Project Title:	Apple: Evaluation of fungicides for the control of apple canker (*Nectria galligena*)
Project Number:	TF 144
Project Leader:	Dr A M Berrie
Annual Report:	Year 1, November 2003
Previous Reports:	None
Key Workers:	Principle scientist: Dr A M Berrie Research assistant: Mrs B E Ellerker Research assistant: Mrs K Lower
Location of Project:	HRI-East Malling West Malling Kent, ME19 6BJ Tel:01732 843833 Fax: 01732 849067
Project Co-ordinator:	
Date Project Commenced:	1 November 2002
Date Project Ends:	31 October 2004
Key Words:	Apple, canker, *Nectria galligena*, fungicide, Bavistin DF, Cuprokylt FL, Elvaron Multi, Folicur, Unix, Flamenco, Octave, Serenade, carbendazim, copper oxychloride, tolylfluanid, tebuconazole, cyprodonil, fluquinconazole, procloraz Mn, *Bacillus subtilis*, copper masquolate + copper oxychloride

CONTENTS

The results and conclusions in this report are based on an investigation conducted over one year. The conditions under which the experiment was carried out and the results obtained have been reported with detail and 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 interpretation of the results especially if they are used as the basis for commercial product recommendations.

Grower Summary

TF 144 Apple: Evaluation of fungicides for the control of apple canker (*Nectria galligena*)

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, 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 such as bud-scale scars, leaf scars, fruit scars or artificial such as pruning wounds. Thus inoculum and points of entry on the tree are available all year round and the only limiting factor is 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 due to canker the following spring and summer.

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. Both products are effective but have undesirable side effects on earthworms and there are also public concerns about their safety. Other products such the scab fungicides captan, dithianon and dodine are known to give some control of canker, but are not as effective as carbendazim.

Recent research funded by DEFRA has confirmed that *Nectria* spores can spread from orchard to orchard and initiate new canker outbreaks in young orchards. However, it also showed that the nursery could be a source of canker in new orchards, the significance of this source being dependent on the nursery supplying the trees and the weather conditions in the year in which the trees were raised. This research may eventually lead to new solutions for canker but there is a need in the short term to identify other fungicides that may be effective against canker.

The expected deliverables from this work include:

- An evaluation of the efficacy of new fungicides for control of *Nectria* canker.
- Whether these treatments are likely to provide a viable alternative to existing fungicides for control of *Nectria* and therefore worth pursuing with PSD for registration or Off label Approval.
- If any of the products tested are a viable alternative to existing products then it may lead to a more successful control of *Nectria* canker, particularly in the autumn. This may lead to reduced fungicide inputs in the growing season, particularly during the post blossom period, when in canker risk orchards, fungicides are applied to protect fruit from *Nectria* infection.

Summary of project and main conclusions

In a replicated small plot orchard experiment, in a cankered orchard of Gala apples, the efficacy of seven fungicides in controlling canker was compared (Table 1). Cuprokylt FL and Bavistin DF and an untreated control were included as standards. Treatments were applied post harvest in the autumn on three occasions, at 10%, 50% and 90% leaf fall. The number of new cankers on the trees was recorded the following autumn. Despite favourable wet weather for the spread and infection of *Nectria* canker in autumn 2002 the incidence of new cankers on extension growth in 2003 was too low and sporadic in the trial plots for meaningful conclusions on efficacy to be drawn. The hot dry weather in 2003 may have influenced canker development. The plots will be reassessed in 2004 and the treatments repeated on new plots in autumn 2003.

Table 1: Fungicide treatments for evaluation for canker control

Fungicide product	Active Ingredient	Product rate/ha	Mean no. new cankers on extension growth per plot Oct 2003
1 Untreated	-	-	3.25
2 Bavistin DF	carbendazim	1.1kg	0
3 Cuprokylt FL	copper oxychloride	5L/1000L water	0.75
4 Elvaron Multi	tolylfluanid	2.25kg	1.75
5 Folicur	tebuconazole	1.0L	0
6 Unix	cyprodonil	0.5kg	4.0
7 Flamenco	fluquinconazole	1.25L	0.75
8 Octave	prochloraz Mn	1kg	0
9 Serenade	*Bacillus subtilis*	8.8kg	3.0
10 Leaf Fall + Cuprokylt FL	copper masquolate + copper oxychloride	10L/1000Lwater + 5L/1000Lwater	2.25

Financial benefits of the project

- Canker reduces tree vigour, increases pruning costs and, as the fruit rot, results in significant losses in long-term stored fruit. The disease also increases costs for the establishment of new orchards due to the need to replace trees killed by canker.
- If any of the products tested are a viable alternative to existing products then it may lead to a more successful control of *Nectria* canker, particularly in the autumn. This may lead to reduced fungicide inputs in the growing season, particularly during the post blossom period, when in canker risk orchards, fungicides are applied to protect fruit from *Nectria* infection. Use at this time may lead to undesirable residues in the fruit.
- Depending on which fungicides are effective, they may be available for use immediately or further work may be needed to gain an Off label Approval.

Action points for growers

No action points at present as the project is at an early stage.

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 (McCracken et al 2003). *Nectria* also causes a fruit rot that can result in significant losses as high as 10% or more in stored fruit (Berrie, 1989). *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 such as bud-scale scars, leaf scars, fruit scars or artificial such as pruning wounds. Thus inoculum and points of entry on the tree are available all year round and the only limiting factor is 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 die-back due to canker the following spring and summer.

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. Both products are effective but have undesirable side effects on earthworms and there are also public concerns about their safety. Other products such as the scab fungicides captan, dithianon and dodine are known to give some control of canker, but are not as effective as carbendazim.

Recent research funded by DEFRA has confirmed that *Nectria* spores can spread from orchard to orchard and initiate new canker outbreaks in young orchards (McCracken *et al*, 2003). However, it also showed that the nursery could be a source of canker in new orchards, the significance of this source being dependent on the nursery supplying the trees and the weather conditions in the year in which the trees were raised. This research may eventually lead to new solutions for canker but there is a need in the short term to identify other fungicides that may be effective against canker.

Objective

To evaluate new fungicides for control of *Nectria* canker.

Materials and Methods

Test fungicides were evaluated in a small plot field trial done to GEP standards.

Orchard site

The trial orchard (TL 161) was located at Rocks Farm, East Malling and was a solid planting of cv Gala on M9 rootstock, planted in March 1998. Tree rows were 3.9m apart with 2.0m separating trees within the rows. The orchard had a high incidence of *Nectria* canker on the trees and was separated by an alder windbreak from a Cox, Spartan and Discovery orchard, also with a high incidence of *Nectria* canker.

Plots

Each plot consisted of 4 trees. Each plot was separated from adjacent plots within the row by two trees and from plots in adjacent rows by a single tree guard row. Each treatment was replicated 4 times in a randomised block design. The trial blocks were located in the centre of the orchard to give maximum benefit of any canker spread from the adjacent infected orchard (TL109).

Treatments

The treatments applied are shown in Table 2. Cuprokylt FL and Bavistin were included as standards. All treatments except treatment 10 (Leaf Fall + Cuprokylt) were applied to the plots on three occasions, at 10% (5 November), 50% (13 November) and 90% (28 November) leaf fall. Treatment 10 was applied once, at 10% leaf fall.

Fungicide application

All treatments were applied at 500 l/ha using a self-propelled small plot orchard sprayer (Solo).

Assessments

The numbers of existing cankers on each tree in the plot were recorded at the start of the trial and marked with yellow paint so that new cankers developing following treatment could be easily identified. The number of existing cankers will be taken into account in the statistical analysis. The plots were regularly inspected for the appearance of new cankers throughout the summer. Numbers of new cankers on the trunk, scaffold branches and extension growth were separately recorded for each tree in the plot in October.

Table 2: Fungicide treatments for evaluation for canker control

Fungicide product	Active Ingredient	Rate/ha
1 Untreated	-	-
2 Bavistin DF	carbendazim	1.1kg
3 Cuprokylt FL	copper oxychloride	5L/1000L water
4 Elvaron Multi	tolylfluanid	2.25kg
5 Folicur	tebuconazole	1.0L
6 Unix	cyprodonil	0.5kg
7 Flamenco	fluquinconazole	1.25L
8 Octave	prochloraz Mn	1kg
9 Serenade	*Bacillus subtilis*	8.8kg
10 Leaf Fall + Cuprokylt FL	copper masquolate + copper oxychloride	10L/1000Lwater + 5L/1000Lwater

Results and Discussion

Weather

The rainfall for the period of the experiment is shown in Table 3. 2002 was in general a wet season and favourable for *Nectria* canker. Observations in the trial orchard TL161 and in the adjacent orchard TL 109 indicated that *Nectria* cankers on the trees were actively sporulating in October and November 2002 with both cream coloured conidial pustules and the red fruiting bodies (perithecia) present on many of the existing cankers on the trees. Therefore there was an adequate supply of inoculum of *Nectria galligena* present in the trial area. Leaf fall in the Gala orchard started at the end of October 2002 and continued until early December. This leaf fall period coincided with heavy and frequent rainfall (Table 3). The weather conditions were therefore very favourable throughout leaf fall for the spread of *Nectria* spores and for subsequent infection through leaf scars. Weather conditions the following spring and summer in 2003, apart from May, were exceptionally hot and dry (Table 3).

Nectria canker

The number of new cankers (ie those not marked with yellow paint) on each tree in the plot were recorded on 27 October. Cankers on extension growth were recorded separately from those on the trunk and main scaffold branches. Cankers on the extension growth are those most likely to have arisen from *Nectria* spores infecting the tree at the time of leaf fall and therefore to have been influenced by the treatments applied. The new cankers appearing on the trunk and scaffold branches are more likely to have arisen from infection already present in the tree (McCracken *et al*, 2003). The incidence of new cankers in the plots was low (Table 4), with no cankers recorded in some plots, including the untreated. For this reason the total number of cankers for each plot and replicate is given in Table 4. The numbers of existing cankers (with yellow paint) for each plot are also included in Table 4. In general the

highest numbers of new cankers occured in plots with high numbers of existing cankers. However, for plots treated with Bavistin or Octave, no new cankers were recorded on the extension growth even in plots where the numbers of existing cankers were high. Similarly no new cankers on extension growth were recorded in plots treated with Folicur.

The incidence of new cankers is too low and sporadic across the trial for any meaningful conclusions to be drawn on the efficacy of the products tested but the trial does give some indication that Folicur and Octave may be effective.

It is surprising that the incidence of new cankers on extension growth is low since the weather conditions at leaf fall were very favourable for canker spread and infection. It is possible that the hot dry weather conditions during the spring and summer have influenced canker development. It is known that canker expression can occur on trees some time after infection has occurred (McCracken et al, 2003). Factors affecting canker expression are not really understood but high temperatures and lack of moisture could be factors. More cankers may appear next spring and it is planned to reassess the plots next year.

Table 3 Rainfall recorded at East Malling from October 2002 – September 2003

Month 2002/2003	Total rain mm	% 50 year mean	No. rain days
October	57.8	88.2	18
November	138.6	200.9	26
December	129.6	195.2	25
January	67.4	107.5	22
February	31.4	73.9	14
March	20.2	45.6	14
April	29.0	65.2	9
May	59.6	130.1	20
June	35.8	72.0	10
July	34.6	74.6	14
August	18.6	35.2	4
September	24.2	38.0	15

Table 4 Total numbers of cankers recorded per plot before and after treatment

Treatment	Block 1			Block 2			Block 3			Block 4			Mean		
	Total existing cankers a	New cankers extension growth b	Total new cankers c	Total existing cankers a	New cankers extension growth b	Total new cankers c	Total existing cankers a	New cankers extension growth b	Total new cankers c	Total existing cankers a	New cankers extension growth b	Total new cankers c	Total existing cankers a	New cankers extension growth b	Total new cankers c
Untreated	3	3	3	4	0	2	3	2	2	3	8	10	3.25	3.25	4.25
Bavistin DF	19	0	5	5	0	1	1	0	0	5	0	2	7.5	0	2.0
Cuprokylt FL	7	1	2	13	1	1	2	0	2	2	1	2	6.0	0.75	1.75
Elvaron Multi	15	2	3	10	4	4	9	0	1	3	1	4	9.25	1.75	3.0
Folicur	2	0	4	9	0	1	6	0	2	4	0	1	5.25	0	2.0
Unix	4	1	1	29	13	18	2	1	2	12	1	2	11.75	4.0	5.75
Flamenco	9	0	2	9	0	3	6	1	2	4	2	4	7.0	0.75	2.75
Octave	7	0	3	20	0	2	5	0	1	1	0	0	8.25	0	1.5
Serenade	5	5	6	12	1	3	8	1	1	3	5	7	7.0	3.0	4.25
Leaf Fall + CuprokyltFL	11	0	3	26	6	10	4	2	2	7	1	2	12.0	2.25	4.25

Notes

a = Total number of cankers existing on the trees in each plot prior to treatment

b = Total number of new cankers on extension growth on the trees in the plot assessed in autumn 2003

c= Total number of cankers on the trees in the plot including cankers on extension growth, on scaffold branches and on the trunk.

Conclusions and Future work

- The incidence of new cankers in the trial was too low and sporadic for meaningful conclusions to be drawn on the efficacy of the products.
- The hot dry weather in spring and summer of 2003 may have influenced the canker development. The assessments of new cankers will therefore be repeated next spring.
- Since the effects of the treatments applied on canker control were inconclusive the trial will be repeated in autumn 2003, using new plots.

Technology transfer

The work is at an early stage. The results have been discussed with individual growers, but no formal presentations have yet been made.

References

Berrie, A M 1989. Storage rots of apple and pear in South-East England 1980-88: incidence and fungicide resistance. IOBC/WPRS Bulletin 1989/xii/6, 229-239

McCracken, A R, Berrie, A, Barbara D J, Locke T, Cooke L R, Phelps K, Swinburne, T R, Brown A R, Ellerker D & Langrell R H 2003. Relative significance of nursery infections and orchard inoculum in the development and spread of apple canker (*Nectria galligena*) in young orchards. Plant Pathology 52, 553-566.