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|---|---|
| **Project title** | Apple: The effect of triazole timing, quantity and product on the occurrence of Diffuse Browning Disorder (DBD) in Cox. |
| **Project number:** | TF 166h |
| **Project leader:** | Tim Biddlecombe, FAST Ltd. |
| **Report:** | Final report, August 2008. |
| **Previous report** | None |
| **Key staff:** | Tim Biddlecombe<br>Gary Saunders |
| **Location of project:** | A commercial fruit farm near Sittingbourne, Kent. |
| **Project coordinator:** | TBC |
| **Date project commenced:** | 1st May 2007 |
| **Date project completed (or expected completion date):** | 31st July 2008 |
| **Key words:** | Diffuse Browning Disorder, DBD, Boggy Bank, Gorgate Syndrome, Cox, triazole, paclobutrazol, Cultar, myclobutanil, Systhane, penconazole, Topenco, Topas |



 

The results and conclusions in this report are based on an investigation 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 interpretation of the results, especially if they are used as the basis for commercial product recommendations.

 

**AUTHENTICATION**

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

[Name]
[Position]
[Organisation]

Signature ............................................................ Date ............................................

[Name]
[Position]
[Organisation]

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**Report authorised by:**

[Name]
[Position]
[Organisation]

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[Name]
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**CONTENTS**



 

# Grower Summary

## Headline

- A link has been shown between the use of triazole fungicides and the occurrence of diffuse browning disorder (DBD).
- Increasing the number of applications of triazole fungicides caused an increase in the occurrence of DBD.
- Applications of triazole fungicides at the end of the season had a greater influence on the occurrence of DBD than applications at the beginning of the season.
- Of the triazole fungicides assessed penconazole (‘Topenco’) promoted a greater occurrence of DBD than myclobutanil (‘Systhane’).

## Background and expected deliverables

The occurrence of diffuse browning disorder (DBD, Boggy Bank or Gorgate Syndrome) in stored Cox apples has become of increasing concern to the industry. Growers who have orchards that are at risk are restricted to storing fruit short term to avoid the potential development of DBD. This reduces the potential income from the crop due to the necessity to market the fruit at a time where there is a traditional over supply of desert apples, resulting in a low market price and in some years a significant financial loss.

The recent HDC projects TF 139 and TF 166a-f have failed to pinpoint the precise cause of DBD; however they have shown a potential link between the use of triazole chemicals and the occurrence of DBD. This project built on the previous work and determined the link between paclobutrazol (‘Cultar’), myclobutanil (‘Systhane’) and penconazole (‘Topenco’) with the occurrence of DBD. Understanding this link will enable growers to produce fruit of consistent high quality, free from symptoms of DBD by manipulation of spray programs.

This project determined the particular link between the occurrence of DBD and:

- use of each of the specific chemicals paclobutrazol, myclobutanil and penconazole and combinations of the three
- number of treatments
- timing of treatment application - beginning or end of season

**Summary of the project and main conclusions**

The project was conducted in a well managed 4 row bed orchard on a farm known to be susceptible to the occurrence DBD. The trial was conducted as two separate experiments:

1. To determine the effect of single and combined product applications on the occurrence of DBD.
2. To determine the effect of the timing of spray application and number of spray applications on the occurrence of DBD.

Trial 1 consisted of eleven spray applications to 2 blocks of 5 trees carried out at approximately weekly intervals for the following products:

- ‘Cultar’
- ‘Cultar’ + ‘Systhane’
- ‘Cultar’ + ‘Systhane’ + ‘Topenco’
- ‘Cultar’ + ‘Topenco’
- ‘Systhane’
- ‘Systhane’ + ‘Topenco’
- ‘Topenco’
- Control (none of the above)

Rates applied were such that the maximum label recommendation was applied when the dose for each of the eleven applications was added together. Application was via a knapsack sprayer to the point of run-off.

Trial 2 was conducted with sprays of ‘Cultar’ + ‘Systhane’ + ‘Topenco’ at the same rate per application as for Trial 1; however application was via a motor-blower with a water volume of 200l $ha^{-1}$ to mimic a conventional orchard sprayer. This part of the trial was divided into two parts:

a. Two adjacent rows were divided into 12 equal blocks. Spray applications were made approximately weekly for 11 weeks. In week 1 spraying stopped at the beginning of blocks 1, in week 2 spraying stopped at the beginning of blocks 2 and so on. This produced blocks with incremental amounts of spray, with the greatest quantity of spray at the end of the growing season.

→ Direction of travel

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 11 | 10 | 9 | 8 | 6 | 6 | 5 | 4 | 3 | 2 | 1 |

b. Two adjacent rows were each divided into 12 equal sections. Spray applications were made weekly for 11 weeks. In week 1 spraying stopped at the beginning of blocks 1, in week 2 spraying stopped at the beginning of blocks 2 and so on. This produced blocks with incremental amounts of spray, with the greatest quantity of spray at the beginning of the growing season.

→ Direction of travel

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

At harvest 100 apples from each of the 48 blocks were picked and stored for DBD assessment in February 2008 for the presence of DBD (Figure 1).

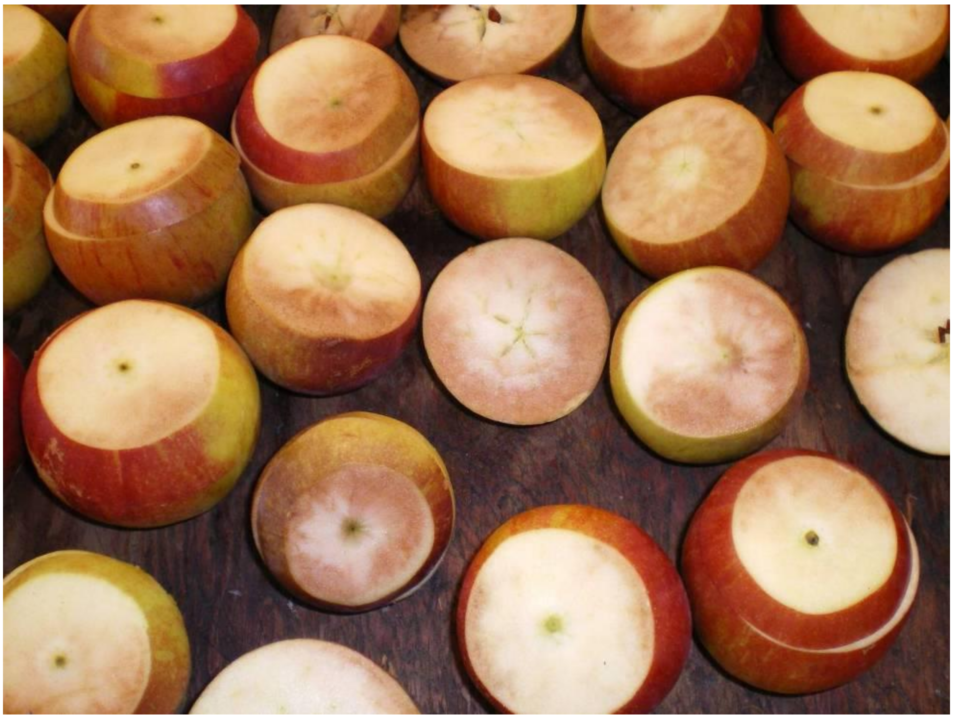

Figure 1: Symptoms of DBD in the assessed samples.

Results for Trial 1 showed that 'Cultar' and the two triazole fungicides assessed produced differing levels of DBD when applied at the respective maximum recommended rates (Figure 2).

 

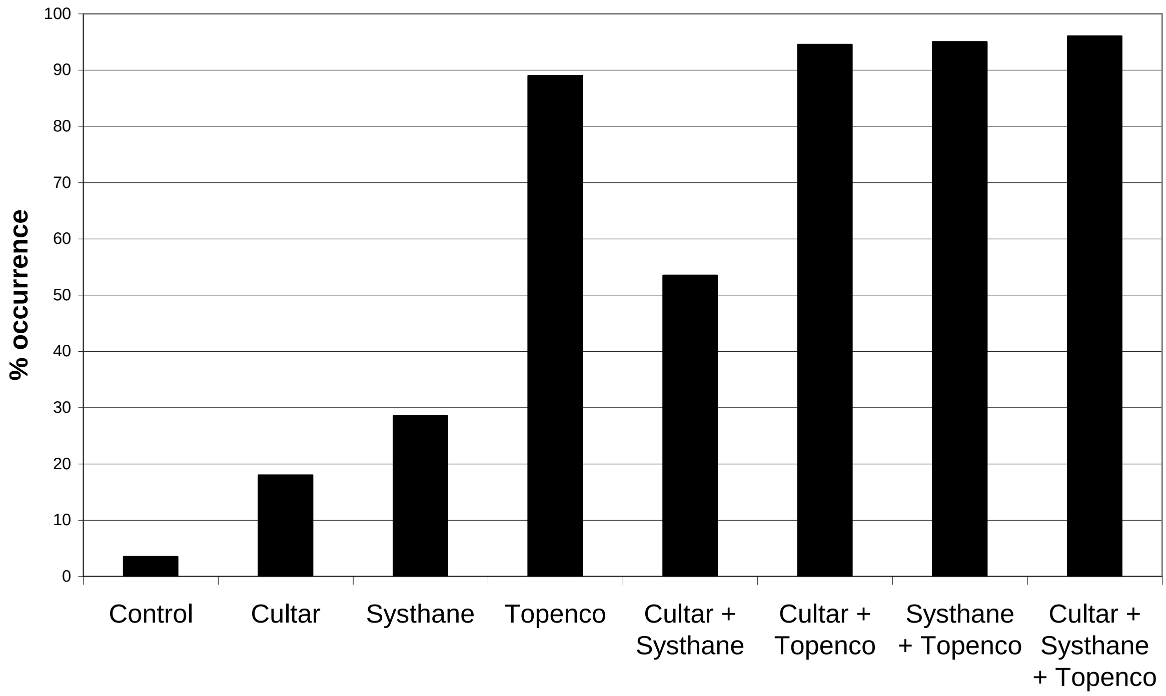


Figure 2: Percentage occurrence of DBD in relation to chemical application.

In this experiment there was a relatively low level of DBD found in the control plots (3.5%). The application of 'Cultar' increased the incidence of DBD to 18%, 'Systhane' to 28.5% and 'Cultar' + 'Systhane' to 53.5%. The greatest increase in incidence of DBD due to a single chemical was for 'Topenco' where incidence increased to 89% and where 'Topenco' was added to the other assessed chemicals the incidence of DBD ranged from 94.5% to 96%.

Combining the results for both parts of Trial 2 showed that increasing the number of applications resulted in an increased occurrence of DBD (Figure 3).

However when assessed separately it was shown that applications made later in the season had a greater effect on the levels of DBD than applications applied early in the season. Specifically, applications made after the end of May caused greater levels of DBD.

 

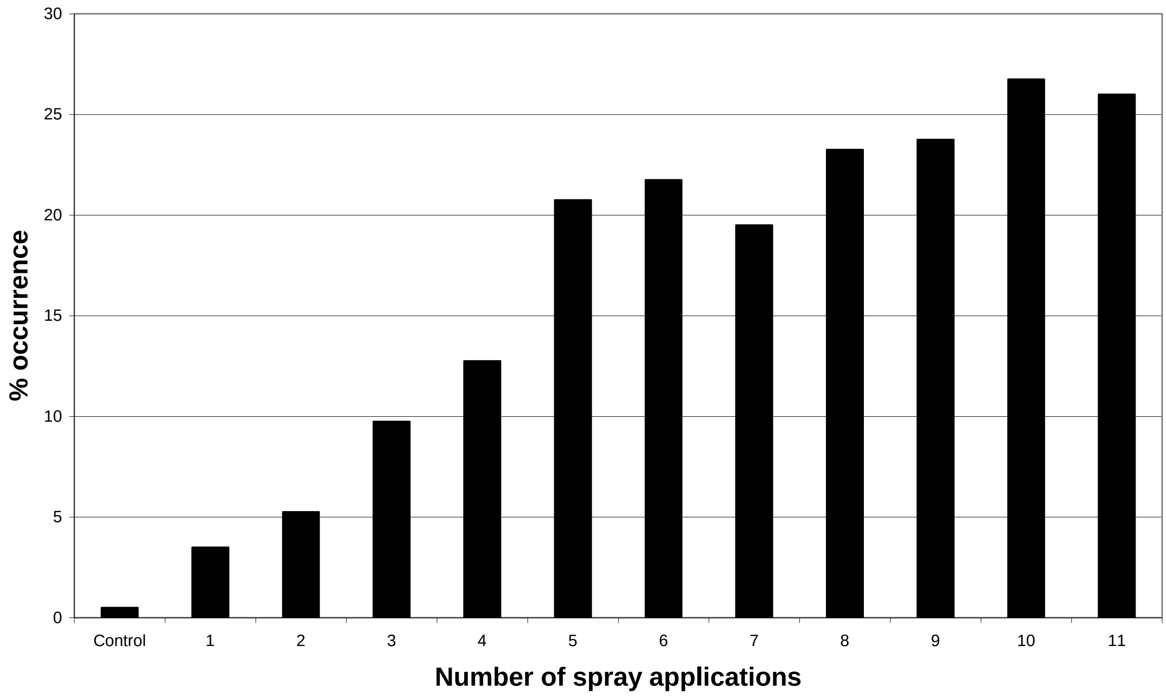


Figure 3: DBD occurrence in relation to the number of spray applications.

The results from this project show that the use of triazole fungicides can precipitate the occurrence of DBD in Cox. The use of penconazole was shown to produce a greater proportion of DBD within the sample than myclobutanil when applied at maximum label recommendations and that applications after the beginning of June also resulted in a greater incidence of DBD.

**Financial benefits**

Growers who have orchards that are at risk are restricted to storing fruit short term to avoid the potential development of DBD. This will reduce the potential income from the crop due to the necessity to market the fruit at a time where there is a traditional over supply of desert apples, resulting in a low market price and in some years a significant financial loss. The findings and recommendations of this study will enable growers to minimise the risk of the development of the disorder and thus maximise the potential value of their Cox crop.

**Action points for growers**

- Discuss you record of DBD occurrence and spray program with your advisor
- If you orchards are at risk, minimise the use of triazoles
- If triazoles are used in an orchard with a history of DBD then consider short term storage

 

## Science Section

### Introduction

Diffuse browning disorder (DBD, formerly variously named Boggy Bank or Gorgate Syndrome) is a physiological disorder that develops progressively in Cox apples during storage and has caused significant losses of stored Cox apples in recent years, particularly in 2000-01 and 2004-05.

The occurrence of DBD in stored Cox apples has become of increasing concern to the industry. Growers who have orchards that are at risk are restricted to storing fruit short term to avoid the potential development of DBD. This will reduce the potential income from the crop due to the necessity to market the fruit at a time where there is a traditional over supply of desert apples, resulting in a low market price and in some years a significant financial loss.

The potential benefits from this project are threefold. Firstly, greater economic returns are more likely from sales of Cox that has been stored long-term than from fruit that that has to be marketed at a time when dessert apple availability is high. Secondly, there will be a greater confidence in storing Cox from orchards where DBD has not yet been observed. A further significant benefit would be a restoring of confidence through the marketing chain in stored Cox.

The recent HDC projects TF 139 and TF 166a-f have shown a potential link between the use of triazole chemicals and the occurrence of DBD in Cox. This project provides an opportunity to determine the link between paclobutrazol ('Cultar'), myclobutanil ('Systhane') and penconazole ('Topenco') use and the occurrence of DBD in Cox. Understanding this link will potentially enable growers to produce fruit of consistent high quality, free from symptoms of DBD by manipulation of spray programs.

This project was set up to determine the particular link between the occurrence of DBD and:

- use of each of the specific chemicals paclobutrazol, myclobutanil and penconazole and combinations of the three
- timing of treatment application, beginning or end of season
- number of treatments

### Materials and methods

This project was conducted on one site with a known susceptibility to the occurrence of DBD, orchard A26 at Monks Farm, Norton, Kent by kind permission of Simon Bray. The Cox (M9) orchard is planted as a well managed four row bed, is of moderate vigour and is situated on a silty clay loam soil type.

The trial was conducted as two separate experiments overlaid on the grower's spray program (Appendix I):

1. To determine the effect of single and combined product applications on the occurrence of DBD.
2. To determine the effect of the timing of spray application and number of spray applications on the occurrence of DBD.

Trial 1 consisted of eleven spray applications to 2 blocks of 5 trees for the following products:

- 'Cultar'
- 'Cultar' + 'Systhane'
- 'Cultar' + 'Systhane' + 'Topenco'
- 'Cultar' + 'Topenco'
- 'Systhane'
- 'Systhane' + 'Topenco'
- 'Topenco'
- Control (none of the treatment applications)

Although applications were planned to be made on a weekly basis, weather constraints altered this and applications were made on the dates in Table 1.

Table 1: Spray application dates.

| Application | Date |
|---|---|
| 1 | 15/05/2007 |
| 2 | 25/05/2007 |
| 3 | 30/05/2007 |
| 4 | 13/06/2007 |
| 5 | 18/06/2007 |
| 6 | 21/06/2007 |
| 7 | 10/07/2007 |
| 8 | 11/07/2007 |
| 9 | 20/07/2007 |
| 10 | 27/07/2007 |
| 11 | 09/08/2007 |

Rates applied were such that the maximum label recommendation was applied when the dose for each of the eleven applications was added together. Application was via a knapsack sprayer to the point of run-off.

20 fruit were picked and put into net bags on the 3rd September from each of the trees within a treated block giving a total of 200 fruit per treatment.

Trial 2 was conducted with sprays of ‘Cultar’ + ‘Systhane’ + ‘Topenco’ at the same rate per application as for Trial 1; however application was via a motor-blower with a water volume of 200l $ha^{-1}$ to mimic a conventional orchard sprayer.  This part of the trial was divided into two parts:

a. Two adjacent rows were divided into 12 equal blocks. Spray applications were made approximately weekly for 11 weeks. In week 1 spraying stopped at the beginning of blocks 1, in week 2 spraying stopped at the beginning of blocks 2 and so on. This produced blocks with incremental amounts of spray, with the greatest quantity of spray at the end of the growing season.

→ Direction of travel

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 11 | 10 | 9 | 8 | 6 | 6 | 5 | 4 | 3 | 2 | 1 |

b. Two adjacent rows were each divided into 12 equal sections. Spray applications were made weekly for 11 weeks. In week 1 spraying stopped at the beginning of blocks 1, in week 2 spraying stopped at the beginning of blocks 2 and so on. This produced blocks with incremental amounts of spray, with the greatest quantity of spray at the beginning of the growing season.

→ Direction of travel

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

100 apples from each of the 48 blocks were picked on the 4th September into net bags giving a total of 4,800 fruit.

After picking all fruit was transported to East Malling for storage under standard Cox conditions. Fruit was stored until 11h February 2008 when the fruit was taken from the store and left for DBD symptoms to develop before conducting post storage assessments. Fruit was assessed on 20th February 2008 for the presence of DBD (Figure 1).

Figure 1: Symptoms of DBD in the assessed samples.

**Results**

Results for Trial 1 showed that 'Cultar' and the two triazole fungicides assessed produced differing levels of DBD when applied at the respective maximum recommended rates (Figure 2).

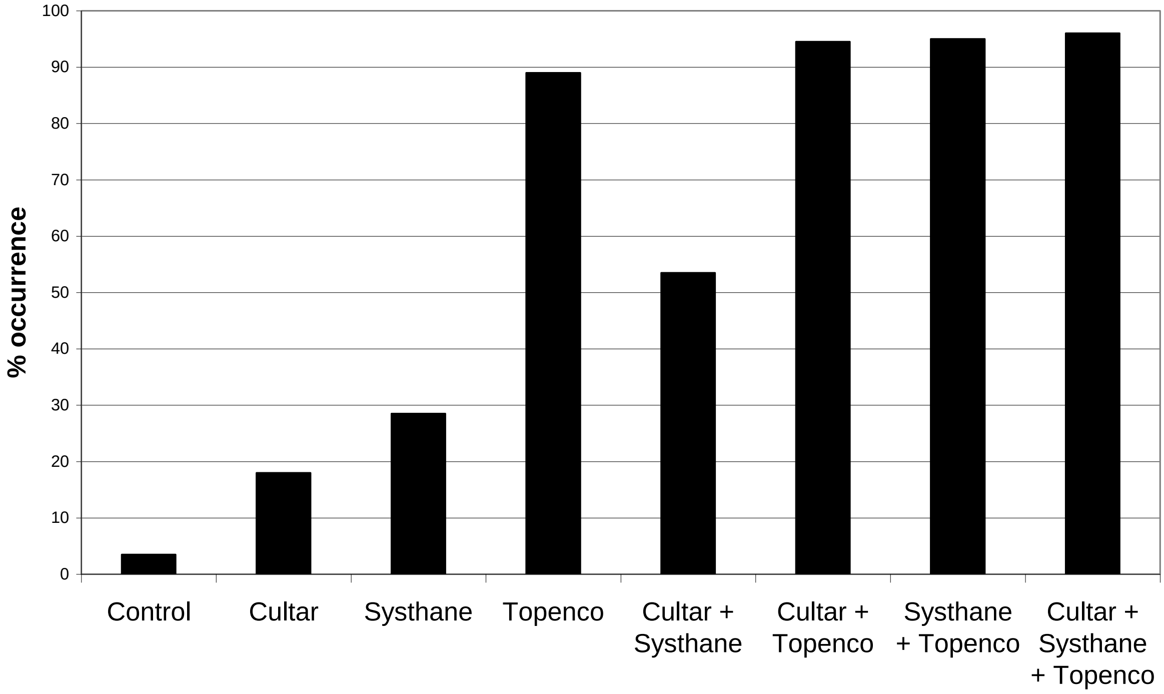


Figure 2: Percentage occurrence of DBD in relation to chemical application.

In this experiment there was a relatively low level of DBD found in the control plots (3.5%). The application of ‘Cultar’ increased the incidence of DBD to 18%, Systhane to 28.5% and ‘Cultar’ + ‘Systhane’ to 53.5%. The greatest increase in incidence of DBD due to a single chemical was for ‘Topenco’ where incidence increased to 89% and where ‘Topenco’ was added to the other assessed chemicals the incidence of DBD ranged from 94.5% to 96%.

Results for Trial 2 when assessed separately showed that the timing of spray application had an effect on the occurrence of DBD (Figures 3 & 4). The later applications were shown to cause a greater percentage of DBD in the sample than early applications. Specifically, applications made after the end of May caused greater levels of DBD.

 

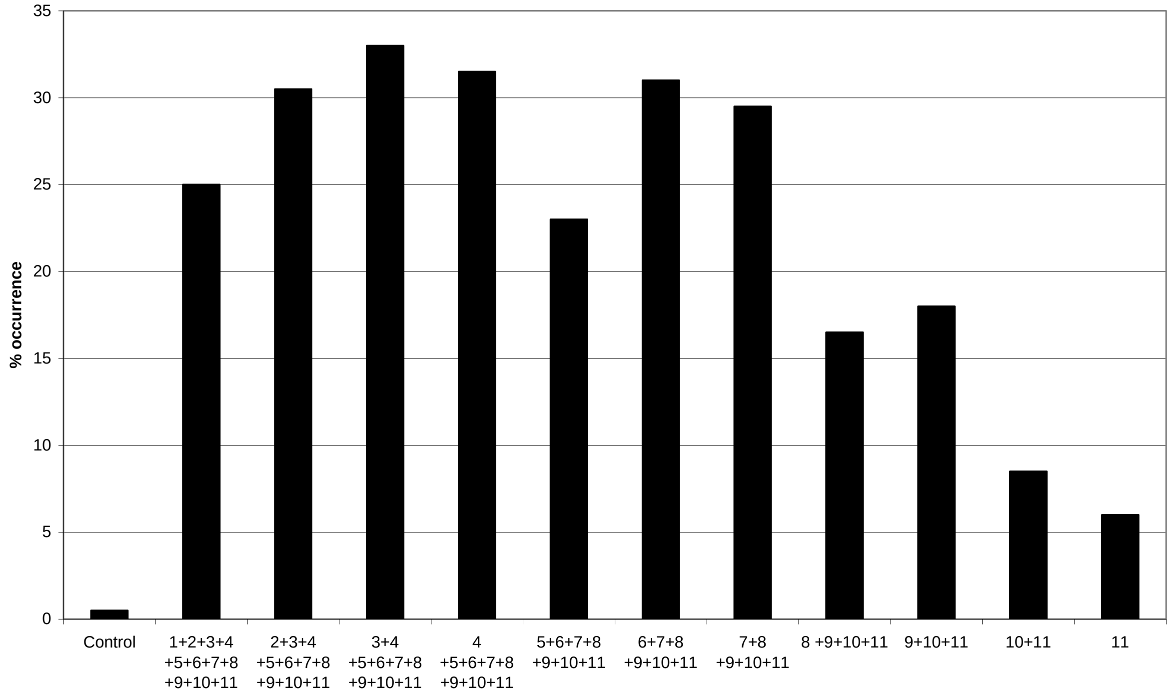


Figure 3: Incidence of DBD in relation to application timing – late season emphasis (numbers on x axis refer to spray application date: Table 1).

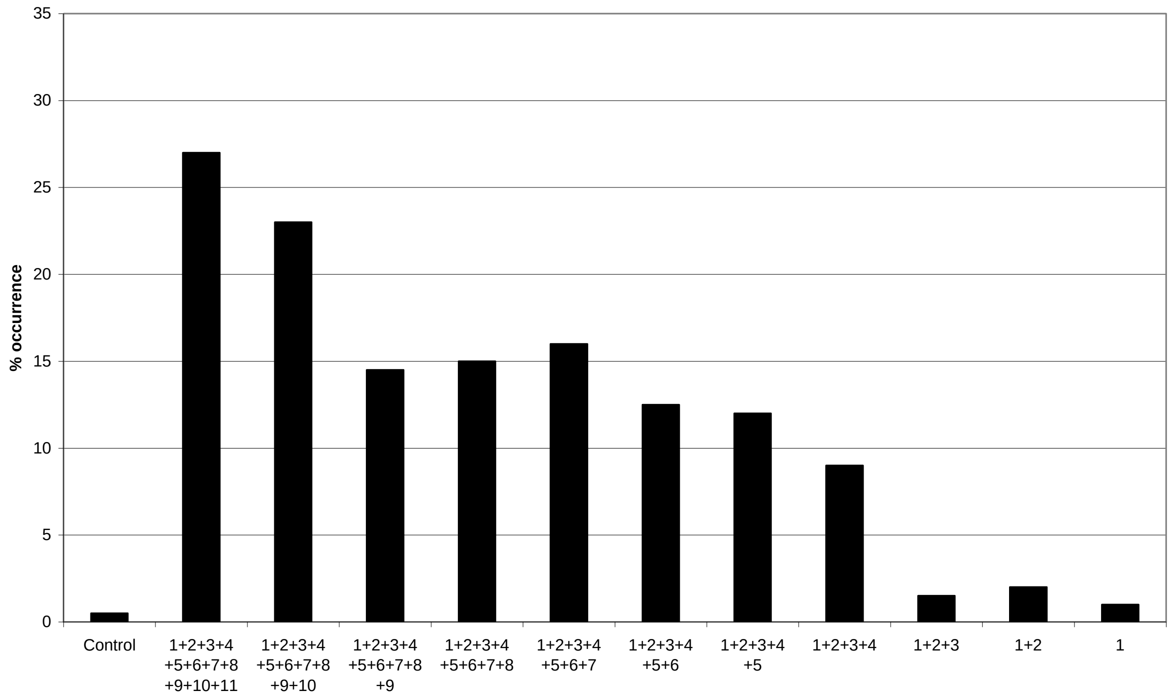


Figure 4: Incidence of DBD in relation to application timing – early season emphasis (numbers on x axis refer to spray application date: Table 1).

Combining the results for both parts of Trial 2 showed that increasing the number of applications resulted in an increased occurrence of DBD (Figure 5).

 

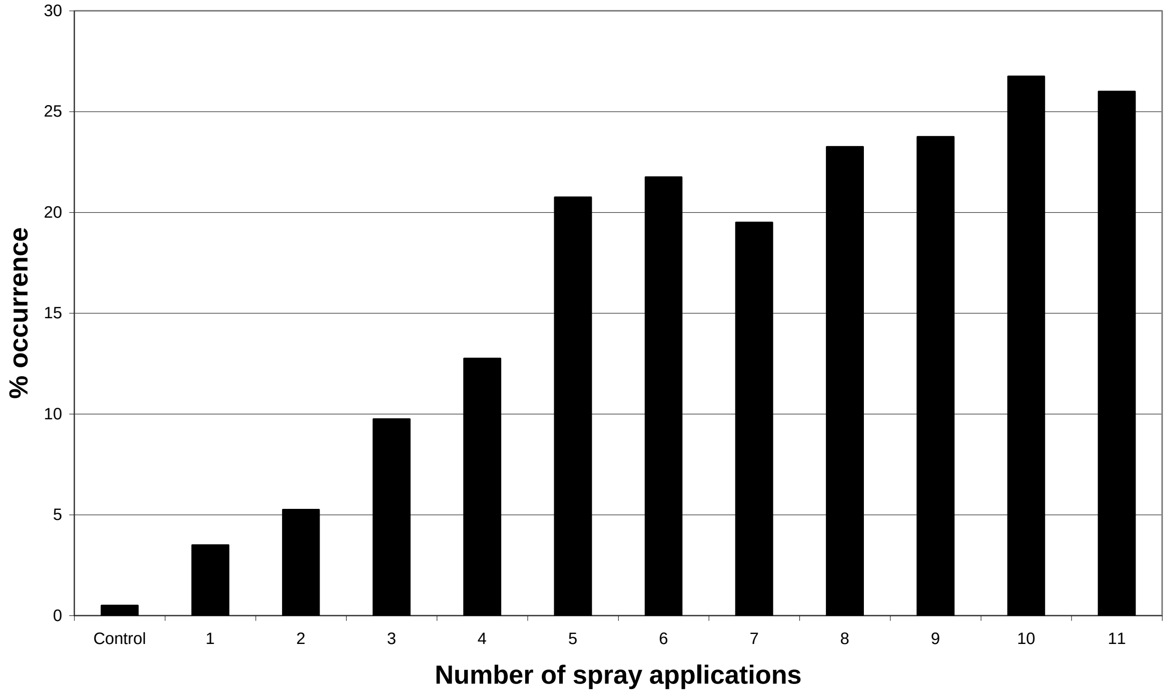


Figure 5: DBD occurrence in relation to the number of spray applications.

## Discussion

The results from this project show that the use of triazole fungicides can precipitate the occurrence of DBD in Cox. The use of penconazole was shown to produce a greater proportion of DBD (89%) within the sample than myclobutanil (28.5%) or paclobutrazol (18%) when applied individually at maximum label recommendations. Combinations of myclobutanil and paclobutrazol at these rates resulted in a 53.5% incidence of DBD but penconazole in any combination with paclobutrazol or myclobutanil resulted in the level of DBD to be between 94.5% and 96%. This clearly shows that not all triazole chemicals pose the same risk in relation to the occurrence DBD.

What was clear from the second part of the trial was that increased doses of applied chemicals caused an increased occurrence of DBD within the sample. However by assessing beginning and ends of the season separately it was apparent that sprays applied towards the end of the season had a greater effect on the occurrence of DBD than sprays applied at the beginning of the season. Specifically sprays applied before the beginning of June had little effect on the occurrence of DBD.

 

This site has a history of DBD occurrence and must therefore be regarded as a susceptible site (not all sites appear to have the same degree of susceptibility). Results from this trial must therefore be used in context with the assessed risk of DBD occurrence for a particular orchard, including the length of time the fruit will remain in store, when deciding whether or not to apply these chemicals for specific orchards.

**Conclusions**

From the results of this project we can conclude that for this site:

- The use of triazole products increases the incidence of DBD
- Fruit from trees treated with paclobutrazol produced nearly 20% DBD by late February compared with less than 5% for the non-triazole treated control fruit
- Fruit from trees treated with myclobutanil produced nearly 30% DBD damaged fruit by late February
- Fruit from trees treated with penconazole produced nearly 90% DBD damaged fruit by late February
- The more applications the greater the incidence of DBD
- Later applications encourage greater incidence of DBD
- If orchards are at risk from DBD growers should minimise the use of triazoles in them
- Growers should limit the number of triazole applications made after the end of May
- If triazoles are used in a high risk orchard growers should consider shorter term storage

**Technology transfer**

HDC Broadcast e-mail in summer 2008.
Potential articles in HDC News and trade magazines.
Potential presentations at grower meetings.

## Appendix I: Grower's Spray Programme

| Application Date | Active Ingredient |
|---|---|
| 27/03/2007 | Dithianon |
| 05/04/2007 | Dithianon |
| 14/04/2007 | Dithianon |
| 14/04/2007 | Flonicamid |
| 15/04/2007 | Fenoxycarb |
| 15/04/2007 | Chlorpyrifos |
| 15/04/2007 | Bupirimate |
| 25/04/2007 | Captan |
| 25/04/2007 | Bupirimate |
| 05/05/2007 | Dithianon |
| 05/05/2007 | Bupirimate |
| 10/05/2007 | Chlorpyrifos |
| 16/05/2007 | Dithianon |
| 16/05/2007 | Pyrimethanil |
| 16/05/2007 | Bupirimate |
| 18/05/2007 | Chlorpyrifos |
| 29/05/2007 | Dithianon |
| 29/05/2007 | Bupirimate |
| 31/05/2007 | Thiacloprid |
| 02/06/2007 | 2,4-D dimethylamine |
| 08/06/2007 | Captan |
| 08/06/2007 | Bupirimate |
| 17/06/2007 | Bupirimate |
| 17/06/2007 | Methoxyfenozide |
| 27/06/2007 | Bupirimate |
| 27/06/2007 | Captan |
| 08/07/2007 | Bupirimate |
| 18/07/2007 | Bupirimate |
| 18/07/2007 | Methoxyfenozide |
| 28/07/2007 | Bupirimate |
| 06/08/2007 | Indoxacarb |
| 11/08/2007 | Bupirimate |
| 22/08/2007 | Boscalid & Pyraclostrobin |