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DISCLAIMER

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.

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GROWER SUMMARY

Headline

Bellis and Switch both had some effect in reducing mouldy core or core rot in Cameo in trials in 2009

Background and expected deliverables

Mouldy core or core rot is an internal rot of certain apple cultivars that have an open eye which allows saprophytic fungi colonising senescing flower parts to be washed into the core. Fungal growth then develops within the apple core, initially without invading the apple flesh (mouldy core). The fungi may then invade the flesh leading to the development of a slow, dry rot confined to the apple centre (core rot). Mouldy core may also continue to develop in store and may then appear at the cheek, eye or stalk end of the fruit as a more distinctive core rot.

The main problem with mouldy core is that it develops inside the apple and can remain undetected until the fruit is eaten or processed. Discovery of mouldy core in this way can obviously affect consumer acceptability of the variety and rejection of consignments by supermarkets. In shelf-life tests conducted by a local pack house after grading, levels of 10-20% mouldy core were commonly found in samples of Cameo and recently in a bag of ten Cameo fruits purchased from a supermarket three were found to have mouldy core. External symptoms in the orchard are rare but fruit may colour and fall prematurely. Many cultivars of apples are affected worldwide, especially Red Delicious and Red Delicious types. In the UK the problem is mainly associated with the cultivars Cameo and Bramley's Seedling, but may also occur in Ida Red, Braeburn, Gloster and certain cider apple cultivars.

Mouldy core can be caused by a range of different fungi including *Alternaria*, *Stemphylium, Cladosporium*, *Epicoccum* and *Fusarium*. In other countries *Alternaria* is generally the most important cause of core rots (Kennel, 1983; Archer, 2002).

Wet weather during blossom encourages colonisation of flower parts by fungi and can increase the risk of mouldy core.

In some apple varieties, especially Bramley, core rots can also result from fungi that enter the core when the fruit is drenched post-harvest in fungicide or anti-scald agents. The core rots then develop during cold storage. These core rots are caused by a range of fungi including *Fusarium*, *Mucor* and *Penicillium.* In most cases the problem can be solved by only drenching post-harvest if necessary and adopting strict hygiene measures in the drenching operation to prevent the build up of mud, fungal spores and other debris in the drenching solution.

There have been many studies conducted in other countries on control of mouldy core or core rot, particularly on the cultivar Red Delicious where *Alternaria* is generally the main cause of the problem. Application of fungicides between first flower and petal fall reduced the incidence of mouldy core in most experiments. Not all fungicide trials were successful and this may be related to differences in the complex of fungi responsible for mouldy core. Treatments found to reduce the incidence of mouldy core in trials included carbendazim, mancozeb (Karamate), various DMI fungicides (e.g. myclobutanil), vinclozolin (Ronilan), strobylurin fungicides (e.g. azoxystrobin) and potassium phosphite. In the UK, vinclozolin, carbendazim or tolylfluanid (Elvaron Multi) were previously used for control of mouldy core. However, these fungicides are no longer approved for use on apples.

The purpose of this project is to identify the main fungi responsible for mouldy core or core rot in Cameo and Bramley, and to identify alternative fungicides or chemicals that are effective in controlling the problem.

Summary of the project and main conclusions

In August 2008-2010, random samples of 100 apples were collected from the orchard floor and from trees in Cameo and Bramley orchards in Kent. Sampled fruit were chopped and checked for the presence of mouldy core or core rot. In Cameo the incidence of mouldy core in fruit on the tree varied from 0-19% in 2008, 0-20% in 2009 and 0-10% in 2010. The incidence in fruit on the orchard floor varied from 0-38% in 2008, 0-50% in 2009 and 3-34% in 2010. In Bramley the incidence of mouldy core or core rot in fruit on the tree varied from 0-14% in 2008, 2-14% in 2009 and 0-4% in 2010. The incidence in fruit on the orchard floor varied from 2-48% in 2008, 27-54% in 2009 and 10-27% in 2010. The main fungi isolated from the rotted cores in both years in both cultivars were *Fusarium* spp. (at least 3 different species), *Alternaria* sp. and *Penicillium* sp. Other fungi recorded included *Cladosporium* sp, *Phomopsis* sp, *Colletotrichum* sp. and *Botrytis cinerea*. In addition, information on core rot incidence in stored Bramley was also obtained. Total losses due to rots ranged from <1-10% in 2008, <1-4% in 2009 and 0.1-5.5% in 2010. In 2008 up to 20% of these losses (mean 8%) could be attributed to core rots. In 2009 the incidence of core rots was higher with up to 32% of rotting due to core rots (mean 14%). In 2010 the incidence of core rots ranged from 0-22.2 % (mean of 7.1%). The survey confirmed that mouldy core and core rot were a significant problem in Cameo and also showed that they were a more significant problem in Bramley than previously thought, particularly in long-term stored Bramley.

In 2010, two trials were established to evaluate fungicides and alternative products for control of mouldy core and core rots. One trial was in a commercial Cameo orchard located in west Kent and the second trial was in an established Bramley orchard located at East Malling Research. Treatments evaluated were Bellis (pyraclostrobin + boscalid), Switch (cyprodonil + fludioxonil), an experimental fungicide, Farmfos 44 (potassium phosphite) and Serenade (*Bacillus subtilis*) all applied as a two spray programme at full bloom and 7-10 days later. An additional treatment of three sprays was included with Switch alternating with Bellis, starting at 50% open bloom. An untreated control was included for comparison. Unfortunately the weather conditions in 2010 were unfavourable for mouldy core and core rot, so the incidence of core rots in the two trials was too low for any meaningful conclusions on control to be made. The results from trials in 2009 indicated that both Bellis and Switch had some effect on reducing mouldy core in Cameo.

Financial benefits

Cameo is a niche variety grown by around 30 growers in the UK. In 2007, about 700 tonnes of apples were produced but this quantity is likely to increase each season as many orchards have only recently been planted. It is well liked by consumers. This variety appears to be very susceptible to mouldy core or core rot, with average incidence in 2007/8 of around 10%.

Bramley is one of the main varieties grown in the UK and is important as a culinary apple and for processing.

The main problem with mouldy core is that it develops inside the apple, often in store or as the fruit ripens during marketing and can remain undetected until the fruit is eaten or processed. Discovery of core rots in this way can obviously affect consumer acceptability of the variety and rejection of consignments by supermarkets and processors. It is therefore important that an effective solution is found for this problem. The problem does occur in other varieties but at a much lower incidence.

Action points for growers

- Mouldy core is a significant problem in Cameo and fungicide treatments should be applied during blossom to reduce losses.
- Core rots are a more significant problem in Bramley than previously thought (particularly in long-term stored Bramley) and fungicide treatments should be applied during blossom to reduce losses.
- The fungicide trials in 2009 indicated that Bellis and Switch have some effect on reducing mouldy core. These should be applied at full bloom and repeated 7-10 days later.

SCIENCE SECTION

Introduction

Mouldy core or core rot is an internal rot of certain apple cultivars that have an open eye which allows saprophytic fungi colonising senescing flower parts to be washed into the core. Fungal growth then develops within the apple core, initially without invading the apple flesh (mouldy core). The fungi may then invade the flesh leading to the development of a slow, dry rot confined to the apple centre (core rot). Mouldy core may also continue to develop in store and may then appear at the cheek, eye or stalk end of the fruit as a more distinctive core rot. The main problem with mouldy core is that it develops inside the apple and can remain undetected until the fruit is eaten or processed. Discovery of mouldy core in this way can obviously affect consumer acceptability of the variety and rejection of consignments by supermarkets. In shelf-life tests conducted by a Kent pack-house after grading, levels of 10-20% mouldy core were commonly found in samples of Cameo and recently in a bag of ten Cameo fruits purchased from a supermarket three were found to have mouldy core. External symptoms in the orchard are rare but fruit may colour and fall prematurely. Many cultivars of apples are affected worldwide, especially Red Delicious and Red Delicious types. In the UK the problem is mainly associated with the cultivars Cameo and Bramley's Seedling, but may also occur in Ida Red, Braeburn, Gloster and certain cider apple cultivars.

Mouldy core can be caused by a range of different fungi, including *Alternaria*, *Stemphylium, Cladosporium*, *Epicoccum* and *Fusarium*. In other countries *Alternaria* is generally the most important cause of core rots (Kennel, 1983; Archer, 2002).

Wet weather during blossom encourages colonisation of flower parts by fungi and can increase the risk of mouldy core.

In some apple varieties, especially Bramley, core rots can also result from fungi that enter the core when the fruit is drenched post-harvest in fungicide or anti-scald agents. The core rots then develop during cold storage. These core rots are caused by a range of fungi including *Fusarium*, *Mucor* and *Penicillium.* In most cases the problem can be solved by only drenching post-harvest if necessary and adopting strict hygiene measures in the drenching operation to prevent the build-up of mud, fungal spores and other debris in the drenching solution.

There have been many studies conducted in other countries on control of mouldy core or core rot, particularly on the variety Red Delicious where *Alternaria* is generally the main cause of the problem (Pinilla *et al*.1996; Reuveni & Prusky 2007). Application of fungicides between first flower and petal fall reduced the incidence of mouldy core in most experiments. Not all fungicide trials were successful and this may be related to the fungi responsible for mouldy core. Treatments found to reduce the incidence of mouldy core in trials included carbendazim, mancozeb (Karamate), various DMI fungicides (e.g. myclobutanil), vinclozolin (Ronilan), strobylurine fungicides (e.g. azoxystrobin) and potassium phosphite (Reuveni *et al*. 2003). In the UK, studies on mouldy core on the variety Gloster were conducted by Edney and Morton (1984, 1985). *Alternaria* and *Stemphylium* were identified as the main fungi responsible. Vinclozolin, carbendazim or tolylfluanid (Elvaron Multi) were previously used for control of mouldy core in the UK. However, these fungicides are no longer approved for use on apples.

Overall aim of project

To identify the fungi responsible for mouldy core in apples, especially cvs Cameo and Bramley, and evaluate fungicides and other chemicals for control.

Specific Objectives

1. To identify the fungi responsible for mouldy core in apples
2. To evaluate fungicides and other chemicals for control of mouldy core

Summary of results from previous years (August 2008-March 2010)

In August 2008 and 2009, random samples of 100 apples were collected from the orchard floor and from trees in orchards of cvs Cameo and Bramley in Kent. Sampled fruit were chopped and checked for the presence of core rot. In Cameo the incidence of core rot in fruit on the tree varied from 0-19% in 2008 and 0-20% in 2009. The incidence in fruit on the orchard floor varied from 0-38% in 2008 and 0-50% in 2009. In Bramley the incidence of core rot in fruit on the tree varied from 0-14% in 2008 and 2-14% in 2009. The incidence in fruit on the orchard floor varied from 2-48% in 2008 and 27-54% in 2009. The main fungi isolated from the rotted cores in both years in both cultivars were *Fusarium* spp. (at least three different species), *Alternaria* sp. and *Penicillium* sp. Other fungi recorded included *Cladosporium* sp, *Phomopsis* sp, *Colletotrichum* sp. and *Botrytis cinerea*.

In addition, information on core rot incidence in stored Bramley was also obtained. Total losses due to rots ranged from <1-10% in 2008 and 0.1-4% in 2009. In 2008 up to 20% of these losses (mean 8%) could be attributed to core rots. In 2009 the incidence of core rots was higher, with up to 32% of rotting due to core rots (mean 14%). The survey confirmed that mouldy core was a significant problem in Cameo and also showed that it was a more significant problem in Bramley than previously thought. Also, the wet core rot previously associated with post-harvest fruit drenching was due to colonisation of the core arising from orchard infection.

In 2009, a trial was established in two Cameo orchards located in east and west Kent to evaluate the efficacy of fungicide products against mouldy core. Sprays of Bellis (pyraclostrobin + boscalid) or Switch (cyprodonil + fludioxonil) or Systhane (myclobutanil) plus Scala (pyrimethanil) applied at full bloom and 10-14 days later were compared to untreated plots for control of mouldy core. The incidence of core rots was assessed in the orchard on fallen fruit in August and on harvested fruit in January 2010. The results indicated that both Bellis and Switch had some effect on reducing mouldy core but Systhane mixed with Scala was ineffective.

Studies in 2010

Materials and methods

Objective 1 – Identification of fungi

Orchards of cvs Cameo and Bramley were visited during August and September and random samples of 100 fruit were collected from the trees, with a further sample of 100 fruit collected from the orchard floor (fallen fruit). In the laboratory the fruit from the 100 fallen fruit sample were immediately chopped and checked for core rot. The incidence of core rot in the sample was recorded and isolations made from the rots onto Potato Dextrose Agar (PDA) to identify the fungi responsible. The apple samples collected from the tree were held at ambient temperature for two weeks to allow any core rot to develop, before chopping to check for core rot.

Visits were also made to packhouses to check and collect affected fruit from Cameo and Bramley during grading after storage. Core rots were similarly isolated and identified.

Objective 2 – Control of mouldy core

Two trials were conducted in 2010. One was on a commercial orchard of cv. Cameo and the second on experimental orchard of cv. Bramley's Seedling at East Malling Research.

Site 1

The first trial was located at Blue House Farm, Marden (by kind permission of Mr N Bardsley) in Randy Jack orchard on cv. Cameo on M9-type rootstock, and consisted of single rows of trees separated by nine rows of cv. Braeburn.

Site 2

The second trial was a small plot trial located at East Malling Research in orchard EE193 on cv. Bramley's Seedling on M9 rootstock with cvs Red Pippin and JonaPrinz pollinators. Each plot consisted of five Bramley trees separated by single guard trees in the row and single rows between blocks.

Treatments

The fungicides evaluated are shown in Table 1 below. At Site 1, the sprays were applied by the grower to whole rows of Cameo using the tractor-trailed orchard sprayer used on the farm at the usual spray volume of 200 L/ha. Treatments 1-4 only were applied. Each treatment was replicated twice in a randomized block design. At site 2, treatments were applied using a Birchmeier motorised Knapsack sprayer at 500 L/ha. Treatments 1-7 were applied and each treatment was replicated four times in a randomized block design. At both sites the standard farm programme for pest, disease and nutrient sprays (including full calcium programme) was applied to all plots but normal treatments for mouldy core were omitted.

Table 1. Fungicide treatments evaluated on apples cv. Cameo and Bramley's Seedling in 2010

Treatment No.	Treatment	Active ingredient	Product rate per ha	Timing
1	Untreated	-	-	-
2	Bellis (2 sprays)	pyraclostrobin +boscalid	0.8 kg	1st spray at full bloom 2nd spray 7-10 days later
3	Switch (2 sprays)	cyprodonil + fludioxonil	0.8 kg	1st spray at full bloom 2nd spray 7-10 days later
	Switch (1st spray)	cyprodonil + fludioxonil	0.8 kg	1st spray 50% open flower
4	Bellis (2nd spray)	pyraclostrobin +boscalid	0.8 kg	2nd spray 7-10 days later
	Switch (3rd spray)	cyprodonil + fludioxonil	0.8 kg	3rd spray 7-10 days later
5	UKA384c (2 sprays)	experimental	0.75 L	1st spray at full bloom 2nd spray 7-10 days later
6	Farmfos (2 sprays)	Potassium phosphite	5 L	1st spray at full bloom 2nd spray 7-10 days later
7	Serenade ASO (2 sprays)	*Bacillus subtilis*	10 L	1st spray at full bloom 2nd spray 7-10 days later

Assessments

Fruit drop

In June at site 1, 15 branches were labeled in each plot and the total number of fruit present recorded. Numbers of fruit on the branches were recounted on 1 September. At site 2, two branches were labeled on the centre three trees in each plot and the total number of fruit present recorded in June and recounted on 6 August.

Fallen fruit

At site 1 (Cameo), 50 fruit were collected from under the trees in each plot in early September. At site 2 (Bramley), 30 fruit were collected from under the trees in each plot in early August. All fruit were chopped and the number with core rot recorded.

Harvest

At harvest at site 1, a random sample of approximately 500 fruit (5 x 15 kg crates of fruit) were harvested from each plot on 28 September and stored at EMR in air at 4^{o}C for three months and then at ambient temperature for three weeks. Fruit were then chopped and core rots recorded. At site 2, all fruit were harvested on 31 August from the five trees in each plot and barn stored in air at ambient temperature until January. All fruit were then chopped and the incidence of mouldy core or core rot recorded.

Results and discussion

Objective 1 - Identification of fungi

Cameo

In 2010, samples were taken from the same seven Cameo orchards as in 2008 and 2009, all of which were located in Kent. The incidence of core rot is shown in Table 2, which also includes data from the previous two years as a comparison. The incidence of core rot in fruit on the tree varied from 0-10%. The incidence in fruit on the orchard floor varied from 3-34%. More core rots were found in fallen fruit, as expected since mouldy core generally results in premature fruit drop. Very few samples of stored Cameo were assessed and the incidence of rotting in store was very low. The main fungi isolated from the rotted cores in 2010 (Table 5) were *Fusarium* spp. (at least three different species), *Alternaria* sp. and *Mucor*. Yeasts were also commonly recorded in 2010. Other fungi recorded included *Cladosporium* sp, *Phompsis sp* and *Botrytis cinerea*. Over the three years *Fusarium* spp were the main fungal species isolated from cores.

Bramley

In 2010, samples were taken from seven orchards all located in Kent. The same orchards were also sampled in 2008 and 2009. The incidence of core rot (Table 3) in fruit on the tree varied from 0-4%. The incidence in fruit on the orchard floor varied from 10-27%. Data from 2008 and 2009 are included for comparison. More core rots were found in fallen fruit as expected, since mouldy core generally results in premature fruit drop. Information on core rot incidence in stored Bramley was also obtained. Total losses due to rots in Bramleys sampled between January and March in 2011 is shown in Table 4. The incidence of rotting due to core rots per 100 rotted fruit in each of the Bramleys sampled is also given in Table 4. Losses due to rots overall ranged from 0.1-5.5% in 2010. Up to 22% of these losses (mean 7.1%) could be attributed to core rots. Data from 2008 and 2009 are included for comparison. The incidence of core rots was higher in 2009 than in 2008 and 2010. The main fungi isolated from the rotted cores in both years (Table 5) were similar to those in Cameo - *Fusarium* spp (at least three different species), *Alternaria* sp. and *Penicillium* sp. Other fungi recorded included *Cladosporium* sp., *Phomopsis* sp. and *Colletotrichum* sp.

Table 2. Percent incidence of core rots in apple cv. Cameo in 100 fruit sampled from the tree and orchard floor in various orchards in Kent in August 2008, 2009 and 2010

Orchard Code	2008		2009		2010	
	Tree	**Orchard floor**	**Tree**	**Orchard floor**	**Tree**	**Orchard floor**
ND	12	9	20	46	9	7
NH	2	16	16	48	4	8
EMR	0	No drops	7	No drops	0	7
RO	19	7	18	11	10	14
RR	6	3	9	22	7	11
HS no spray	-	-	-	11	-	-
HS spray	12	0	-	2	8	3
HF no spray	-	-	-	50	-	-
HF spray	18	38	-	36	6	34
Overall mean	**9.9**	**12.2**	**14.0**	**28.0**	**6.3**	**12.0**

Table 3. Percent incidence of core rots in apple cv. Bramley in fruit sampled from the tree and orchard floor in various orchards in Kent in August 2008, 2009 and 2010

Orchard Code	2008		2009		2010	
	Tree	Orchard floor	Tree	Orchard floor	Tree	Orchard floor
RMB	0	12	4	-	-	-
RMG	-	-	3	-	-	-
RMTF	-	-	7	-	0	-
RMHC	-	-	2	-	2	-
RMY	-	-	4	-	0	-
NLH	-	-	5	31	2	10
NT	14	48	14	54	4	27
HS	0	7	14	40	1	16
EMR	0	-	6	-	-	10
EMRCW	0	17	-	-	-	-
BW	0	2	6	27	2	24
Overall mean	**0.7**	**14.3**	**6.5**	**38.0**	**1.6**	**17.4**

- = Not sampled

Table 4. Percent incidence of core rots in stored cv. Bramley sampled at seven packhouses in Kent between January and March in 2008, 2009 and 2010

2008			2009			2010		
Site code	**% losses due to rots**	**% incidence of core rot per 100 rotted fruit**	**Site code**	**% losses due to rots**	**% incidence of core rot per 100 rotted fruit**	**Site code**	**% losses due to rots**	**% incidence of core rot per 100 rotted fruit**
Br	<1	6.0	**Ma**	1.5	13.8	**Am**	1.0	2.9
Br	?	9.0	**Ma**	1.8	7.0	**Nf**	0.8	1.2
Br	4.0	2.0	**Am**	2.5	30.5	**Ma**	2.5	1.0
Br	2.5	12.8	**Ch**	2.5	8.9	**Ma**	0.1	10.0
Am	<1	4.7	**Br**	2.5	11.9	**Ch**	2.0	4.5
Ch	<1	9.4	**Am**	2.0	1.4	**Am**	3.0	5.7
Ma	1.5	20.7	**Ch**	2.0	8.7	**Ma**	1.5	8.6
Br	1.5	4.7	**Wy**	<1	5.2	**Am**	3.5	9.1
Ch	1.0	8.9	**Am**	0.1	12.5	**Am**	1.7	4.7
Ma	2.0	1.2	**Ch**	3.5	31.7	**Ma**	2.0	7.0
Wy	1.0	8.2	**Ba**	4.0	22.4	**Br**	5.5	2.2
Nf	3.0	6.7				**Br**	3.0	0
Mb	10.0	7.5				**Ma**	1.0	22.2
						Nf	1.0	20.0
						Am	2.2	9.0
						Ma	1.7	6.1
Mean	1.6	8.0	**Mean**	2.1	14.0	**Mean**	2.0	7.1

Table 5. Percent incidence of fungi isolated from core rots of cv. Cameo and Bramley apples sampled from orchards in 2008, 2009 and 2010

Fungus	**Cameo**			**Bramley**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**
Fusarium	40.3	21.1	44.5	32.9	23.5	56.6
Alternaria	19.4	9.1	5.5	17.8	6.4	0
Penicillium	14.4	27.9	0	18.2	35.4	6.6
Stemphylium	0	2.7	0	0	0.5	0
Cladosporium	3.6	0	0	6.3	0	10.0
Colletotrichum	0	0	0	8.3	9.0	0
Phomopsis	0	1.8	0	0	9.2	10.0
Botrytis	0	1.9	0	0	0	0
Mucor	0	0.8	2.8	0	3.1	0
Brown rot	0	0.6	0	0	0	0
Yeast	-	24.5	10.3	-	9.0	6.6
Other	21.1	7.6	37.0	7.2	0.5	10.0

Objective 2 – Control of mouldy core

At site 1 (Blue House Farm) numbers of fruit that had dropped by the assessment in September was low (Table 6) and the incidence of core rot in the dropped fruit was also low (3-6%). In harvested samples assessed in January 2011 the incidence of core rot was low (1.5-2.0%) with no obvious differences between treatments.

At site 2 (East Malling Research) numbers of dropped fruit under the trees was higher (Table 7) but there was no significant effect of treatment. The incidence of core rots in the dropped fruit was also higher than at site 1 but again there was no significant effect of treatment. The incidence of core rots in the barn-stored harvested fruit was relatively low. It was highest in the fruit from untreated plots and least in fruit from plots receiving two sprays of Switch. However, the differences were not significant.

Table 6. Apple cv. Cameo - effect of fungicide treatments applied at various timings in blossom on fruit drop and on % apples with core rots in fallen fruit assessed in September 2010 and in harvested fruit assessed in January 2011 after short-term cold storage

Treatment No.	**Treatment**	**% fruit drop**	**% core rot in fallen fruit 6 Sep 2010**	**% core rot in barn-stored fruit 31 Jan 2011**
1	Untreated	24.2	3.0	1.8
2	Bellis (2 sprays)	25.4	4.0	1.7
3	Switch (2 sprays)	33.2	6.0	1.5
4	Switch (1st spray) Bellis (2nd spray) Switch (3rd spray)	31.8	4.0	2.0

Table 7. Apple cv. Bramley - effect of fungicide treatments applied at various timings in blossom on fruit drop and on % apples with core rots in fallen fruit assessed in August 2010 and in harvested fruit assessed in January 2011 after barn storage. Data presented are angular transformed with back-transformed means in parenthesis

Treatment No.	**Treatment**	**% fruit drop**	**% core rot in fallen fruit 16 Aug 2010**	**% core rot in harvested fruit 13 Jan 2011**
1	Untreated	43.3 (47.0)	16.8 (8.3)	12.4 4.6)
2	Bellis (two sprays)	39.6 (40.7)	11.8 (4.2)	11.5 (4.0)
3	Switch (two sprays)	44.2 (48.6)	13.5 (5.5)	9.5 (2.7)
4	Switch (1st spray) Bellis (2nd spray) Switch (3rd spray)	38.6 (38.8)	11.8 (4.2)	12.1 (4.4)
5	UKA384c (two sprays)	40.8 (42.8)	16.6 (8.2)	11.9 (4.3)
6	Farmfos (two sprays)	46.8 (53.1)	17.7 (9.3)	11.0 (3.6)
7	Serenade ASO two2 sprays)	42.2 (45.1)	10.1 (3.1)	11.8 (4.2)
	F Prob	0.393	0.827	0.300
	SED (18)	3.79	6.19	1.214
	LSD (p=0.05)	7.96	13.01	2.551

General Discussion

Samples collected from Cameo orchards in August 2008-2010 confirmed that mouldy core was a significant problem, but varied considerably depending on orchard sampled and season. Mouldy core incidence was greater in 2009 than in 2008 or 2010. All orchards sampled had received fungicide treatment at blossom time for mouldy core which could have accounted for the variation in incidence. The incidence of mouldy core is dependent on weather conditions during blossom and on the openness of the calyx of the fruit. Wet weather during blossom and petal fall increases colonisation of senescing petals with saprophytic fungi and therefore the risk of mouldy core. However, weather conditions during blossom and petal fall were wetter in 2008 than in 2009 and 2010 (Table 8 and appendix) so a higher incidence would have been expected in 2008. Factors that determine the openness of the calyx are not understood but could have accounted for differences between the three seasons.

Samples collected from Bramley orchards in the two years showed that mouldy core was also an important problem in this cultivar that was probably not previously recognised. The incidence of mouldy core in Bramley was also greater in 2009 than in the other two years. Samples collected from pack-houses also showed that mouldy core continued to develop in cold store, appearing as visible rots on the fruit cheek by January. Observations indicate that core rots are probably a significant cause of losses in long- term stored Bramley and have previously been misidentified as *Mucor*.

Table 8. Rainfall recorded at East Malling in 2008, 2009 and 2010 during April and May

Month	**2008** Total rain mm	**2008** No. rain days	**2009** Total rain mm	**2009** No. rain days	**2010** Total rain mm	**2010** No. rain days
April	50	19	29.6	13	10.8	9
May	67.8	10	24.2	13	37.0	14

Fusarium spp were the most frequent cause of core rots in both Cameo and Bramley, although in general a range of fungal species were isolated from rotted cores. In other countries generally *Alternaria* is the most frequent cause of rotting. Activity is claimed against *Fusarium* by both Bellis and Switch, fungicides evaluated in the trials.

In the fungicide trials the incidence of core rots was too low in both trials to draw any meaningful conclusions. However, in general, over the two seasons of the trials the results indicated that both Bellis and Switch reduced the incidence of mouldy core.

Conclusions

- Mouldy core is a significant problem in both Cameo and Bramley
- A range of fungi are responsible, of which *Fusarium* spp, *Alternaria* and *Penicillium* are the most frequently isolated
- Orchard assessments indicate that infected fruit drop early in the summer
- Fungicide trials on Cameo indicate that Bellis and Switch have some effect on reducing mouldy core

Technology transfer

The results of the survey of Cameo and Bramley orchards and the fungicide trial were presented at the EMRA Members' Day at East Malling in March 2010 and 2011. An article was also produced for HDC News. The results were also presented at an IOBC orchard diseases workshop in Belgium in September 2011 and published in the conference proceedings.

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Appendix

Weather data for East Malling (1 March – 30 September 2010)

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL
01/03/2010	9.7	-2.2	0
02/03/2010	9.5	-0.2	0.2
03/03/2010	6.4	3.1	0
04/03/2010	6	-3.6	0
05/03/2010	8.7	1.6	0
06/03/2010	4.5	-3.6	0
07/03/2010	3.5	-4.3	0
08/03/2010	5.6	2.3	0
09/03/2010	5.6	2.6	0
10/03/2010	4.9	2.6	0
11/03/2010	6.1	-0.7	0.2
12/03/2010	8.1	3.4	3.2
13/03/2010	8.6	4.8	0
14/03/2010	12.1	2.9	0
15/03/2010	14.1	3.4	0
16/03/2010	12.5	0	0
17/03/2010	14.7	4.7	0
19/03/2010	12.9	9.9	3.4
20/03/2010	13.5	6.6	2.4
22/03/2010	12	1	1.4
23/03/2010	11.2	4.7	0
24/03/2010	15.1	10.3	4
25/03/2010	14.1	6.2	6.6
26/03/2010	12.8	5.4	0.2
27/03/2010	13	3.5	2.2
28/03/2010	13.4	6.9	3.6
29/03/2010	12.3	7.7	10.4
30/03/2010	12.9	4.4	5
31/03/2010	7.1	1.2	1
01/04/2010	9.6	4.6	0.4
02/04/2010	10.3	5.9	3.6
03/04/2010	11.8	5.6	3.4
04/04/2010	11	2.9	0
05/04/2010	12.9	6.9	0
06/04/2010	15	5.5	0
07/04/2010	13.1	4.7	0.6
08/04/2010	15.5	1.5	0
09/04/2010	17.7	3.8	0
10/04/2010	14.3	5.9	0
11/04/2010	11.3	6.2	0
12/04/2010	13.4	5	0
13/04/2010	14	6.5	0

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL
14/04/2010	9.4	4.5	0
15/04/2010	13.1	5.2	0
16/04/2010	11.6	-0.5	0.2
17/04/2010	15.3	-0.3	0
18/04/2010	17.8	4.1	0
19/04/2010	15.6	3.5	0
20/04/2010	14.6	2.2	0
21/04/2010	12.2	-1.3	0
22/04/2010	11.3	-0.5	0
23/04/2010	15.3	-0.2	0
24/04/2010	19.1	6.5	0.4
25/04/2010	18	7.4	0
26/04/2010	17.2	4.1	0.2
27/04/2010	20.1	4.9	0
28/04/2010	20.5	6.9	0
29/04/2010	21.2	8.4	1.2
30/04/2010	16	9.7	0.8
01/05/2010	15.7	7.9	7.2
02/05/2010	9	4.9	11
03/05/2010	10.7	3.4	0.4
04/05/2010	10.4	0.3	0
05/05/2010	12.8	7.2	0
06/05/2010	13.4	4.6	0
07/05/2010	12.7	6.5	0.6
08/05/2010	9.2	6.6	1.2
09/05/2010	9.9	2.8	0.2
10/05/2010	11.9	3.2	0
11/05/2010	10.6	-0.7	0.2
12/05/2010	11.1	1.8	1.2
13/05/2010	12.7	1.1	0
14/05/2010	15	1.6	0
15/05/2010	16	3.1	0
16/05/2010	15.3	5.6	7
17/05/2010	17	3.4	0.2
18/05/2010	16.9	4	0
19/05/2010	19.9	8.3	0
20/05/2010	21.7	9.9	0
21/05/2010	21.5	9.6	0.2
22/05/2010	19.3	7.8	0
23/05/2010	26	9.9	0
24/05/2010	27.7	9.5	0
25/05/2010	17	10.7	0
26/05/2010	14.1	8.3	3.6
27/05/2010	15.2	4.2	0.4
28/05/2010	18.8	6.8	0

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL
29/05/2010	16	11.7	3.6
30/05/2010	19	10.8	0
31/05/2010	15.5	7.9	0
01/06/2010	13.2	7.4	4.2
02/06/2010	20.2	5.8	0
03/06/2010	20.6	7	0
04/06/2010	24.1	8.4	0
05/06/2010	26.5	15.5	2.8
06/06/2010	22.2	12	5.6
07/06/2010	19.9	12	5.8
08/06/2010	19.3	11.8	0.6
09/06/2010	19.7	14.3	5
10/06/2010	18.1	13	22.2
11/06/2010	17.8	8.6	0
12/06/2010	18.3	6.8	0
13/06/2010	19.6	8.7	0.2
14/06/2010	19.4	9.4	0
15/06/2010	16.2	9.9	0
16/06/2010	16.2	9.4	0
17/06/2010	18.7	10.8	0
18/06/2010	17.4	9.3	0
19/06/2010	14.2	8.8	0.4
20/06/2010	18.4	8.9	0
21/06/2010	22	8.2	0
22/06/2010	25	9.2	0
23/06/2010	25.9	10.5	0
24/06/2010	25.2	14.4	0
25/06/2010	24.7	11.2	0
26/06/2010	25	10.8	0
27/06/2010	29.1	15.3	0
28/06/2010	27.8	12.8	2.8
29/06/2010	25.8	15.6	0
30/06/2010	24.5	12	0
01/07/2010	25.3	15.4	0
02/07/2010	28.4	17.5	0
03/07/2010	25.9	12.2	0
04/07/2010	23.1	11.6	0
05/07/2010	24.4	12.4	0
06/07/2010	22	12.2	0
07/07/2010	23.9	14.7	0
08/07/2010	27.6	13.3	0
09/07/2010	30.3	13.7	0
10/07/2010	29.3	14.7	0
11/07/2010	26.3	13.9	7.6
12/07/2010	22.8	14.4	2

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL
13/07/2010	21.2	14.2	0.6
14/07/2010	21.5	14.7	2
15/07/2010	20.1	14.4	0.8
16/07/2010	20.6	13.1	0
17/07/2010	21.6	8.6	0
18/07/2010	23.2	12.2	0
19/07/2010	27.7	15.3	0
20/07/2010	27.2	16.5	0
21/07/2010	23.8	10.7	0.6
22/07/2010	22.7	11.3	2.2
23/07/2010	22.2	10	0
24/07/2010	24.9	16	0.2
25/07/2010	26	17.4	0
26/07/2010	24.1	15.1	0.2
27/07/2010	24	16.1	4.8
28/07/2010	27.1	14.1	0.4
29/07/2010	21.7	10.6	0
30/07/2010	22.9	16.5	0.4
31/07/2010	24	12.2	1.2
01/08/2010	21.8	15.7	0
02/08/2010	23	9.6	0
03/08/2010	23.1	14.6	0.6
04/08/2010	21.1	10.8	0.6
05/08/2010	22.3	7.4	0
06/08/2010	21.2	16.2	1.4
07/08/2010	22.6	14.2	0
08/08/2010	23.5	9.6	0
09/08/2010	23.1	16.5	5.6
10/08/2010	20.9	11.5	2
11/08/2010	20.8	11.4	0
12/08/2010	20.6	10.7	0.4
13/08/2010	19.3	12.8	3.8
14/08/2010	18.6	13.5	9
15/08/2010	21.2	13.3	0
16/08/2010	23.1	14.5	0.2
17/08/2010	19	14	0
18/08/2010	21	10.5	0.2
19/08/2010	22.3	15.1	0
20/08/2010	22.9	18.9	0
21/08/2010	22.2	18.5	0
22/08/2010	22.2	17.3	17
23/08/2010	21.3	11.1	0.2
24/08/2010	20.2	10.6	0.4
25/08/2010	19	13.3	31
26/08/2010	20.1	12	9

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL
27/08/2010	17.4	8	0
28/08/2010	20.5	12	0.6
29/08/2010	19.6	9.7	0.8
30/08/2010	20.1	6.1	0
31/08/2010	18.8	4.9	0.2
01/09/2010	19.4	6.5	0
02/09/2010	19.4	8	0
03/09/2010	20.5	7.5	0.2
04/09/2010	20	9.7	0
05/09/2010	20.3	13.3	0
06/09/2010	20.3	10.8	7
07/09/2010	19.8	10.7	9
08/09/2010	17.8	11.9	3.6
09/09/2010	21.6	12.9	0.4
10/09/2010	19.8	14.9	0.2
11/09/2010	19.6	11.1	3.4
12/09/2010	19.6	8.1	0.2
13/09/2010	18	14	0.2
14/09/2010	19.7	8.4	4.4
15/09/2010	17.5	10.2	0.2
16/09/2010	16.9	8.3	0
17/09/2010	15.5	4	0.2
18/09/2010	16.9	10.4	0
19/09/2010	17.5	14.4	0.2
20/09/2010	20.8	7.6	0.2
21/09/2010	20.7	7.8	0.4
22/09/2010	23.2	12.6	0.2
23/09/2010	18.8	9.6	1.4
24/09/2010	15.4	6.2	0.4
25/09/2010	14	8.5	0
26/09/2010	13.3	10.9	10.8
27/09/2010	15.5	11.9	0.8
28/09/2010	17.3	12.4	0.8
29/09/2010	17.4	7	8
30/09/2010	16.3	10.6	0.2