6b	0.3b	0.6c
SF	**2.9**	3.0	6.2	9.0	5.6	4.5	2.4	1.8	1.7	0.8b	0.9b	0.5b	1.0c
SF 3 mth	2.0	**4.1**	6.5	10.3	7.6	7.1	4.0	3.0	2.8	1.5b	1.3b	1.0b	0.5
SI 0 mth	**2.3**	4.8	10.7	22.3	13.3	13.2	8.3	7.3	5.5	5.2b	4.2b	3.8b	4.5b
SI 3 mth	3.5	**5.4**	6.1	10.3	5.5	5.3	3.2	2.4	1.7	0.9b	0.2b	0.4b	0.8c
SI 6 mth	6.2	13.7	**9.9**	15.4	8.4	8.2	5.3	3.4	2.6	1.2b	0.6b	0.9b	0.5c
S Coat hanger	3.9	2.2	5.7	10.8	6.6	5.5	3.6	2.6	1.7	0.7b	0.4b	0.4b	0.6c
Unpruned	2.8	2.2	4.5	5.3	3.7	3.4	2.7	2.7	2.9	1.8b	1.3b	1.1b	1.2bc
No WF	-	-	6.4	9.8	10.4	10.9	9.7	7.6	5.4	2.6b	1.7b	1.8b	2.1bc
WF	-	-	**4.5**	7.3	4.9	3.7	3.1	2.2	2.1	1.0b	0.6b	0.4b	0.4c
WF 3 mth	-	-	6.3	**11.0**	9.4	10.2	6.9	4.7	4.8	1.7b	1.5b	1.4b	2.0bc
WI 0 mth	-	-	**5.4**	18.3	22.3	24.7	21.9	21.0	18.9	13.3a	11.2a	11.2a	12.3a
WI 3 mth	-	-	4.2	**9.0**	10.3	10.6	7.8	6.6	5.9	3.6b	1.6b	2.5b	1.4bc
WI 6 mth	-	-	4.9	7.7	**8.0**	7.1	5.1	3.6	3.3	1.8b	0.7b	1.0b	0.6c
Overall	**3.3**	**4.9**	**6.3**	**11.2**	**8.7**	**8.6**	**6.3**	**5.1**	**4.3**	**2.6**	**1.9**	**1.9**	**2.1**

Red font indicates date treatment applied
Means with the same letter not significantly different
SF – Summer Fungicide, SI – Summer Inoculation
WF – Winter Fungicide, WI – Winter Inoculation
June 2005 data have been removed (refer to January 2007 report for details)

Table 2 - Percentage of fluted stubs by treatment (second lift whorls)

Treatment	March 2005	June 2005	Sept 2005	Dec 2005	April 2006	August 2006	Jan 2007	March 2009
No SF	6.5	8.0	10.2	11.7abc	13.6 bc	12.0 bc	12.3 bc	8.5bc
SF	6.9	10.7	11.3	12.2abc	10.0 bc	9.8 bc	11.9 bc	7.9bc
SF 3 mth	7.6	8.7	11.1	9.6 bc	10.4 bc	10.3 bc	10.5 bc	4.7bc
SI 0 mth	5.1	5.6	8.2	7.7 c	7.6 c	8.8 c	7.6 c	2.9 c
SI 3 mth	12.8	12.4	16.3	16.2 ab	16.3 bc	15.2 bc	16.5 b	12.3 b
SI 6 mth	9.4	11.1	12.5	12.5abc	10.9 bc	12.2 bc	12.6 bc	6.1 bc
S Coat hanger	5.8	7.1	10.6	11.2abc	12.9 bc	13.4 bc	12.1 bc	7.6 bc
No WF			7.1	10.0 bc	16.9 b	18.0 b	17.3 b	9.7 bc
WF			8.2	7.4 c	12.0 bc	13.1 bc	13.0 bc	6.7 bc
WF 3 mth			8.2	9.6 bc	12.0 bc	15.4 bc	14.7 bc	7.4 bc
WI 0 mth			9.3	17.9 a	37.2a	38.6a	39.7a	32.4a
WI 3 mth			6.6	9.3 bc	15.3 bc	15.8 bc	15.4 bc	7.6 bc
WI 6 mth			7.7	8.1 c	14.2 bc	12.2 bc	14.9 bc	6.5 bc
Overall	7.8	9.1	9.8	11.1	14.9	15.5	15.5	9.6bc

Red font indicates date treatment applied
Means with the same letter not significantly different

Fruit body development

First lift whorls

In February 2004, fruit bodies were recorded on two trees only. After just over a year, in March 2005, fruit bodies were recorded on 38 trees (5.7%). By June 2005, fruit bodies were observed on 45 trees (6.7%). In December 2005, the number of trees where fruit bodies were seen had decreased to 36 (5.4%). The decline in trees with fruit bodies present on first lift whorls has continued. In August 2006 and January 2007, 22 trees (3.3%) and 23 trees (3.4%) respectively were recorded with fruit bodies on their first lift whorls. During the 2009 assessment, fruit bodies were seen on only 11 trees (1.7%).

Second lift whorls

Numbers of fruit bodies varied during the first 9 months after pruning. During the first assessment in March 2005, fruit bodies were seen on 4 trees. In June, no fruit bodies were recorded, in September 2 trees had fruit bodies, and in December 2005 one tree had fruit bodies. Fruit bodies can be difficult to see if light is not suitable, or if the stems are wet. The variation could well have been due to the assessor not seeing fruit bodies that were present.

In 2006, a dramatic increase in fruit bodies was noted. By April 2006, fruit bodies were recorded from 22 trees (3.6%) and by August 62 trees (10.1%) had fruit bodies present on second lift whorls. In January 2007, fruit bodies were seen on 87 trees (14.2%). A very high percentage of trees inoculated immediately after winter pruning (62.5%) had fruit bodies present on their second lift whorls. The number of trees with visible fruit bodies has now declined to 47 (14.2%), with 38% of trees inoculated immediately after winter pruning displaying fruit bodies (Figure 2).

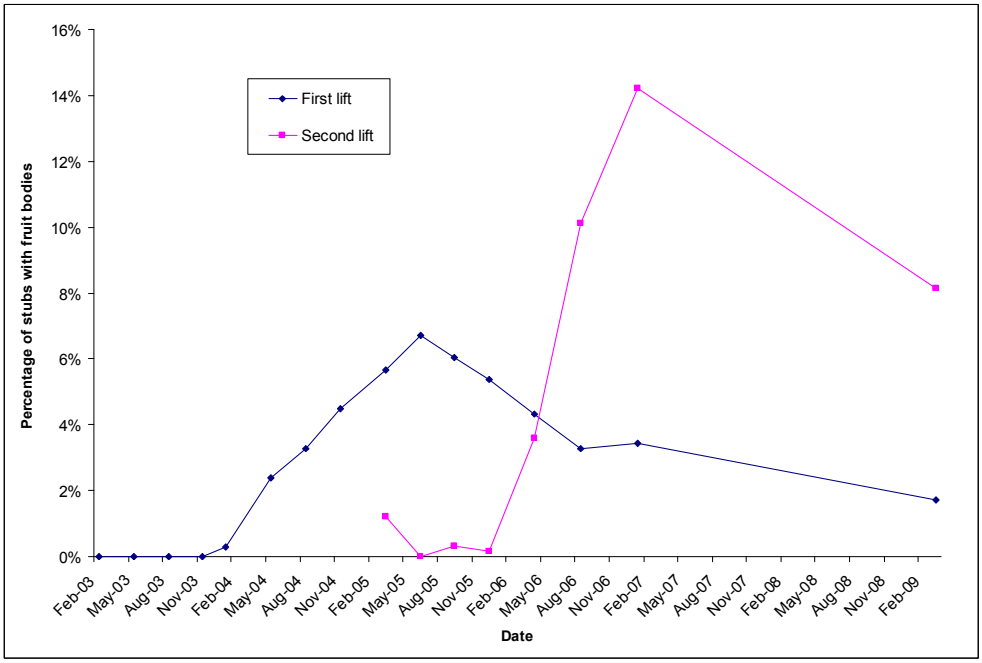


Figure 2: Percentage of stubs with fruit bodies

Disease progress

Percentage of stubs with flutes

Figures 3 and 4 show disease progress after first and second lift pruning. Infection in the winter inoculation treatment is significantly different (P<0.0001) than the other treatments.

Incidence of fluted stubs from the first lift pruning operation has stabilised (Figure 3). For the second lift whorls, the percentage of stubs with flutes has decreased since 2007 (Figure 4).

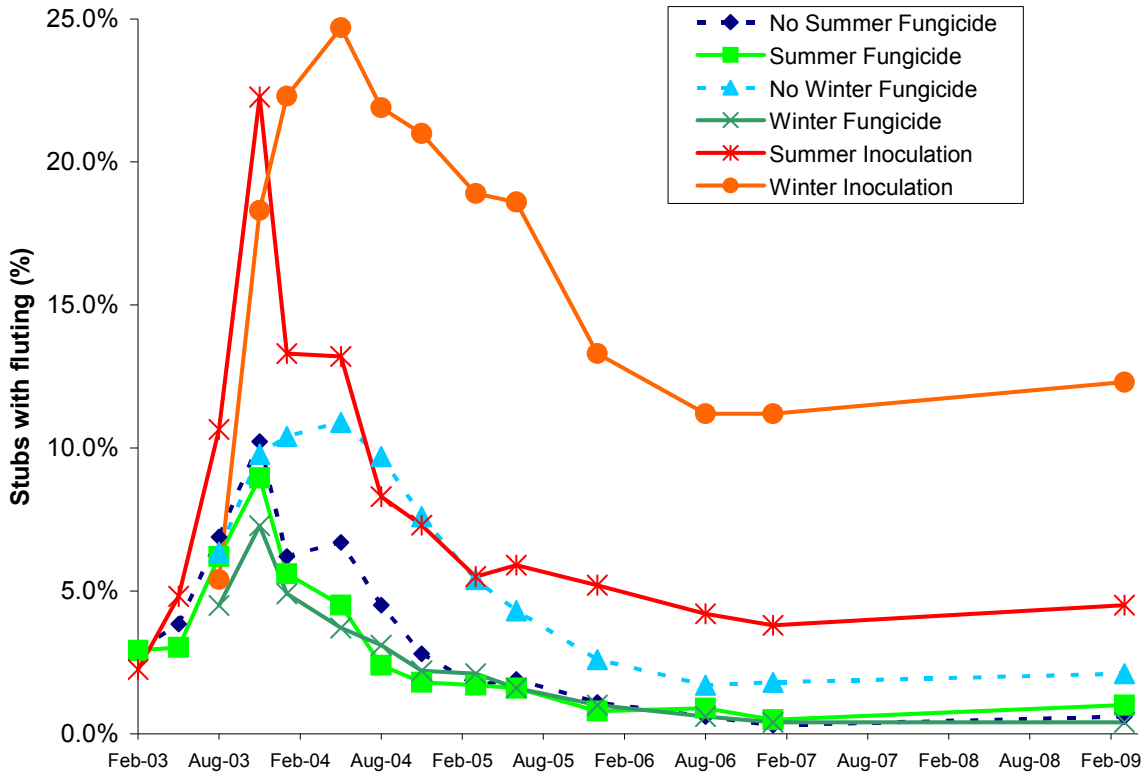


Figure 3: Disease progression of the six major treatments (first lift whorls)

Incidence of fluting on the stubs inoculated in winter peaked at 25%, 9 months after first lift pruning, followed by a steady decline. A similar pattern is evident after second lift pruning, except that the peak is higher at 40% and the decline was slower to be initiated, starting some time after 16 months after inoculation.

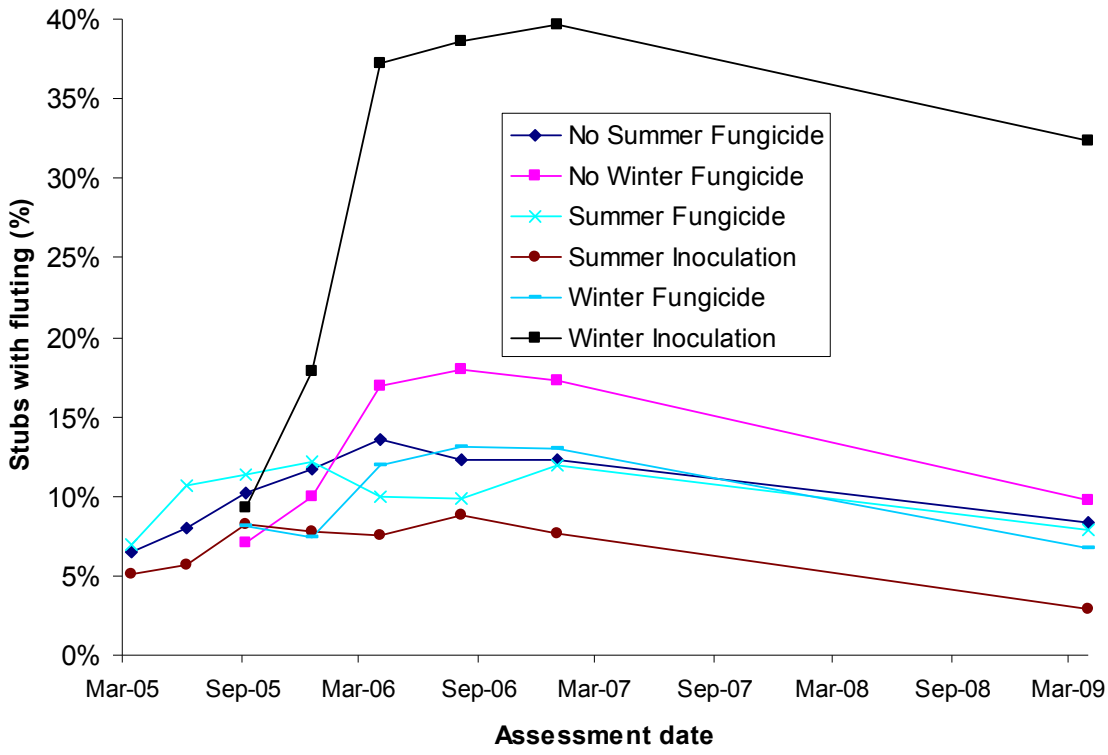


Figure 4: Disease progression of the six major treatments (second lift whorls)

Fluting severity

Fluting severity remained stable in first lift whorls and increased in second lift whorls. The immediate summer and winter inoculation treatments had the highest incidence of severe fluting on first lift whorls, at 0.9% and 2.4%, respectively.

For second lift whorls, severe fluting has developed. At January 2007, 2 years after pruning, severe fluting was recorded on only 9 (0.02%) stubs of the 8,673 assessed. Now, 4 years after pruning, severe flutes were recorded on 82 (0.1%) of the 8,175 stubs assessed.

Whorl height

As noted in previous reports discussing the first pruning lift, there was a trend towards higher incidence of fluting with increasing height up the stem (Table 3). The upper whorl had the highest incidence of fluting for all fourteen assessments when data from all treatments were combined. The lower whorl had the lowest incidence of fluting.

Whorl height varied between trees, but on average the lower whorl was approximately 1 m above ground level, the mid whorl 1.5 m and the upper whorl about 2.0 m above ground level. For the second lift pruned whorls, the lower and upper whorls were about 3 m and 4 m above ground level, respectively.

Table 3 - Percentage fluting by whorl position (from first pruning lift)

Date	Whorl position		
	Lower	Mid	Upper
February 2003	2.9	2.3	4.6
May 2003	3.8	3.7	6.9
August 2003	4.0	4.9	9.7
November 2003	7.5	9.9	15.6
February 2004	5.8	7.1	12.7
May 2004	5.8	7.3	12.2
August 2004	3.9	5.0	9.6
November 2004	3.3	4.0	7.7
March 2005	3.2	3.6	6.0
June 2005	2.9	3.2	5.6
December 2005	2.9	3.2	5.6
August 2006	1.5	1.5	2.7
January 2007	1.4	1.6	2.6
March 2009	1.6	1.7	2.8

The relationship held with whorls from the second pruning lift. Generally the upper whorls had higher disease incidence than the lower whorls, but the relationship was not nearly as pronounced as that seen with the first lift whorls.

Table 4 - Percentage fluting by whorl position (from second pruning lift)

Date	Whorl position	
	Lower	Upper
March 2005	7.4	8.2
June 2005	8.8	9.5
September 2005	9.7	9.9
December 2005	11.1	11.0
April 2006	14.1	15.8
August 2006	14.3	16.7
January 2007	14.2	16.8
March 2009	9.3	9.8

Effect of stub size

Fluting is rarely associated with stubs smaller than 30 mm (Tables 5 and 6). Of the 10,322 stubs smaller than 30 mm after the first lift prune (76% of the total number of stubs) only 189 (1.8%) were fluted. The same result applied with the second lift stubs – only 65 of the 3,657 stubs (1.8%) had flutes, and a large proportion of these were in the winter inoculation treatment.

Table 5 – Number of stubs and number of flutes by stub size (first lift whorls)

Stub size	NSF	NWF	SI3	SI6	SC	SF	SF3	SI0	UP	WF	WF3	WI0	WI3	WI6	Total
0-9	171	138	113	192	156	122	173	169	171	175	115	127	144	112	2078
	0	1	0	0	0	1	0	8	1	0	1	14	2	0	28
	0.0%	0.7%	0.0%	0.0%	0.0%	0.8%	0.0%	4.7%	0.6%	0.0%	0.9%	11.0%	1.4%	0.0%	1.3%
10-19	291	291	287	349	260	278	295	344	345	306	252	293	311	244	4146
	2	6	2	0	1	3	4	17	6	2	5	33	2	1	84
	0.7%	2.1%	0.7%	0.0%	0.4%	1.1%	1.4%	4.9%	1.7%	0.7%	2.0%	11.3%	0.6%	0.4%	2.0%
20-29	278	277	279	312	287	354	278	389	377	288	202	283	247	247	4098
	4	4	0	1	3	1	1	22	2	2	4	31	1	1	77
	1.4%	1.4%	0.0%	0.3%	1.0%	0.3%	0.4%	5.7%	0.5%	0.7%	2.0%	11.0%	0.4%	0.4%	1.9%
30-39	162	199	159	187	177	174	154	203	227	145	121	166	111	144	2329
	2	6	1	1	2	2	0	13	2	0	2	16	4	1	52
	1.2%	3.0%	0.6%	0.5%	1.1%	1.1%	0.0%	6.4%	0.9%	0.0%	1.7%	9.6%	3.6%	0.7%	2.2%
40-49	50	72	52	57	38	45	39	60	81	68	49	63	29	42	745
	0	1	1	0	0	0	0	5	3	1	0	6	0	1	18
	0.0%	1.4%	1.9%	0.0%	0.0%	0.0%	0.0%	8.3%	3.7%	1.5%	0.0%	9.5%	0.0%	2.4%	2.4%
50-59	4	13	5	6	9	5	4	11	19	20	17	9	5	8	135
	0	2	0	0	0	0	0	1	1	0	0	0	0	0	4
	0.0%	15.4%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%
60-69	2	2	0	2	0	3	1	0	2	0	8	5	1	2	28
	0	0	0	0	0	1	0	0	0	0	0	4	0	1	6
	0.0%	0.0%		0.0%		33.3%			0.0%		0.0%	80.0%	0.0%	50.0%	21.4%
70+	1	1	0	0	0	0	3	0	0	0	2	0	0	1	8
	1	1	0	0	0	0	3	0	0	0	2	0	0	1	8
	100.0%	100.0%					100.0%				100.0%			100.0%	100.0%
Stubs	959	993	895	1105	927	981	947	1176	1222	1002	766	946	848	800	13567
Flutes	9	21	4	2	6	8	8	66	15	5	14	104	9	6	277
%	0.9%	2.1%	0.4%	0.2%	0.6%	0.8%	0.8%	5.6%	1.2%	0.5%	1.8%	11.0%	1.1%	0.8%	2.0%

Table 6 – Number of stubs and number of flutes by stub size (second lift whorls)

Stub size	NSF	NWF	SC	SF	SF3	SI0	SI3	SI6	WF	WF3	WI0	WI3	WI6	Total
1-9	37	38	48	26	38	27	40	30	50	44	59	40	36	513
	1	0	0	0	0	0	0	0	0	0	1	1	0	3
	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	2.5%	0.0%	0.6%
10-19	125	87	92	106	116	108	90	99	117	77	115	90	87	1309
	0	0	0	0	0	0	2	0	0	0	6	0	0	8
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	5.2%	0.0%	0.0%	0.6%
20-29	166	129	146	163	142	171	140	141	142	105	128	150	112	1835
	4	0	1	5	1	0	4	0	1	2	29	5	2	54
	2.4%	0.0%	0.7%	3.1%	0.7%	0.0%	2.9%	0.0%	0.7%	1.9%	22.7%	3.3%	1.8%	2.9%
30-39	114	148	116	143	150	140	149	101	137	113	152	134	136	1733
	9	6	4	9	3	0	19	3	6	8	62	12	8	149
	7.9%	4.1%	3.4%	6.3%	2.0%	0.0%	12.8%	3.0%	4.4%	7.1%	40.8%	9.0%	5.9%	8.6%
40-49	74	101	81	68	61	66	91	61	85	76	97	73	79	1013
	12	16	14	16	8	4	20	10	15	4	56	11	15	201
	16.2%	15.8%	17.3%	23.5%	13.1%	6.1%	22.0%	16.4%	17.6%	5.3%	57.7%	15.1%	19.0%	19.8%
50-59	34	40	28	19	33	12	29	27	41	31	43	31	29	397
	8	18	9	9	8	3	13	7	10	8	35	5	4	137
	23.5%	45.0%	32.1%	47.4%	24.2%	25.0%	44.8%	25.9%	24.4%	25.8%	81.4%	16.1%	13.8%	34.5%
60-69	9	17	10	5	11	5	14	8	11	18	12	7	9	136
	3	10	4	4	4	2	4	3	7	5	10	5	5	66
	33.3%	58.8%	40.0%	80.0%	36.4%	40.0%	28.6%	37.5%	63.6%	27.8%	83.3%	71.4%	55.6%	48.5%
70-79	4	4	5	2	1	2	4	3	5	8	7	3	0	48
	4	4	5	0	1	2	3	2	2	3	5	1	0	32
	100.0%	100.0%	100.0%	0.0%	100.0%	100.0%	75.0%	66.7%	40.0%	37.5%	71.4%	33.3%		66.7%
80-89	2	2	1	0	0	2	2	0	1	2	0	0	1	13
	1	2	1	0	0	2	2	0	1	2	0	0	1	12
	50.0%	100.0%	100.0%			100.0%	100.0%		100.0%	100.0%			100.0%	92.3%
90+	2	1	3	1	0	0	2	2	3	3	6	2	0	25
	2	1	3	1	0	0	2	2	3	2	6	2	0	24
	100.0%	100.0%	100.0%	100.0%			100.0%	100.0%	100.0%	66.7%	100.0%	100.0%		96.0%
Stubs	567	567	530	533	552	533	561	472	592	477	619	530	489	7022
Flutes	44	57	41	44	25	13	69	27	45	34	210	42	35	686
	7.8%	10.1%	7.7%	8.3%	4.5%	2.4%	12.3%	5.7%	7.6%	7.1%	33.9%	7.9%	7.2%	9.8%

Figures 5 and 6 show the incidence of fluting by stub size. Fluting is rare in stubs from the first lift pruning, apart from the large stubs 60 mm or over. For the second lift pruning, a similar trend occurs but the increase in fluting starts with stubs 30 mm or over. Figures 7 and 8 show the change in incidence of fluting by stub size from August 2004 (Figure 7) to March 2009 (Figure 8) for first lift stubs. Nearly all flutes associated with stubs smaller than 60 mm have occluded. The only flutes persisting in any numbers are those associated with large stubs.

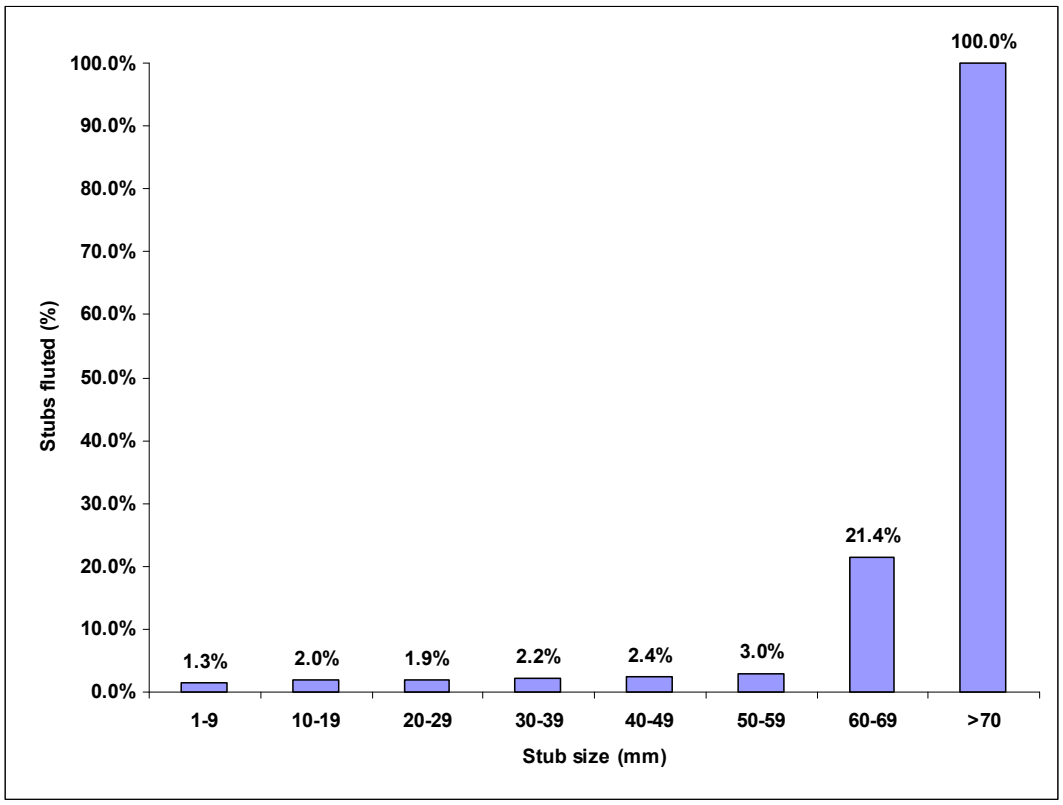


Figure 5 – Percentage of fluted stubs for all treatments (first lift whorls, excluding immediate summer and winter inoculation).

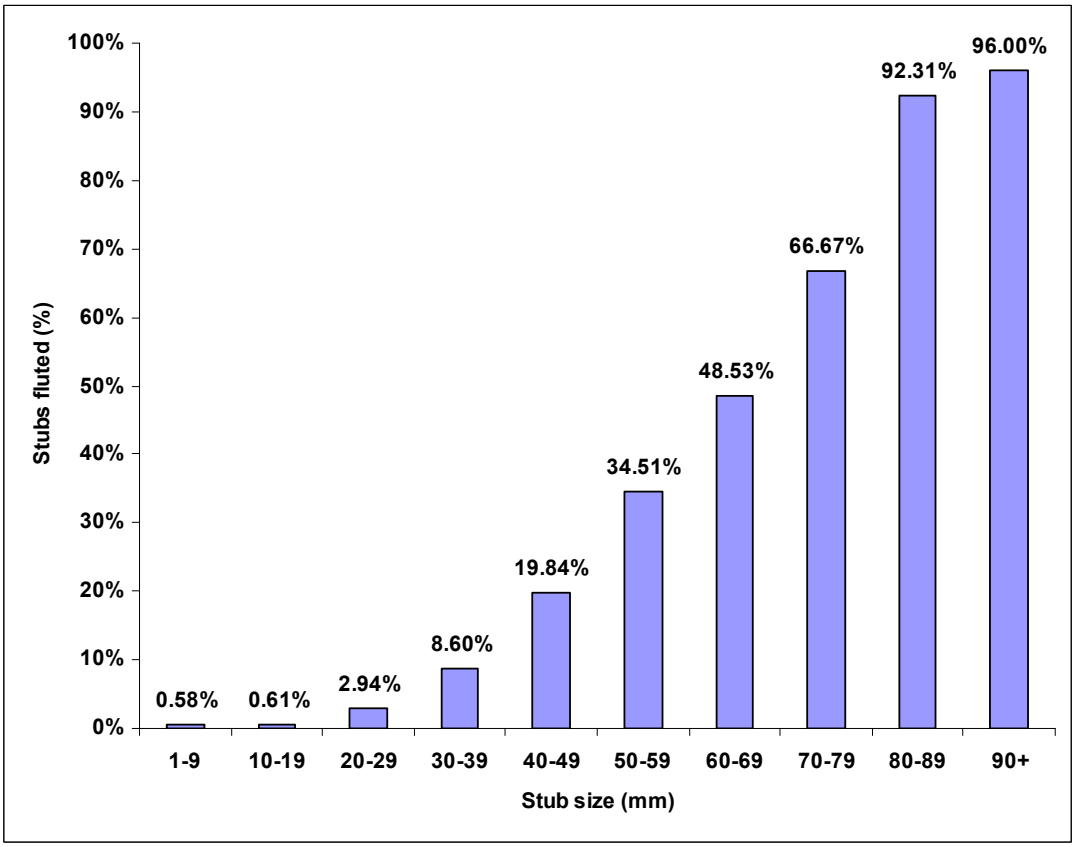


Figure 6 – Percentage of fluted stubs for all treatments (second lift whorls, excluding immediate summer and winter inoculation).

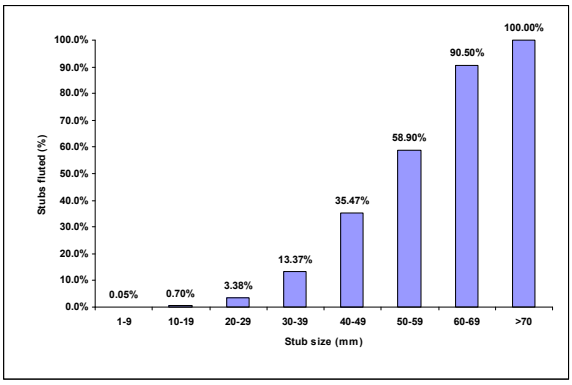


Figure 7 - Percentage of fluted stubs for all treatments, first lift whorls, in August 2004

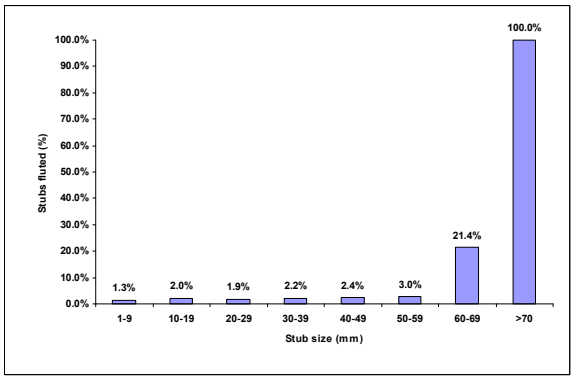


Figure 8 - Percentage of fluted stubs for all treatments, first lift whorls, in March 2009

Figure 9 demonstrates the change in the distribution of flutes over time. In August 2004 there was a lineal increase in fluting incidence when stubs were over 20 mm. Over time the lineal relationship has flattened and the minimum stub size for flutes has increased to 60 mm or more.

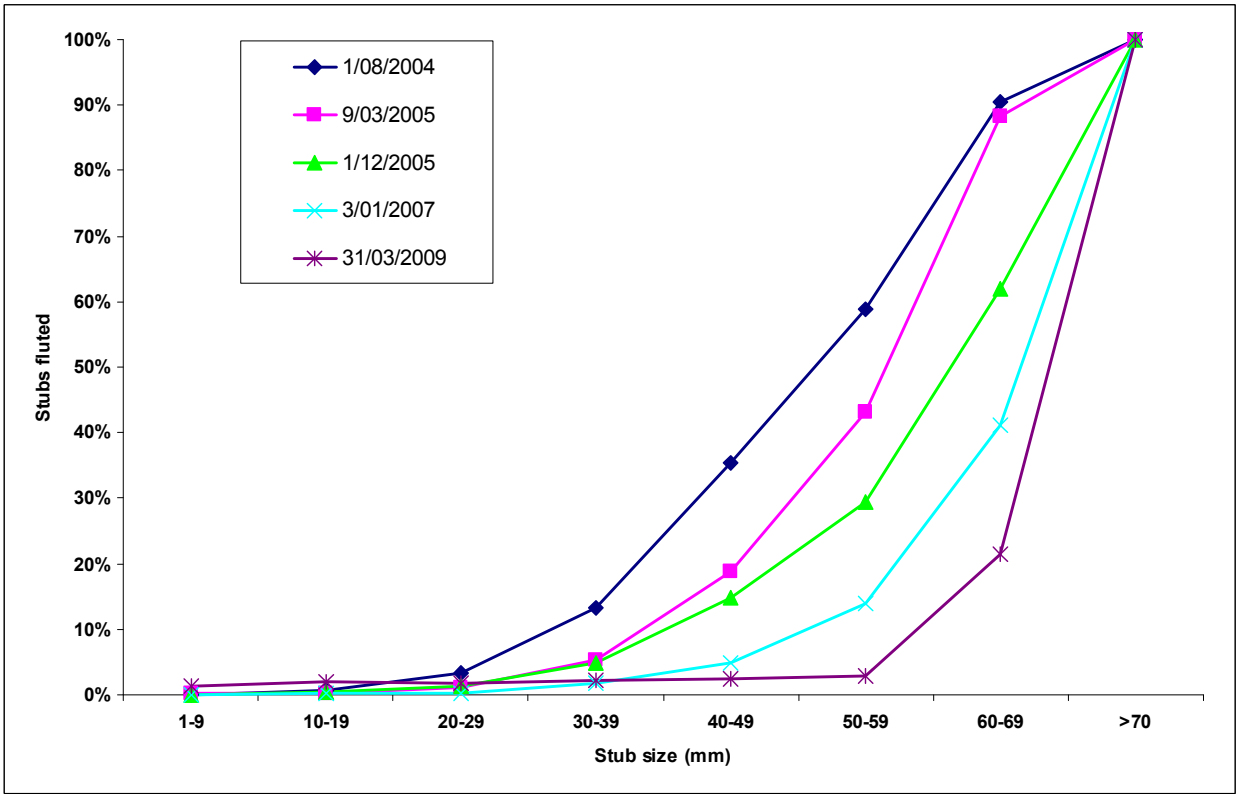


Figure 9 - - Percentage of fluted first lift stubs for all treatments by year

DISCUSSION

Three significant findings have been made from this trial.

Firstly, it is clear that *Neonectria fuckeliana* is playing a role in flute development. Stubs inoculated with the fungus continue to display a higher incidence of fluting than those where inoculation was not carried out. The effect is greater when inoculum was applied in winter. The interaction between season of treatment, inoculation, weather, pruning, and presence of the fungus in the tree before treatment is not clear and needs to be further elucidated.

Secondly, many of the flutes that were present on first lift whorls up to 3 years after pruning are now no longer visible. The incidence of flutes appears to peak about one year after treatment followed by decline over a two-year period. After that, fluting remains stable. This pattern is consistent at the tree and stub level, and after both summer and winter treatment. It appears to be similar after second lift pruning, but it is too soon to tell if the decline will follow at the same rate.

Thirdly, when incidence of fluting is followed over time by stub and stub size, it is apparent that flutes persist only when associated with large stubs. So, the previous finding that stubs smaller than 30 mm are not at risk was conservative and it is likely that stubs between 30 and 60 mm may be tolerated without increasing risk of disease. It is also likely that the incidence of fluting has been overestimated, particularly if assessments were carried out in the 1-2 year period after pruning.

CONCLUSIONS

1. Fluting incidence is related to stub size.
2. Stubs smaller than 60 mm seldom lead to serious Nectria damage.
3. Winter pruning results in more infection than summer pruning.
4. Inoculation immediately after pruning results in increased infection.
5. Flute development is slow and fruit bodies take at least 9 months to develop after treatment.

The most significant results from the trial, from a management perspective, are that it appears that only large stubs are associated with disease. Limiting branch stub size to less than 60 mm and avoiding pruning operations in winter should significantly reduce levels of Nectria disease.

RECOMMENDATIONS

The trial received a full assessment in March 2009. It is important to determine if that the trends seen in stubs from the first lift pruning are followed in second lift stubs. For that reason it is recommended that the trial is reassessed in March 2010.

ACKNOWLEDGMENTS

Paul Cox and his associate carried out the assessments. City Forests provided the trial site and substantial support when the trial was established and afterwards. Many trees have been sacrificed. City Forests' in kind contribution, led by Peter Oliver and Ross Chambers, is gratefully recognised. Margaret Dick and Anna Hopkins, as always, cheerfully contributed advice on the trial and reviewed the draft of this report.