Project title:	Apple: Investigation into fruit position in relation to tree structure and the occurrence of diffuse browning disorder (DBD) in Cox.
Project number:	TF 166c
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Report:	Final report, June 2006
Previous reports:	None
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Location of project:	H.W. Twyman, Lee Priory Farm, Littlebourne, Canterbury, Kent
Grower co-ordinator:	To be advised
Date project commenced:	1 July 2005
Date completion due:	30 June 2006
Key words:	

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Grower Summary

Headline

No clear headline result was forthcoming from this investigation in part due to the atypically low level of DBD (0.74%) at the trial site. However it appears that DBD may be linked to specific trees and portions of those trees but this requires further investigation.

Background and expected deliverables

The occurrence of diffuse browning disorder 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 dessert apples, resulting in a low market price and in some years a significant financial loss.

The recent HDC project TF 139 “Investigating diffuse browning disorder (DBD) in stored Cox apples” failed to identify the cause of this problem and consequently further research is necessary to determine factors influencing the onset of DBD in Cox.

This project provides an opportunity to determine any link between fruit position in relation to the canopy and associated tree characteristics and the occurrence of DBD in Cox. Specifically:

- To determine any relationship between fruit in sun and shade and the occurrence of DBD in Cox.

- To determine any relationship between fruit number in a cluster and the occurrence of DBD in Cox.
- To determine any relationship between the age of fruiting wood and the occurrence of DBD in Cox.
- To determine any relationship between the proximity to a strong shoot and the occurrence of DBD in Cox
- To determine any relationship between number of seeds in the fruit and the occurrence of DBD in Cox

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.

Summary of the project and main conclusions

Only 21 of the 2,825 fruit picked and recorded (0.74%) developed symptoms of DBD. This result was unexpected as fruit stored in previous years from this site had developed high levels of DBD.

As a whole sample, fruit within the selected trees was either found singly or in clusters of two to five fruit, predominantly as one, two or three fruit. In the portion showing DBD, fruit was predominantly in clusters of two or three.

Across the whole sample, fruit was found around all sides of the tree but within the DBD sample virtually all fruit was found on the North and West sides of the tree. This however is only a fraction of fruit found on these sides of the tree and no recommendations for altered tree management can be drawn from this.

The occurrence of DBD at differing heights in the canopy followed the pattern of total yield as did the pattern for age of wood and presence of a strong shoot arising from the fruit cluster. There also appears to be no correlation between number of viable seeds and occurrence of DBD.

The number of fruit was greater on the inner portion of the canopy but results from the DBD sample indicated that there was a greater occurrence of DBD in the outer canopy.

In the case of all of the above results it must be remembered that only 0.74% of the sample showed any signs of DBD, a value much lower than for previous years for this orchard. The relevance of differences between fruit with and without symptoms of DBD may therefore be coincidental and further investigation in a subsequent year needs to be carried out.

However it is worth noting that of the 21 fruit with DBD, 11 were found on one tree and the other 10 fruit were found as 2 fruit on each of 5 trees. It was also observed that the occurrence of DBD appeared to be specific to particular branches and that branches with DBD fruit were commonly adjacent to each other. This potential link between DBD and specific position within the tree requires further investigation.

Financial benefits

There are no financial benefits at this stage.

Action points for growers

There are no action points for growers.

Science section

Introduction

The occurrence of diffuse browning disorder 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 dessert apples, resulting in a low market price and in some years a significant financial loss.

The recent HDC project TF 139 “Investigating diffuse browning disorder (DBD) in stored Cox apples” failed to identify the cause of this problem and consequently further research is necessary to determine factors influencing the onset of DBD in Cox.

This project provides an opportunity to determine if there is any link between fruit position in relation to the canopy and associated tree characteristics and the occurrence of diffuse browning disorder (DBD) in Cox.

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.

Materials and Methods

The trial was conducted at Lee Priory Farm, Littlebourne, Kent by kind permission of Stephen Twyman. The Cox (M9) orchard is well managed and was planted in 1987/88, is of moderate - high vigour and is situated on a silt loam soil type.

Ten trees spaced at regular intervals within the orchard were strip picked between 12/09/05 and 15/09/05. Each fruit was numbered at the time of picking and the following characteristics for each fruit were recorded:

- Apple number
- Tree number
- Number of fruit in cluster
- Aspect (N,E,S,W)
- Height (top175cm+, middle 90-175cm or bottom 0-90cm portion of the tree)
- Canopy position (outside or inside)
- Age of wood that produced the fruit cluster
- Presence of a strong shoot arising from the cluster
- Branch length (cm)

After picking the fruit was transported to East Malling Research for storage under standard Cox conditions. Fruit was stored until 6th February 2006 when the fruit was taken from the store and left for one week for DBD symptoms to develop before conducting post storage assessments. Fruit was assessed on 14th – 16th February 2006 and the following characteristics were recorded:

- Presence/absence of DBD
- Fruit diameter
- Presence/absence of other storage disorders
- Number of viable seeds
- Fruit firmness (on one in ten fruit)

Results of fruit in relation to tree structure characteristics were then compared with incidence of DBD to indicate potential causes of DBD and to provide recommendations to for further research and initial recommendations to growers.

Results

Total occurrence of DBD

Only 21 of the 2,825 fruit picked and recorded (0.74%) developed symptoms of DBD. This result was unexpected as fruit stored in previous years had developed high levels of DBD.

Occurrence of DBD in relation to recorded characteristics

Of the fruit that exhibited symptoms of DBD:

- 5% occurred in fruit that were singular on the tree, 38% occurred in fruit that had 2 apples in the cluster, 43% occurred in fruit that had 3 apples in the cluster and 14% occurred in fruit that had 4 apples in a cluster
- 48% were found on the West sides of the trees, 43% on the North sides and 9% on the South sides
- 57% were found in the mid section of the tree and 43% were found in the lower section of the tree
- 62% occurred on the outside canopy of the tree and 38% occurred on the inside canopy of the tree
- 38% occurred in fruit arising from 2 year wood, 48% occurred in fruit arising from 3 year wood and 14% occurred in fruit arising from 4 year wood
- 29% occurred in fruit from clusters with a strong shoot emerging from the cluster and 71% occurred in fruit without the presence of a strong shoot arising from the cluster
- fruit density along the branch ranged from one fruit per 2.3cm of branch length to one fruit per 33.5cm of branch length
- fruit diameter ranged from 52mm to 72mm
- 19% occurred in fruit with no viable seeds, 24% occurred in fruit with one viable seed, 9% occurred in fruit with two viable seeds, 15% occurred in fruit with three viable seeds, 5% occurred in fruit with four viable seeds, 9% occurred in fruit with five viable seeds, 9% occurred in fruit with six viable seeds and 9% occurred in fruit with eight viable seeds
- the average fruit firmness was 5.30 kg

It was observed that of the 21 fruit with DBD, 11 were found on one tree and the other 10 fruit were found as 2 fruit on each of 5 trees. It was also observed that the occurrence of DBD appeared to be specific to particular branches and that branches with DBD fruit were commonly adjacent to each other.

Of the total fruit recorded:

- 24% were singular on the tree, 38% had 2 apples in the cluster, 27% had 3 apples in the cluster, 9% had 4 apples in a cluster and 1% had 5 apples in a cluster
- 26% were found on the North sides of the trees, 28% on the East sides, 16% on the South sides, 23% on the West sides and 7% were found on a single leader at the top of the tree
- 8% were found at the top of the tree, 50% were found in the mid section of the tree and 42% were found in the lower section of the tree
- 49% occurred on the outside canopy of the tree and 51% occurred on the inside canopy of the tree
- 2% occurred on fruit arising from 1 year wood, 37% occurred on fruit arising from 2 year wood, 37% occurred on fruit arising from 3 year wood, 19% occurred on fruit arising from 4 year wood and 5 % occurred on fruit arising from 5 year wood
- 25% occurred in fruit from clusters with a strong shoot emerging from the cluster and 75% occurred in fruit without the presence of a strong shoot arising from the cluster
- fruit density along the branch ranged from one fruit per 1.0cm of branch length to one fruit per 140.0cm of branch length
- fruit diameter ranged from 38mm to 83mm
- 7% occurred as fruit with no viable seeds, 13% occurred as fruit with one viable seed, 16% occurred as fruit with two viable seeds, 14% occurred as fruit with three viable seeds, 15% occurred as fruit with four viable seeds, 15% occurred as fruit with five viable seeds, 10% occurred as fruit with six viable seeds, 6% occurred as fruit with seven viable seeds and 4% occurred as fruit with eight viable seeds
- the average fruit firmness was 5.36kg

Discussion

As a whole sample, fruit within the selected trees was either found singly or in clusters of two to five fruit, predominantly as one, two or three fruit. In the portion showing DBD, fruit was predominantly in clusters of two or three. Again, across the whole sample fruit was found around all sides of the tree but within the DBD sample virtually all fruit was found on the North and West sides of the tree. This however is only a fraction of fruit found on these sides of the tree and no recommendations for altered tree management can be drawn from this.

The occurrence of DBD at differing heights in the canopy followed the pattern of total yield as did the pattern for age of wood and presence of a strong shoot arising from the fruit cluster. The number of fruit was greater on the inner portion of the canopy but results from the DBD sample indicated that there was a greater occurrence of DBD in the outer canopy. There also appears to be no correlation between number of viable seeds and occurrence of DBD.

In the case of all of the above results it must be remembered that only 0.74% of the sample showed any signs of DBD, a value much lower than for previous years for this orchard. The relevance of differences between fruit with and without symptoms of DBD may therefore be coincidental and further investigation in a subsequent year that has a higher percentage of DBD needs to be carried out.

However it is worth noting that of the 21 fruit with DBD, 11 were found on one tree and the other 10 fruit were found as 2 fruit on each of 5 trees. It was also observed that the occurrence of DBD appeared to be specific to particular branches and that branches with DBD fruit were commonly adjacent to each other. This potential link between DBD and specific position within the tree requires further investigation.

Conclusions

Due to the low occurrence of DBD within the sample no specific conclusions or practical grower recommendations relating to the occurrence of DBD can be made from these results.

The only conclusion that can be drawn is that the apparent local occurrence of DBD on one tree needs to be investigated to ascertain if this condition is indeed tree specific, with ideally the same trees being assessed for a second year.

Appendix I.

Characteristics of fruit showing DBD

Apple number	Tree number	Number of apples in cluster	Aspect	Canopy: Top / Middle / Bottom	Canopy: Outside / Inside	Age of wood	Shoot from cluster	Fruit per cm branch length	Fruit diameter	DBD present	Number of viable seeds
1 - 2825	1 - 10	1/2/3/	N/E/S/W	T/M/B	O/I/S	1/2/3/	Y/N		mm	Y / N	
5	1	3	N	M	O	3	N	15.6	68	y	0
6	1	3	N	M	O	3	N	15.6	63	y	0
33	1	2	N	B	O	3	N	5.7	65	y	4
54	1	3	N	M	O	2	N	5.4	57	y	3
57	1	2	N	M	O	2	N	5.4	72	y	3
64	1	3	W	M	O	2	Y	7.3	60	y	0
69	1	3	W	B	O	2	N	4.4	67	y	1
74	1	4	W	B	O	4	Y	4.4	62	y	2
75	1	4	W	B	O	4	Y	4.4	61	y	2
107	1	2	W	M	O	2	N	2.3	66	y	5
125	1	4	W	M	I	3	N	6.8	52	y	0
337	2	2	N	M	I	3	N	21.3	61	y	1
388	2	1	W	B	I	3	N	33.5	55	y	8
522	3	2	W	B	O	3	N	5.6	61	y	3
538	3	3	W	M	I	2	N	8.5	70	y	1
1,599	6	3	N	B	I	3	Y	8.0	58	y	1
1,618	6	3	N	M	O	4	Y	11.8	62	y	1
2,323	9	2	W	B	I	3	N	7.6	62	y	6
2,460	9	3	N	B	O	3	Y	5.4	68	y	5
2,635	10	2	S	M	I	2	N	9.0	65	y	6
2,639	10	2	S	M	I	2	N	9.0	64	y	8