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Key Staff:	**EMR**	Principle scientist:	Dr A M Berrie
		Research assistant:	Mrs B E Ellerker
	FAST	Mr T Biddlecombe	
		Mr G Saunders	

Location of Project: East Malling Research
New Road
East Malling
Kent, ME19 6BJ
Tel: 01732 843833 Fax: 01732 849067
E-mail: angela.berrie@emr.ac.uk

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DISCLAIMER

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work, it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with the interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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Apple: evaluation of methods to control canker (*Nectria galligena*)

Headline

- New cankers and *Nectria* fruit rots can be significantly reduced by a 'key stage' fungicide programme.

Background and expected deliverables

Canker, caused by the fungus *Nectria galligena*, is one of the most important diseases of apple and pear. The fungus attacks trees in the orchard, causing cankers and die back of young shoots, resulting in loss of fruiting wood and increasing pruning costs. Apple canker can be particularly damaging in young orchards where, in some years, up to 10% of trees can be lost annually, in the first few years of orchard establishment, as a result of trunk cankers. *Nectria* also causes a fruit rot that can result in significant losses as high as 10% or more in stored fruit. *Nectria* rot, which is often at the fruit stalk end, is also difficult to spot on the grading line, but becomes obvious during marketing leading to rejection of fruit consignments.

The fungus produces two spore types, conidiospores from white pustules called conidia in the spring and summer and ascospores from red fruiting bodies called perithecia in the autumn and winter. These enter shoots and branches on the tree through wounds, either natural wounds such as bud-scale scars, leaf scars, fruit scars or artificial wounds such as pruning wounds. Thus inoculum and points of entry on the tree are available all year round and the only limiting factor is frequency and duration of rain, which is essential for spore production, spread, germination and infection. Autumn leaf fall is usually the main infection period and wet autumns are usually followed by a high incidence of shoot dieback the following spring and summer due to canker.

Currently, canker is controlled by a combination of cultural methods to remove canker lesions and the use of protectant fungicides. Effective fungicides are limited. Generally, copper fungicides are used at autumn leaf fall and before budburst to protect leaf scars and bud-scale scars and carbendazim has been applied during the spring and summer. In HDC project TF144 potential alternative fungicides were evaluated for canker control. None of the products evaluated were more effective than carbendazim, but Octave (prochloraz), Folicur (tebuconazole) and Elvaron Multi (tolylfluanid) were as effective or almost as effective as carbendazim and therefore could be considered as potential replacements. There are also other chemicals, mainly commodity chemicals or nutrients such as potassium phosphite or potassium bicarbonate which may also contribute to canker control.

Tree growth and nutrition may also influence canker infection and development. Canker incidence is often greater in poorly growing trees or in trees with excessive growth. It is most likely that a tree subject to stress or that is not in ‘growth balance’ is more prone to canker. Nitrogen is known to encourage canker development but other nutrients, possibly trace elements, may also influence disease development. Which factors are important is not understood.

Up until the 1970s, it was normal orchard practice to remove prunings from the orchard and burn them. Any cankers pruned out would therefore have been eliminated from the orchard. Removal and burning of prunings from orchards is now rare, most being pulverised in the tree alleyways. What is not clear is the effect of this practice on canker survival and viability and the likely risk to trees from spores generated by canker debris on the ground. Previous studies by Upstone (late 1970s) and Swinburne (early 1980s), which focused on canker infection in the trees, have indicated a minimal risk of canker from pulverised prunings. Despite this there are still concerns among growers. Studies on canker pulverisation in HDC project TF161 showed that pruned out cankers left in the orchard either pulverised or not pulverised could produce perithecia for at least 16 months after being detached from the trees and so could provide inoculum for infection of wounds.

Applying an integrated programme for canker control is costly, especially pruning out cankers and additional fungicide sprays. In addition, an intensive fungicide programme can contribute to residues in fruit. Such costs and risks would be considered worthwhile if it resulted in significantly better canker control. However, such an evaluation of the full integrated approach has never been undertaken.

The overall aim of this project is to evaluate a programme in which all the known key methods for canker control are combined, for efficacy in controlling canker. Key methods to be included are:

- best fungicide programme
- spray timing
- summer pruning to remove cankers
- tree nutrition

The information generated will be used to produce an HDC Fact Sheet on canker control.

Summary of project and main conclusions

At two orchard sites, both of the cv. Gala on M9 rootstock, the effect of a full integrated programme for canker control on the incidence of new cankers, *Nectria* fruit rot and shoot growth was compared with that of a standard fungicide programme with no additional specific measures for control of canker. At each site the orchard was divided in half. A standard fungicide programme was applied to one half and a best practice programme, with additional treatments for canker control applied at key timings pre and post blossom and at leaf fall, to the other half (Table 1). In addition the plots were sub divided to include removal or non-removal of cankers during the summer. The soil was sampled at the start of the trial and leaf samples taken for chemical analysis in spring and summer and additional nutrients applied as necessary.

The trials were established in October 2005. The weather in summer 2006 was relatively dry and not very favourable for spread and infection of *Nectria*. At site 1, the programme of treatments applied to the best practice half of the orchard significantly reduced the numbers of new cankers and the incidence of *Nectria* fruit rot compared to that in the half receiving a standard programme. At site 2 the numbers of new cankers were also reduced but not significantly so. The incidence of *Nectria* fruit rot was too low for any effects to be determined. There was no significant effect on shoot growth. The trial will continue until March 2009.

Financial benefits of the project

Apple canker is one of the most difficult disease problems facing the apple industry, mainly because of the difficulties in achieving successful control of the problem and the expense involved in applying what is considered to be best practice. This project will identify the current key methods for canker control, combine them into an integrated approach, apply them over three seasons to a commercial apple orchard with canker and compare the resultant canker incidence with that resulting from a standard fungicide programme without specific canker controls. This will provide the industry with clear evidence whether applying the current best practice for canker control is effective and worthwhile. Ultimately clear guidelines could be provided to the industry on canker prevention and control.

Table 1. **Treatments applied to orchard plots at both Site 1 and Site 2. Each plot was further split for removal or no removal of cankers in summer**

Standard Farm Practice	Canker Best Practice
Standard fungicide programme	Standard fungicide programme + additional sprays for canker at key times as follows: 2-3 at bud burst –bloom (protection of bud scale scars and late frost damage) petal fall petal fall + 2-4 weeks (summer leaf fall) June/July (fruit thinning) August (summer pruning)
	Sprays for fruit rot at bloom and pre-harvest
Cuprokylt at 10% and 50% leaf fall	Folicur pre-leaf fall (October) Folicur and/or carbendazim or Cuprokylt at 10%, 50% and 90% leaf fall

Action points for growers

- The treatments applied as part of the canker best practice programme in 2005 and 2006 – carbendazim products and Elvaron Multi – have since been withdrawn for use on apples and therefore, despite the success of the programme in reducing numbers of cankers and fruit rot incidence, cannot be recommended for growers
- Folicur has an off label approval for use on apples post-harvest (Sola 1734/2005) and should be used in conjunction with Cuprokylt FL at leaf fall
- In 2007, Captan at the full rate of 3.4kg/ha and Bellis were used in place of carbendazim and Elvaron Multi in the best practice programme. The impact of this changed programme on canker will not be known until later in the project

Science Section

Introduction

Canker, caused by the fungus *Nectria galligena*, is one of the most important diseases of apple and pear. The fungus attacks trees in the orchard, causing cankers and die back of young shoots, resulting in loss of fruiting wood and increasing pruning costs. Apple canker can be particularly damaging in young orchards where, in some years, up to 10% of trees can be lost annually, in the first few years of orchard establishment, as a result of trunk cankers. *Nectria* also causes a fruit rot that can result in significant losses as high as 10% or more in stored fruit. *Nectria* rot, which is often at the fruit stalk end, is also difficult to spot on the grading line, but becomes obvious during marketing leading to rejection of fruit consignments.

The fungus produces two spore types, conidia in the spring and summer and ascospores in the autumn and winter. These enter shoots and branches on the tree through wounds, either natural wounds such as bud-scale scars, leaf scars, fruit scars or artificial wounds such as pruning wounds. Thus inoculum and points of entry on the tree are available all year round and the only limiting factor is frequency and duration of rain, which is essential for spore production, spread, germination and infection. Autumn leaf fall is usually the main infection period and wet autumns are usually followed by a high incidence of shoot dieback the following spring and summer due to canker.

Currently, canker is controlled by a combination of cultural methods to remove canker lesions and the use of protectant fungicides. Effective fungicides are limited. Generally copper fungicides are used at autumn leaf fall and before budburst to protect leaf scars and bud-scale scars and carbendazim is applied during the spring and summer. In HDC project TF144 potential alternative fungicides were evaluated for canker control. None of the products evaluated were more effective than carbendazim, but Octave (prochloraz), Folicur (tebuconazole) and Elvaron Multi (tolylfluanid) were as effective or almost as effective as carbendazim and therefore could be considered as potential replacements. There are also other chemicals, mainly commodity chemicals or nutrients such as potassium phosphite or potassium bicarbonate which may also contribute to canker control.

Tree growth and nutrition may also influence canker infection and development. Canker incidence is often greater in poorly growing trees or in trees with excessive growth. It is most likely that a tree subject to stress or that is not in growth balance is more prone to canker. Nitrogen is known to encourage canker development but other nutrients possibly trace elements may also influence disease development. Which factors are important is not understood.

Up until the 1970s, it was normal orchard practice to remove prunings from the orchard and burn them. Any cankers pruned out would therefore have been eliminated from the orchard. Removal and burning of prunings from orchards is now rare, most being pulverised in the tree alleyways. What is not clear is the effect of this practice on canker survival and viability and the likely risk to trees from spores generated by canker debris on the ground. Previous studies by Upstone (Late 1970s) and Swinburne (Early 1980s), which have focused on canker infection in the trees, have indicated a minimal risk of canker from pulverised prunings. Despite this there are still concerns among growers. Studies on canker pulverisation in HDC project TF161 showed that pruned out cankers pulverised or unpulverised could produce perithecia for at least 16 months after being detached from the trees and so could provide inoculum for infection of wounds.

Applying an integrated programme for canker control is costly, especially pruning out cankers and additional fungicide sprays. In addition the intensive fungicide programme can contribute to residues in fruit. Such costs and risks would be considered worthwhile if it resulted in significantly better canker control. However, such an evaluation of the full integrated approach has never been undertaken.

The overall aim of this project is to evaluate a programme in which all the known key methods for canker control are combined, for efficacy in controlling canker. Key methods to be included are:

- best fungicide programme
- spray timing
- summer pruning to remove cankers
- tree nutrition

The information generated will be used to produce an HDC Fact sheet on canker control.

Overall objective: to evaluate the efficacy of an integrated programme combining the current best practices in controlling apple canker.

Specific objectives

1. To investigate the effect of an integrated programme on canker incidence on the trees
2. To investigate the effect of an integrated programme on the incidence of *Nectria* fruit rot in store

Materials and Methods

Site

Two orchard sites, both of the cultivar Gala, where canker is a problem were chosen for study. Site (1) was located at Rocks Farm, East Malling Research and was an orchard of Gala on M9 rootstock (TL161 – 30 rows of 27 trees) with a high incidence of nectria canker. Site (1) was managed by East Malling Research. Site (2) was located in a commercial orchard of Gala with Cox pollinators on M9 rootstock (Marsh Gala – approx. 22 rows of 80 trees) at Elverton Farm, Teynham. The second site was managed by FAST.

Experimental details

At each site the orchard was divided into half. One half received a standard pesticide programme for control of scab, mildew and pests but with no specific measures for control of canker apart from copper sprays at leaf fall in the autumn. The other half received the same standard pesticide programme but included specific measures for canker control at key timings as detailed in Table 1.

At site (1) each half was divided into four sub-plots, in two of which cankers were cut out and removed in summer, giving eight plots in total for the trial. At site (2) each orchard half was sub divided into two plots, cankers being cut out and removed in summer from one sub-plot in each half only, giving a total of four sub-plots for the trial. A plan of site two showing the four sub-plots is included in the appendix.

Table 1. Treatments applied to orchard plots at TL161 EMR (Site 1) and Marsh Gala, Elverton Farm, Teynham (Site 2). Each plot was further split for removal or no removal of cankers in summer

Standard Farm Practice	Canker Best Practice
Standard fungicide programme	Standard fungicide programme + additional sprays for canker at key times as follows: 2-3 at bud burst –bloom (protection of bud scale scars and late frost damage) petal fall petal fall + 2-4 weeks (summer leaf fall) June/July (fruit thinning) August (summer pruning) Sprays for fruit rot at bloom and pre-harvest
Cuprokylt at 10% and 50% leaf fall	Folicur pre leaf fall (October) Folicur and/or/ carbendazim or Cuprokylt at 10%, 50% and 90% leaf fall

Pesticide treatments

The standard pesticide programme applied at the two sites was as similar as possible to allow comparisons to be made between the sites. Additional fungicide treatments applied to the canker best practice half were based on carbendazim (various products), Elvaron Multi (tolylfluanid), Folicur (tebuconazole) and Captan (captan).

Nutrition

The soil in each half of the orchard at each site was sampled at the start of the trial and analysed to determine fertiliser inputs. Leaf samples for mineral analysis were taken at mouse ear and in August and foliar feeds applied at key stages according to need.

Other orchard treatments

Other treatments such as growth regulators and herbicides were applied as necessary to both halves. Both halves of the orchards were pruned according to commercial practice including removal of cankers, but pruning was delayed until after canker assessments were completed. In the best practice half prunings were removed from the orchard and burnt. In the standard practice half the prunings were pulverised in the grass alley and left in the orchard.

Experimental design

Because of the need to have large plots to minimise the influence between treatments, replication was not possible. After discussion with the statistician, to overcome this problem at site (1), in each of the 8 sub-plots assessments of extension growth and numbers of new cankers were made on 20 marked trees. Similarly, for assessment of fruit rot, four bins of fruit were harvested from different areas within each of the eight sub-plots. At site (2), assessments of canker and extension growth were made on 10 trees in each of five rows per sub-plot. The large sample size allowed some statistical analysis of the data.

Assessments

Cankers – At the start of the trial existing cankers were labelled with paint and recorded. Numbers of new cankers were recorded on the assessment trees in November 2006 or February 2007. Any cankered shoots removed from the assessment trees or plots in summer were also recorded.

Nectria fruit rot

At site (1) at harvest 2006 four bins of fruit were picked from each of the eight sub-plots, clearly labelled and placed in store at 3.5^{o}C; 1.2%O_2, <1%CO_2. At harvest 2007 three bins of fruit were picked from each sub-plot and similarly stored. The storage conditions were not normally used for Gala (normal storage temperature 1-2^{o}C), but the higher temperature will encourage the development of *Nectria* rot. At the end of the storage period the bins were removed from store, weighed and graded. The rots were removed during grading, visually identified and weighed and recorded as weight and number of rots per bin.

At site (2) in both 2006 and 2007 the orchard was destined for immediate marketing and not stored. Therefore in order to obtain information on fruit rot incidence a random sample of fruit of ten nets of 50 fruit was harvested from each sub plot of the trial at Elverton Farm and stored at East Malling Research as above and assessed for rots at the end of the storage period.

Extension growth

Extension growth was measured in winter on 10 shoots on each of the 20 labelled trees in each sub-plot at East Malling Research and on each of 10 trees in five rows per sub plot at site (2) at Elverton Farm.

Weather

Climatic conditions were recorded on a weather station located in the orchard or nearby.

Statistical analysis

For all analyses of assessments the treatments were set up as a 2x2 factorial with the factors standard or best practice and removal or non-removal of cankers in summer.

Site 1

For numbers of cankers, analysis was done on counts and square root transformations of the counts using ANOVA. For each rot variate two analyses were done. For one analysis the F-tests for treatments were based on the residual between sub-plots within the main plots and the second analysis included the variation between bins within sub-plots.

Site 2

For numbers of cankers, analysis was similarly done on counts and square root transformations of the counts using ANOVA. Treatments were tested against the residual based on the variation between rows within sub-plots. For extension growth treatments were tested against the between tree residual in sub-plots.

Results and Discussion

Fungicide treatments

The fungicide programmes applied to plots in 2005/2006 and in 2007 at Site 1 are shown in Tables 2 and 3. In 2005 / 2006 the additional treatments applied to the best practice half of the orchard were based on folicur (tebuconazole), carbendazim and Elvaron Multi (tolylfluanid). Use of carbendazim was no longer permitted on apples after August 2006 so Elvaron Multi was applied in place of it. Leaf fall sprays included Folicur and Cuprokylt FL (copper oxychloride). In 2007, Elvaron Multi was withdrawn for use on apple so the additional treatments in the best practice half were based on full rate captan (3.4kg/ha) with a spray of Bellis (pyraclostrobin + boscalid) during blossom.

The fungicide programme applied to plots at Site 2 in 2005/2006 is shown in Table 4. The additional treatments applied to the best practice half were based on carbendazim and Folicur. The programme applied in 2007 will be reported in 2008.

Soil and leaf analysis

Analysis of soil and leaf samples from standard and best practice plots were satisfactory so no additional nutrients apart from the normal practice were applied at either site in 2006 or 2007.

Numbers of new cankers

Site 1

Numbers of cankers were recorded on the 20 labelled trees in each sub-plot in February 2007 as A/B cankers (those on the rootstock or main trunk) or C/D/E cankers (those associated with pruning cuts, leaf scars, bud scale scars or shoot base). The cankers removed from the labelled trees in summer 2006 were included in the final counts for C/D/E cankers. The mean number of cankers per tree is shown in Table 5. There was no significant effect of the treatments on numbers of A/B cankers per tree. A/B type cankers are those most likely arising from infection already present within the tree as a result of *Nectria* infection of trees in the nursery (McCracken *et al*. 2000) and are unlikely to be influenced by any treatments applied. The mean number of C/D/E type cankers per tree was significantly reduced (P=0.013) by the treatments applied in autumn 2005 and in 2006 in the best practice half of the orchard. These cankers were most likely the result of infection of wounds by *Nectria* spores (conidia or ascospores) and therefore likely to be influenced by the treatments applied. As expected there was no significant effect of summer canker removal on numbers of new cankers. This treatment should have most effect on the incidence of *Nectria* fruit rot.

The mean number of cankers per tree removed from the marked trees in summer 2007 is shown in Table 6. Less than one canker per tree was removed from the best practice half compared to almost three cankers per tree in the standard practice half. The cankers removed during summer 2007 were the result of infections during autumn 2006.

Site 2

The incidence of canker in Marsh Gala has decreased since the trial started such that there were almost no cankers to remove in summer 2006 and 2007. The mean number of cankers per tree recorded in November 2006 is shown in Table 7. There were no significant effects of the treatments on numbers of cankers, but fewer cankers were recorded in the best practice half.

Nectria fruit rot

Site 1

Four bins of fruit were harvested per sub-plot on 15 September 2006 and stored until 28 March 2007. The rainfall in April and May 2006 (Table 8) was above average and very favourable for infection of fruit by *Nectria galligena*. The subsequent weather up until harvest was hot with below average rainfall and therefore not favourable for fruit infection. The incidence of rotting per bin was therefore relatively low and varied from 0.3% to 2.8%. Most of the rotting was due to *Nectria*. Mean % total losses per bin due to rots and to nectria are shown in Table 9. The incidence of both total rots and *Nectria* rots was significantly less ($P<0.001$ for both total rots and *Nectria* rots) in bins harvested from plots receiving the best practice programme. There was no significant effect of removing cankers during the summer on the incidence of rotting. Cankers present on one and two year old wood generally sporulate during the summer months and spores (conidia) are spread from these by rain splash to infect fruit. Therefore removal of these during the summer might be expected to reduce the amount of inoculum and hence reduce rotting. The hot dry conditions in June and July were not conducive to *Nectria* sporulation or spread. Hence it was not unexpected that removal of cankers would have any significant effect on the incidence of fruit rotting.

In 2007, three bins of fruit were harvested per plot and placed in cold store as above. Rot incidence will be assessed in February or March 2008. Rainfall in summer 2007 (Table 8) was well above average and therefore exceptionally favourable for *Nectria* sporulation on cankers and spread and infection of fruit. Therefore, the removal of summer cankers would be expected to have a more significant effect on rotting.

<u>Site 2</u>

As there were no cankers present to remove in summer in 2006, ten nets of 50 fruit were sampled from the whole plot rather than separately from the sub plots on 14 September and placed in cold store as above at EMR. Rot incidence was assessed on 29 March 2007. The incidence of rotting was very low and no rots due to *Nectria* were recorded.

Similarly, in 2007 no cankers were present to remove in summer so ten nets of 50 fruit were sampled from the whole plot as in 2006. The fruit was placed in store at EMR and will be assessed in 2008.

<u>Extension growth</u>

<u>Site 1</u>

Extension growth was not measured in 2006. One and two year old growth will be measured in winter 2007/8 and reported on in 2008.

Site 2

Mean extension growth was 72-73cm (Table 10). There was no significant effect of treatments on shoot length.

Conclusions

- The fungicide programme applied in the best practice half of the orchard significantly reduced both incidence of *Nectria* fruit rot and numbers of new cankers at site (1) (TL161, EMR) compared to the half of the orchard that received the standard farm programme
- Numbers of new cankers were also reduced in the best practice half of the orchard at site (2) (Marsh Gala, Elverton Farm), but differences were not significant. *Nectria* rot was not recorded in the sample of fruit from site (2)
- There was no effect of treatment on shoot growth at site (2)

Technology transfer

Results from the project were reported to members of the HDC Top Fruit Panel in November 2006 and 2007. and will be used to produce an HDC factsheet at the end of the project.

References

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Table 2. Fungicide treatments applied to Standard Practice and Canker Best Practice plots in 2005/6 at Site (1) (TL161 EMR). Fungicide rates are shown in brackets where the rates differed between treatments

Timing/Growth stage	Treatment	
	Standard Practice (rate/ha)	Best Practice (rate/ha)
2005		

9 November	pre-leaf fall		Folicur (0.6l)
25 November	10% leaf fall	Cuprokylt FL (5l/ha)	Folicur (0.6l) + Occidor (1.1l)
14 December	50% leaf fall	Cuprokylt FL (5l/ha)	Folicur (0.6l) + Occidor (1.1l)
2006			
12 March	pre-bud burst		Cuprokylt FL (5l)
29 March	bud burst	Radspor	Radspor
7 April		Dithianon	Dithianon + Occidor (1.1l)
18 April	mouse ear/green cluster	Systhane + Captan (1.5kg)	Systhane + Captan (1.5kg) + Occidor (1.1l)
27 April	green cluster/pink bud	Systhane + Captan (1.5kg)	Systhane + Captan (1.5kg)
12 May	bloom	Systhane + Captan (1.5kg)	Systhane + Captan (1.5kg) +Delsene 50Flo (1.1l)
25 May	petal fall	Systhane + Captan (1kg)	Systhane + Captan (2kg) + Delsene 50Flo (1.1l)
6 June		Systhane + Captan (1kg)	Systhane + Captan (1.5kg) + Delsene 50Flo (1.1l)
16 June		Systhane + Captan (1kg)	Systhane + Captan (1kg)
28 June		Systhane + Captan (1kg)	Systhane + Captan (1.5kg) + Delsene 50Flo (1.1l)
6 July		Nimrod	Nimrod
20 July		Nimrod	Nimrod + Elvaron Multi (1.5kg)
4 August		Nimrod	Nimrod + Elvaron Multi (1.5kg)
16 August		Nimrod	Nimrod + Elvaron Multi (2.25kg)
17 October	pre-leaf fall		Folicur (0.6l)
17 November	10% leaf fall	Cuprokylt FL (5l)	Cuprokylt FL (5l)
29 November	50% leaf fall	Cuprokylt FL (5l)	Folicur (0.6l)
12 December	90% leaf fall		Cuprokylt FL (5l)

Table 3. **Fungicide treatments applied to Standard Practice and Canker Best Practice plots in 2007 at Site (1) (TL161 EMR). Fungicide rates are shown in brackets where the rates differed between treatments**

Timing/Growth stage	Treatment	
	Standard Practice (rate/ha)	Best Practice (rate/ha)
9 March pre-bud burst	Cuprokylt Fl (5l/ha)	Cuprokylt Fl (5l/ha)
23 March bud burst	Dithianon + Scala	Dithianon + Scala
2 April early mouse ear	Dithianon + Scala	Dithianon + Scala
13 April green cluster /pink bud	Systhane + Captan (1kg)	Systhane + Captan (2kg)
23 April full bloom	Systhane + Captan (1kg)	Systhane + Captan (2kg)
27 April late bloom		Bellis (0.8kg)
30 April petal fall	Systhane + Captan (1kg)	Systhane + Captan (3kg)
14 May	Systhane + Captan (1kg)	Systhane + Captan (3.4kg)
29 May	Systhane + Captan (1kg)	Systhane + Captan (3.4kg)
8 June	Systhane + Captan (1kg)	Systhane + Captan (3.4kg)
19 June	Systhane + Captan (1kg)	Systhane + Captan (3.4kg)
3 July	Nimrod + Captan (1kg)	Nimrod + Captan (3.4kg)
23 July	Rubigan	Rubigan + Captan (3.4kg)
3 August	Nimrod	Nimrod + Captan (3.4kg)
15 October pre-leaf fall		Folicur (0.6l)
5 November 10% leaf fall	Cuprokylt FL(5l/ha)	Cuprokylt FL (5l/ha)

Table 4. Fungicide treatments applied to Standard Practice and Canker Best Practice plots in 2005/6 at Site 2 (Marsh Gala, Elverton Farm). Fungicide rates are shown in brackets where the rates differed between treatments.

Timing / Growth stage		Treatment	
		Standard Practice (rate/ha)	**Best Practice (rate/ha)**
2005			
10 November	leaf fall	Cuprokylt FL (5l/ha)	Folicur (0.6l) + Occidor* (1.1l)
2006			
30 March	pre-bud burst	Cuprokylt FL (5l)	Cuprokylt FL (5l) + Occidor* (1.1l)
13 April	bud burst	Dithianon	Dithianon + Occidor (1.1l)
27 April	green cluster/pink bud	Systhane + Stroby + Dithianon	Systhane + Dithianon + Clean Crop Curve* (1.1l)
12 May	bloom	Systhane + Stroby	Systhane + Stroby +Delsene 50Flo* (1.1l)
25 May	petal fall	Systhane + Stroby	Systhane + Stroby
7 June		Systhane + Sroby	Systhane + Stroby
19 June		Systhane + Stroby	Systhane + Stroby
29 June		Nimrod + Captan	Nimrod + Captan
13 July		Nimrod + Captan	Nimrod + Captan
18 July	(apple thinning)		Delsene 50Flo* (1.1l)
27 July		Nimrod + Captan	Nimrod + Captan
1 August	(summer pruning)		Delsene 50Flo* (1.1l)
10 August		Nimrod + Captan	Nimrod + Captan
15 August		Elvaron Multi	Elvaron Multi
21 August		Elvaron Multi	Elvaron Multi
17 October	pre-leaf fall		Folicur (0.6l)

*Occidor, Clean Crop Curve and Delsene 50Flo are all products containing carbendazim

Table 5. **Mean number of cankers per tree recorded in February 2007 as A/B types (rootstock and main trunk) or C/D/E types (leaf scars, pruning wounds, shoot base) in plots receiving a Standard fungicide or Best Practice programme with and without removal of cankers in summer at Site (1) (TL161 Gala orchard, EMR)**

Main plot treatment	No cankers removed in summer	Cankers removed in summer	Overall mean
A/B cankers			
Standard programme	0.9	0.9	0.9
Best practice programme	1.6	1.4	1.5
Overall mean	1.24	1.18	
C/D/E cankers			
Standard programme	9.5	9.7	9.6
Best practice programme	3.6	5.7	4.7
Overall mean	6.6	7.7	

Table 6. **Mean number of C/D/E cankers per tree removed during summer pruning in 2007 in plots receiving a Standard fungicide or Best Practice programme at Site (1) (TL161 Gala orchard, EMR)**

Main plot treatment	Mean number of cankers per tree
Standard practice	2.7
Best Practice programme	0.6

Table 7. **Mean number of cankers per tree recorded in November 2006 in plots receiving a Standard fungicide or Best Practice programme with and without removal of cankers in summer at Site (2) (Marsh Gala, Elverton Farm, Teynham)**

Main plot treatment	No removal of cankers in summer	Removal of cankers in summer	Overall mean
Standard programme	0.28	0.78	0.53
Best Practice programme	0.46	0.28	0.37
Overall mean	0.37	0.53	

Table 8. **Monthly rainfall (mm) recorded at EMR in April to September in 2006 and 2007, compared to 50-year average**

Month	2006	2007	50 year average
April	70.8		44.5
May	77.0		45.8
June	8.4	74.6	49.7
July	11.0	119.2	46.4
August	40.8	40.8	52.0
September	42.0	25.4	63.7

Table 9. **Mean % losses due to rots following storage of fruit (at 3.5°C; 1.2%O_2, <1%CO_2) harvested in September 2006 from plots receiving a Standard fungicide or Best Practice programme with and without removal of cankers in summer at Site (1) (TL161 Gala orchard, EMR)**

Main plot treatment	No removal of cankers in summer		Removal of cankers in summer		Overall mean	
	Nectria	Total rot	Nectria	Total rot	Nectria	Total rot
Standard programme	1.5	1.9	1.5	1.9	1.5	1.9
Best Practice programme	0.2	0.7	0.4	0.8	0.3	0.7
Overall mean	0.7	1.2	0.9	1.3		

Table 10. **Mean annual shoot growth (cm) in 2006 on trees from plots receiving a Standard fungicide or Best Practice programme with and without removal of cankers in summer at Site (2) (Marsh Gala, Elverton Farm, Teynham)**

Main plot treatment	No removal of cankers in summer	Removal of cankers in summer	Overall mean
Standard programme	72.3	74.2	73.2
Best Practice programme	73.3	71.0	72.2
Overall mean	72.8	72.6	

Appendix

	Farm Practice (FP)	FP + Trial treatments
Winter removal of canker (WR)	B	C
WR + post blossom removal x 2	A	D