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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

- Brown rot (*Monilinia fructigena*) is the most important cause of rotting in stored apples, whilst Gloeosporium rot is increasing in incidence in all apple cultivars.

Background and expected deliverables

What are the main rots responsible for losses in stored apples?

Fungal rots can result in significant losses in stored apples, particularly in fruit stored beyond January. They also increase the cost of grading. Successful control of storage rots depends on a clear understanding of the rots to be controlled. The current strategy is based on rot surveys from the 1990s when *Nectria*, *Botrytis*, brown rot, *Penicillium, Phytophthora* and *Gloeosporium* were identified as the main rots in apple. Since then the rot profile may have changed due to changes in climate and agronomic practices. Rot trials in orchards at EMR have indicated an increase in incidence of rots such as *Botryosphaeria sp.*, *Phomopsis sp.* and *Colletotrichum sp.* in stored fruit. Whether these are also of increased prevalence in commercial orchards is not known, but it is important to know their incidence as rot control strategies may need to be modified. Growers often report increased rots during fruit grading but rarely identify the rots present. The objective of this project was to conduct surveys of rots in stored apples to re-evaluate rot incidence and to assess the success of the current rot control strategy on commercial farms.

Storage rot control

Until recently control of storage rots was mainly achieved by the use of post-harvest fungicide drenches that were generally applied regardless of need**.** Use of post-harvest treatments has declined as a result of a combination of factors including reduced efficacy due to fungicide resistance, non-availability of fungicides and dislike of the resulting residues by consumers and hence markets**.** An alternative strategy was developed for rot control based on rot risk assessment (which determines whether treatment is required and if orchard sprays are necessary), selective picking at harvest and early marketing of fruit where a high risk of rotting is identified**.** Pre-harvest orchard sprays and selective picking were successful alternative treatments for control of Phytophthora and brown rot, but control of other rots such as Nectria was based on identifying problem orchards and early marketing of fruit. In Defra project HH3232STF the efficacy of treatments applied at blossom and petal fall on rot control, in particular Nectria rot were evaluated. This treatment timing was based on inoculation studies which showed that fruit was most susceptible to *Nectria galligena* at blossom and petal fall. Fruit susceptibility declined in summer but increased slightly near harvest**.** The early season treatments were shown to reduce Nectria fruit rot. However, there is a need to compare early season treatments with pre-harvest treatments to establish whether additional late sprays are important in controlling rots. These comparisons were not included in the Defra work.

The concept of rot risk assessment was introduced via the Apple Best Practice Guide in 2001. HDC-funded training courses on rot risk assessment were conducted in 2005 and numerous presentations on storage rots have been made at various grower meetings. Despite this, when wet conditions prevail during spring and summer many growers resort to late season sprays and post-harvest treatments. Pre-harvest fungicides applied for rot control are generally applied 2-4 weeks before harvest with a high risk of residues in the fruit. If fungicide treatments pre-harvest were shown to be of no additional benefit then such treatments could be avoided and reduce the risk of pesticide residues in the fruit. Similarly if other control measures such as selective picking were shown to be effective in controlling Phytophthora and brown rot then growers would be encouraged to adopt them. There is therefore a need to evaluate early season treatments compared to pre-harvest treatments and integrated control based on rot risk assessment and selective picking.

The overall aim of the project was to develop a sustainable, cost effective system for control of storage rots in apple. The specific objectives were:

1. To identify losses due to rots in commercial orchards and the main fungi responsible for the rots.
2. To evaluate the efficacy of fungicides applied at blossom and petal fall compared to sprays applied pre-harvest and treatments based on selective picking for control of storage rots.

Summary of the project and main conclusions

Rot survey (summary for 2008-2010)

Seven pack-houses were visited weekly from January-March in 2009, 2010 and 2011. Three were located in East Kent and four south of Maidstone. Visits were also made to pack houses in Hereford. Each of these pack-houses graded fruit from their own farm and from other farms. Thus the survey covered fruit from a number of different farms. At each visit at least 100 rotted fruit were removed from the rot bin or collected from the grader of fruit that was being graded at the time of the visit. Rots were identified visually and numbers recorded. Only one of the pack houses visited in any of the three years kept formal records of losses due to rots during grading or identified the rots present.

The losses due to rots for all the cultivars over the three years are summarised in Tables GS1-3.

Actual losses in Cox due to rots were low to moderate on average 1.8-2.8% over the three years of the survey. The overall range of losses from individual samples over the three years was 0.1-20%, indicating that actual losses due to rots were very variable depending on orchard site. Most losses were due to brown rot (*Monilinia fructigena*) which accounted for up to 50% of the rots. *Nectria* accounted for about 20% of losses with *Botrytis* and *Gloeosporium* also important and *Phytophthora* important in some samples in 2008 and 2010 when rainfall was significant pre-harvest. *Colletotrichum, Fusarium, Botryosphaeria*, *Phomopsis* and *Mucor* were recorded at low incidence.

Losses in Egremont Russet were similar to those in Cox and ranged from 0.8-4.0 % over the three years.

Losses due to rots in Gala were low and 1% or less. Brown rot and *Nectria* were the main fungi responsible with *Phytophthora* important in 2008 and 2010 when rainfall was significant pre-harvest. *Gloeosporium*, *Colletotrichum, Fusarium, Botryosphaeria*, and *Mucor* were recorded at low incidence.

In Braeburn and Jazz, harvested in October, losses due to rots were negligible (0.1-0.9%). On average most losses were due to brown rot and *Botrytis*. *Phytophthora* was also important in all three years as weather conditions for apples harvested in October were generally wet. *Penicillium, Nectria, Gloeosporium, Fusarium* and *Mucor* were also recorded.
In Bramley losses due to rots ranged on average from 1.6-3%. As with the other cultivars, on average, most of the losses (over 40%) were accounted for by brown rot. *Fusarium* was also important. Much of the *Fusarium* was present as cheek rots which appeared to have originated from the core. *Botrytis, Penicillium, Nectria,* and *Phomopsis* were also present.

The risk of *Phytophthora* rot was significant for all apple cultivars in 2010 and for cultivars picked in October in all three years. The risk is reflected in the percentage of apple samples in which *Phytophthora* rot was present (44%, 19% and 66% for 2008-2009 respectively). The incidence of Gloeosporium rot increased in all cultivars, apart from Bramley, over the three years of the survey. In most cases, although the rot was present it was not causing significant losses. However, in some samples of Cox it accounted for 1-2.0% of losses in 2009 and up to 2.5% losses in some consignments in 2010. Gloeosporium rot is obviously increasing in importance and may need specific control measures to be applied.

Losses due to rots in Conference and Comice were on average around 1%. Over three-quarters of this rotting was accounted for by *Botrytis* and brown rot. The incidence of other rots was very low.

Table 1. Summary of losses due to rots and % rot incidence in various apple cultivars in 2008 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2009

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Bramley (Kent)	Bramley (Herefordshire)
Brown rot	32.2	18.3	20.4	41.0	33.3	47.3	42.3	8.0
Botrytis	15.0	9.3	10.1	14.9	30.7	3.0	3.3	0
Phytophthora	1.8	5.3	20.2	2.6	0.3	0	1.6	0
Penicillium	8.2	1.7	3.3	14.3	6.7	13.7	13.7	1.0
Nectria	28.1	11.0	22.6	6.9	6.0	22.3	13.2	12.0
Gloeosporium	12.2	48.3	0	0.8	3.0	12.7	0	0
Colletotrichum	1.2	0	0	0	0	0	0.5	49.0
Fusarium	0.4	0	1.8	2.5	0	1.0	12.4	30.0
Mucor	0.8	0	1.5	4.6	0	0	0.5	0
Botryosphaeria	0.3	0.3	0	0	0	0	0.3	0
Phomopsis	0.1	6.0	0	0	0	0	7.2	0
Other	0	0	0	0	0	0	0.1	0
No. of samples	23	3	5	8	5	3	11	1
Mean Loss	1.8	<1.0	<0.5	0.9	0.1	1.5	1.6	?
Range	<0.5-5.5	<1.0	<0.5-1.0	0-4.8	0-<1.0	1.0-2.0	<1.0-4.0	

Table 2. Summary of losses due to rots and % rot incidence in various apple cultivars in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Cameo	Bramley (Kent)	Bramley (Herefordshire)
Brown rot	52.7	13.0	53.8	38.9	15.8	68.9	15.7	43.1	27.9
Botrytis	5.6	2.3	4.3	12.5	31.7	5.6	5.7	0.06	0
Phytophthora	0.2	0	0.8	13.4	25.5	0	0	0.09	0
Penicillium	10.7	1.7	7.3	27.3	10.5	9.8	20.0	15.3	27.3
Nectria	14.4	28.1	27.5	1.9	0.8	12.9	7.1	8.3	17.0
Gloeosporium	12.5	53.8	4.4	4.8	4.1	2.8	42.9	0.04	0
Colletotrichum	0.2	0.6	1.1	0	11.8	0	0	2.8	0
Fusarium	0.3	0	0.2	0	0	0	8.6	23.4	2.6
Mucor	0.1	0	0	1.3	0	0	0	0.8	0.9
Botryosphaeria	2.0	0	0	0	0	0	0	0	0
Phomopsis	0	0	0	0	0	0	0	2.8	0
Other	0.7	15.8	0.2	0	0	0	0	1.9	17.9
No. of samples	24	2	15	7	3	3	1	13	2
Mean Loss	2.8	0.5	1.0	0.2	0.2	0.8	1.0	3.0	?
Range	0.1-20.0	0.5	0.1-2.0	0-0.5	0.01-0.5	0.5-1.5	1.0	0.1-7.5	

Table 3. Summary of losses due to rots and % rot incidence in various apple cultivars in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Ida Red	Jonagored	Cameo	Bramley
Brown rot	42.1	36.8	32.4	17.0	4.9	37.0	2.8	31.8	39.1	45.1
Botrytis	6.7	15.4	4.7	23.0	12.6	2.2	13.9	40.9	3.9	3.0
Phytophthora	4.2	7.7	13.1	24.0	10.5	0	44.4	22.7	7.3	0.7
Penicillium	6.0	7.4	5.3	11.5	8.0	16.4	8.3	4.5	8.2	12.2
Nectria	26.1	10.9	34.9	4.2	37.6	25.6	30.6	0	0.8	10.9
Gloeosporium	13.5	21.0	1.7	10.5	26.5	18.7	0	0	6.0	0.4
Colletotrichum	0.1	0	0	0	0	0	0	0	0	0.8
Fusarium	0	0	1.1	1.6	0	0	0	0	32.0	14.2
Mucor	0.6	0	0.8	8.0	0	0	0	0	2.6	1.2
Botryosphaeria	0.4	0.4	0.05	0	0	0	0	0	0	0
Phomopsis	0	0	0	0.08	0	0	0	0	0	9.7
Other	0.3	0.4	0.4	0.1	0	0.3	0	0	0	1.6
No. of samples	22	3	18	16	3	2	1	1	3	16
Mean Loss	2.0	1.8	0.9	0.4	0.3	4.0	1.0	0.05	0.6	2.0
Range	0.5-4.0	1.0-2.3	0.1-3.0	0.1-1.5	0.1-0.5	3.0-5.0	-	-	0.1-1.5	0.1-5.5

Control of storage rots

In a large plot replicated orchard trial, fungicide treatments of Captan or Bellis (pyraclostrobin + boscalid) applied at blossom and / or pre-harvest were compared to an untreated control for control of storage rots. An additional treatment where fungicides were applied at blossom and selective picking at harvest was also included. In this treatment fruit pickers at harvest were instructed to place only undamaged fruit in the bin and to exclude all fruit below knee height (<0.5 metres above the ground) from the bin. This minimizes the risk of introducing fungal rots such as brown rot, *Penicillium* rot (damaged fruit) or *Phytophthora* rot (low hanging fruit) into the bin. In the other treatments, fruit was harvested as in commercial practice and included low hanging fruit. Fruit was harvested in September and one bin of apples picked per plot. Bins were stored in controlled atmosphere at Cox storage conditions (3.5^{o}C, 1%O_2<1%CO_2) until March and the rots assessed on removal from store.

In 2009 overall, there was significantly more rotting in untreated plots compared to treated plots. The pre-harvest sprays only treatment and blossom and pre-harvest sprays treatment had significantly less rots in total than the untreated. The main rots recorded were brown rot, *Botrytis*, *Penicillium*, *Nectria*, *Phomopsis*, *Botryosphaeria* and *Colletotrichum.* In general most rotting was recorded in the untreated plots apart from *Penicillium.* Overall significantly less rotting was recorded in treated plots compared to untreated plots for *Nectria*, *Phomopsis* and *Botryosphaeria* but the incidence of rots was too low for differences between individual treatments to be identified. There were no significant effects of treatments on brown rot, *Botrytis*, *Penicillium* or *Colletotrichum.*

In 2010, a late frost in blossom resulted in poor fruit set and low numbers of apples at harvest. The incidence of rots in store was low and none of the treatments had any significant effects. No individual treatment had any significant effect on brown rot in the orchard pre-harvest but overall the treatments applied pre-harvest appeared to give a significant reduction in brown rot in the orchard. These effects were not carried over into the incidence of brown rot in store.

The incidence of storage rots was low in both years with around 2-3% rotting in total in untreated plots. Therefore it is difficult to draw any meaningful conclusions from the trial regarding the efficacy of early season sprays versus pre-harvest sprays for control of storage rots.

Financial benefits

Significant losses can result from rotting in store. Use of post-harvest fungicides is no longer an option for control. Effective control depends on knowing which rots require control measures and when to apply them. It is clear from the last two seasons when rot risk has been higher due to wet weather in summer that many growers prefer to spray regardless of need rather than make treatment decisions based on risk assessments. This project has identified the main rots responsible for losses which will provide growers with the information needed for successful rot management provided they can obtain the specific orchard rot information for their farm from the fruit packer.

Action points for growers

- It is important for management of storage rots that the losses due to rots for orchards are known and that the fungi responsible for the losses identified. Only one of the pack-houses visited recorded rots during grading. Growers should request that information on rots is provided by their fruit packers.
- The surveys showed that brown rot and Nectria rot are important causes of rotting in store. An estimate of the risk of these rots can be determined from the rot risk assessment system which can be used pre-harvest. Details of the risk assessment system can be found in the Apple Best Practice Guide, available on the HDC website or on the HDC Rot Risk Assessment DVD.
- Similarly the risk of Phytophthora rot can be determined pre-harvest using the rot risk assessment system.
- Nectria rot continues to be an important cause of losses in stored apples. Rot risk assessment can be used to determine the risk and help minimize losses. In addition, control of Nectria canker in the orchard needs to be addressed.
- Gloeosporium rot appears to be increasing in incidence in all cultivars apart from Bramley. Growers should monitor the situation in their orchards as specific control measures may need to be applied.
- Losses due to rots were most significant in stored Bramley, especially those stored long-term. Core rots, mainly caused by *Fusarium* sp, were the most important cause of losses after brown rot. Growers should ensure that treatments to control core rot are applied during blossom and petal fall.

SCIENCE SECTION

Introduction

Storage rot incidence

Fungal rots can result in significant losses in stored apples, particularly in fruit stored beyond January, and increase grading costs. Successful control of storage rots depends on a clear understanding of the rots to be controlled. The current strategy is based on rot surveys from the 1990s when *Nectria*, *Botrytis*, brown rot, *Penicillium, Phytophthora* and *Gloeosporium* were identified as the main rots in apple. Since then the rot profile may have changed due to changes in climate and agronomic practices. Rot trials in orchards at EMR have indicated an increase in incidence of rots such as *Botryosphaeria sp.*, *Phomopsis sp.* and *Colletotrichum sp.* in stored fruit. Whether these are also of increased prevalence in commercial orchards is not known, but it is important to know their incidence as rot control strategies may need to be modified. Growers often report increased rots during fruit grading but rarely identify the rots present. The objective of this project was to conduct surveys of rots in stored apples to re-evaluate rot incidence and to assess the success of the current rot control strategy on commercial farms.

Storage rot control

Until recently, control of storage rots was mainly achieved by the use of post-harvest fungicide drenches that were generally applied regardless of need. Use of post-harvest treatments has declined due to a combination of factors, including reduced efficacy due to fungicide resistance, non-availability of fungicides and dislike by consumers and hence markets. An alternative strategy was developed for rot control based on rot risk assessment to determine whether treatment was needed, the use of orchard sprays where necessary, selective picking at harvest and early marketing of fruit where a high risk of rotting was identified**.** Pre-harvest orchard sprays and selective picking were successful alternative treatments for control of Phytophthora and brown rot, but control of other rots such as Nectria was based on identifying problem orchards and early marketing of fruit. In Defra project HH3232STF the efficacy of treatments applied at blossom and petal fall on rot control, in particular Nectria rot, were evaluated. This treatment timing was based on inoculation studies which showed that fruit was most susceptible to *Nectria galligena* at blossom and petal fall (Xu & Robinson, 2010). Fruit susceptibility declined in summer but increased slightly near harvest**.** The early season treatments were shown to reduce Nectria fruit rot. However, there is a need to compare early season treatments with pre-harvest treatments to establish whether additional late sprays are important in controlling rots. These comparisons were not included in the Defra work.

The concept of rot risk assessment was introduced via the Apple Best Practice Guide in 2001. HDC-funded training courses on rot risk assessment were conducted in 2005 and numerous presentations on storage rots have been made at various grower meetings. Despite this when wet conditions prevail during spring and summer many growers resort to late season sprays and post-harvest treatments. Pre-harvest fungicides applied for rot control are generally applied 2-4 weeks before harvest with a high risk of residues in the fruit. If fungicide treatments pre-harvest were shown to be of no additional benefit then such treatments could be avoided and reduce the risk of pesticide residues in the fruit. Similarly if other control measures, such as selective picking, were shown to be effective in controlling Phytophthora and brown rot then growers would be encouraged to adopt them. There is therefore a need to evaluate early season treatments compared to pre-harvest treatments and integrated control based on rot risk assessment and selective picking.

Overall aim of project

To develop a sustainable, cost effective system for control of storage rots in apple

Specific objectives

1. To identify losses due to rots in commercial orchards and the main fungi responsible for the rots
2. To evaluate the efficacy of fungicides applied at blossom and petal fall compared to sprays applied pre-harvest and treatments based on selective picking for control of storage rots

Summary of previous report

Rot survey

Seven pack-houses were visited weekly from January-March in 2009. Three were located in East Kent and four south of Maidstone. Visits were also made to a pack-house in Hereford. At each visit at least 100 rotted fruit were removed from the rot bin or collected from the grader of fruit that was being graded at the time of the visit. Rots were identified visually and numbers recorded.

Actual losses in Cox and Gala due to rots were very low, less than 2% losses overall, range <0.5-5. Most losses were due to brown rot (*Monilinia fructigena*) which accounted for over a third of losses. *Nectria* accounted for about 20% of losses with *Botrytis* and *Gloeosporium* also being important. *Phytophthora*, *Colletotrichum, Fusarium, Botryosphaeria*, *Phomopsis* and *Mucor* were also recorded at low incidence.

In Braeburn and Jazz harvested in October losses due to rots were negligible but on average most losses were due to brown rot. *Phytophthora, Botrytis, Penicillium*, *Nectria, Gloeosporium, Fusarium* and *Muco*r rots were also recorded.

In Bramley losses due to rots were on average 1.8% (range <1-4%). As with the other cultivars, on average, most of the losses (over 40%) were accounted for by brown rot. *Botrytis, Penicillium, Nectria, Fusarium* and *Phomopsis* rots were also present. Much of the *Fusarium* was present as cheek rots which appeared to have originated from the core.

Losses due to rots in Conference and Comice were on average 1.3% (range 0.5-2.5). Over three quarters of this rotting was accounted for by *Botrytis* and brown rot. The incidence of other rots was very low.

Control of storage rots

In a large plot replicated orchard trial, fungicide treatments of Captan or Bellis (pyraclostrobin + boscalid) applied at blossom and / or pre-harvest were compared to an untreated control for control of storage rots. An additional treatment, where fungicides were applied at blossom and selective picking at harvest was included in place of pre-harvest sprays, was also compared. In this treatment fruit pickers at harvest were instructed to place only undamaged fruit in the bin and to exclude all fruit below knee height (<0.5 metres above the ground) from the bin. This minimizes the risk of introducing fungal rots such as brown rot, Penicillium rot (damaged fruit) or Phytophthora rot (low hanging fruit) into the bin. In the other treatments fruit was harvested as in commercial practice and including low hanging fruit. Fruit was harvested on 10 September and one bin of apples picked per plot. Bins were stored in controlled atmosphere at Cox storage conditions (3.5^{o}C, 1%O_2<1%CO_2) until March and the rots assessed on removal from store.
The incidence of storage rots was low, with just over 2% rotting in total in untreated plots. Overall there was significantly more rotting in untreated plots compared to treated plots. Treatments 3 (pre-harvest sprays only) and 4 (blossom sprays + pre-harvest sprays) had significantly less rots in total than the untreated. The main rots recorded were brown rot, *Botrytis*, *Penicillium*, *Nectria*, *Phomopsis*, *Botryosphaeria* and *Colletotrichum.* Overall significantly less rotting was recorded in treated plots compared to untreated plots for *Nectria*, *Phomopsis* and *Botryosphaeria,* but the incidence of rots was too low for

differences between individual treatments to be identified. There were no significant effects of treatments on brown rot, *Botrytis*, *Penicillium* or *Colletotrichum.*

Materials and methods

Storage rot incidence

Seven pack houses (Table 1) were visited weekly from January-March in 2010 and 2011. Three were located in East Kent and four south of Maidstone. Visits were also made to pack houses in Hereford. Each of these pack houses graded fruit from their own farm and from other farms. So the survey covered fruit from a number of different farms. At each visit at least 100 rotted fruit were removed from the rot bin or collected from the grader of fruit that was being graded at the time of the visit. Rots were identified visually and numbers recorded. Unknown rots were taken back to the laboratory and isolated on to Potato Dextrose Agar (PDA) and identified from spores or characteristic growth in culture.

Table 4. Fruit Pack houses visited weekly in January – March 2010 and 2011

Pack house	Location	Number times visited	
		2010	2011
Newmafruit Farms Ltd	Howfield Farm, Chartham Hatch, Kent	7	8
F W Mansfield & Sons Ltd	Nickle Farm, Chartham, Kent	8	9
A R Neaves & Sons Ltd	Little Sharsted Farm, Doddington, Kent	6	7
The Breach	Goudhurst, Kent	9	9
G H Chambers	Northiam Farm, Horsmonden, Kent	8	6
Bardsley & Sons	River Farm, Staplehurst, Kent	8	9
J L Baxter & Son Ltd	Amsbury Farm, Hunton, Kent	8	9
Wye Fruit Ltd	Ledbury, Herefordshire	2	1
Man of Ross	Ross-on-Wye, Herefordshire	0	1

Control of storage rots

Site: East Malling Research.

Orchard details

The trial was located in orchard TL109, located at Rocks Farm, East Malling Research. The orchard was planted in 1984 and is 0.73 ha in size and consists of Cox on MM106 rootstock with Discovery and Spartan pollinators with 3.5 m between trees in the row and 5.0 m between rows. There is a moderate incidence of Nectria canker in the orchard, which also has a history of brown rot and other storage diseases.

Plot size and experimental design

Each plot consisted of three rows of five Cox trees (15 trees in total). The yield from these should be sufficient to fill one or two bulk bins per plot. Treatments were replicated three times in a randomised block design.

Treatments

The treatments in Table 2 were applied to plots. Fungicide treatments were either applied at blossom and/or pre-harvest. Selective picking at harvest was included in place of pre-harvest sprays in treatment 5. In this treatment fruit pickers at harvest were instructed to place only undamaged fruit in the bin and to exclude all fruit below knee height (<0.5 metres above the ground) from the bin. This minimizes the risk of introducing fungal rots such as brown rot, Penicillium rot (damaged fruit) or Phytophthora rot (low hanging fruit) into the bin. In treatments 1-4 fruit was harvested as in commercial practice and including low hanging fruit.

A standard programme for scab and mildew control was applied to the orchard from bud burst up to the start of treatments. Systhane (myclobutanil) or Nimrod (bupirimate) was applied to all plots for control of powdery mildew. Insecticides were applied to all plots as necessary. Nutrient sprays (including full calcium programme) was also applied to all plots.
All treatments were applied by tractor trailed orchard sprayer at 200 L/ha.

Assessments

Growth stages at application

The phenological stage was recorded at each spray application timing.

Rots

The incidence of Nectria eye rot was recorded in June. The risk and incidence of other rots in the plots was assessed pre-harvest as necessary.

Harvest

At harvest, one or two bins of apples were harvested per plot. Fruit from plots in treatment 5 (plots 1, 6, 11) were selectively picked i.e. no low hanging fruit or damaged fruit were picked. Fruit in all other plots were picked as normal commercial picking. Bins were stored in controlled atmosphere stores at Cox storage conditions (3.5^{o}C, 1%O_2<1%CO_2) until March.

Post store rot assessment

At the end of the storage period the bins were graded individually, the rots removed and identified. Each bin was weighed prior to and after grading and the total weight of rotted apples from each bin was also recorded. The rots were identified visually where possible and also weighed. Unidentified rots were cultured on to Potato Dextrose Agar (PDA) and identified from spores or characteristic culture growth.

Results storage surveys

Weather risks

In 2009, in most months apart from July, rainfall was below average (Table 6). Therefore the risk of rots, in particular Nectria rot, was expected to be low-moderate depending on orchard inoculum incidence. The risk of Phytophthora rot for cultivars picked in September and early October was also expected to be low (Table 7). Phytophthora risk was higher for cultivars picked in mid and late October where rainfall exceeded to threshold of 20 mm of rain in 15 days pre-harvest (Table 7).

In 2010, the risk of rotting was higher with wetter conditions during early fruit development in May and June compared to 2009 (Table 6). Rainfall was exceptionally high in August, September and October giving a high risk of Phytophthora rot for most of the harvest period (Table 7).

Table 5. Fungicide programmes and treatments to be applied to TL109, EMR in 2010

	Treatment	Active ingredient	Product rate per ha	Timing
1	untreated	-	-	-
2	Captan (1 spray)	captan	3.4kg	Full bloom
	Bellis (1 spray)	pyraclostrobin + boscalid	0.8 kg	Full bloom + 10 days
3	Captan (1 spray)	captan	3.4kg	4 weeks and 2 weeks pre-harvest
	Bellis (1 spray)	pyraclostrobin + boscalid	0.8 kg	
4	Captan (1 spray)	captan	3.4kg	Full bloom
	Bellis (1 spray)	pyraclostrobin + boscalid	0.8 kg	Full bloom + 10 days
	Captan (1 spray)	captan	3.4kg	4 weeks and 2 weeks pre-harvest
	Bellis (1 spray)	pyraclostrobin + boscalid	0.8 kg	
5	Captan (1 spray)	captan	3.4kg	Full bloom
	Bellis (1 spray)	pyraclostrobin + boscalid	0.8 kg	Full bloom + 10 days Selective picking at harvest

Table 6. Monthly rainfall (mm) recorded at EMR in March to October in 2006, 2007, 2008, 2009 and 2010 compared to 50 year average

Month	2006	2007	2008	2009	2010	50 year average
March	40.4	51.0	97.8	41.2	43.8	44.3
April	70.8	0.8	50.0	34.4	10.8	44.5
May	77.0	85.0	67.8	24.2	37.0	45.8
June	8.4	67.4	22.2	27.2	49.6	49.7
July	11.0	117.8	55.8	60.0	25.6	46.4
August	40.8	40.8	60.8	20.8	83.0	52.0
September	42.0	25.4	50.8	26.4	52.4	63.7
October	24.2	9.4	54.2	46.8	71.8	65.6

Storage rot incidence

Apple – Cox, Gala, Egremont Russet, Cameo – 2009/2010

In the rot survey conducted in January-March 2010 (Tables 8 and 9), the below average rainfall for much of the spring and summer resulted in losses due to rots in cv. Cox being low-moderate - around 2% (range 0.1-20%). Losses in cvs. Gala, Egremont Russet and Cameo (Tables 11 and 12) were on average around 1% (range 0.1-2%). Most losses were due to brown rot (*Monilinia fructigena*) which accounted for about half of the losses. *Nectria* accounted for up to 20% or more of losses with *Gloeosporium* also important. The risk of phytophthora rot was low for fruit picked in September and this rot was not present in most fruit sampled. *Penicillium, Colletotrichum, Fusarium, Botryosphaeria*, and *Mucor* were also recorded.

Table 7. Risk of Phytophthora rot in 2009 and 2010 – rainfall in 15 days pre-harvest, >20 mm = risk

Harvest date	Rain in 15 days pre-harvest 2009	2010
1 September	3.6	59.4
5 September	10.4	59.4
10 September	9.8	22.0
15 September	25.6	28.8
20 September	16.4	29.2
25 September	17.0	9.0
30 September	0.8	23.6
5 October	8.4	65.6
10 October	37.8	63.6
15 October	38.2	47.4
20 October	34.8	10.6
31 October	9.2	24.4
% apple samples with Phytophthora	**19**	**65**

Apple – Cox, Gala, Egremont Russet, Cameo – 2010/2011

The risk of rots was higher in 2010, especially pre-harvest. Moderate losses due to rots were recorded in Cox – average 2% (range 0.5-4%) and Egremont Russet – average 4% (range 3-5%) (Tables 15 and 19). Losses in Gala and Cameo were <1% (range 0.1-3%) (Tables 18 and 19). Brown rot was again the most important cause of rotting, accounting for one third of losses. Nectria rot was responsible for more than 25% of losses and Gloeosporium rot was also important. As expected from the weather risk pre-harvest, the incidence of Phytophthora rot was higher in 2010 than in 2009 with the rot recorded in most samples examined.

Apple – Braeburn, Jazz – 2009/2010

In Braeburn and Jazz, harvested in October, (Table 10) losses due to rots were negligible. On average most losses in cv. Braeburn were due to brown rot. Botrytis and Penicillium rots were also important. Fruit picked in October was also at risk from *Phytophthora* (Table 7) which was recorded in 50% of samples of Braeburn and Jazz. *Nectria, Gloeosporium* and *Muco*r were also recorded.

Apple – Braeburn, Jazz, Jonagored – 2010/2011

In Braeburn, Jazz and Jonagored, harvested in October, (Tables 16, 17 and 19) losses due to rots were negligible. On average most losses in cv. Braeburn were due to brown rot. Botrytis and Penicillium rots were also important. Fruit picked in October was also at risk from *Phytophthora* (Table 7) which was recorded in almost all samples of Braeburn, Jazz and Jonagored. *Nectria, Gloeosporium* and *Muco*r were also recorded.

Apple – Bramley – 2009/2010

Losses due to rots (Table 13) were on average 3% (range 0.1-7.5%). As with the other cultivars, on average, most of the losses (over 40%) were accounted for by brown rot. *Botrytis, Penicillium, Nectria, Fusarium* and *Phomopsis* were also present. Much of the *Fusarium,* which was the second most important rot recorded, was present as cheek rots which appeared to have originated from the core.

Apple – Bramley – 2010/2011

Losses due to rots (Table 20) were on average 2% (range 0.8-5.5%). Again more than 40% of rotting was accounted for by brown rot. *Penicillium, Nectria, Fusarium* and *Phomopsis* were also present. *Fusarium* was the second most important rot recorded and was associated with core rot.

Pear – Conference and Comice – 2009/2010

Losses due to rots were on average 1% (range 0.1-3.5%) (Table 14). Over three quarters of this rotting was accounted for by *Botrytis* and brown rot. Penicillium rot was the next most important rot. The incidence of other rots was very low.

Pear – Conference and Comice – 2010/2011

Losses due to rots were on average 1.2% (range 0.1-3.3%) (Table 21). Up to 70% of the rotting was due to brown rot and Botrytis rot. Penicillium and Mucor rots were also present. The incidence of other rots was very low.

General discussion rot surveys

The rot surveys reported here are obviously only sampling a very small proportion of fruit in store. However, by carrying out the visits over a three month period and visiting several pack houses the information obtained does give indication of the range of rots present on stored fruit. In addition it should be noted that all of the fruit samples examined are likely to have been treated with fungicides for rot control as they are from commercial orchards. Rot incidence and losses would most likely have been considerably higher in fruit from untreated orchards.

It was also noted that only one of the pack houses visited in any of the three years kept formal records of losses due to rots during grading or identified the rots present.

In rot surveys conducted between 1995 and 2000 (Berrie, 1997) losses due to rots ranged from an average of 1.5-5.6%. Most losses were due to brown rot (*Monilinia fructigena*) but Botrytis eye rot was also important and Nectria rot increasing in significance from 1998-2000. Phytophthora rot was important in 1995 when there was significant rain fall during the harvest period. In the surveys conducted here average losses were around <1-4% for Cox, and Egremont Russet and exceptionally low for the newer cultivars Gala, Cameo, Braeburn and Jazz which were not present in the earlier surveys. In Bramley losses were on average 2-3% which was in general higher than that recorded previously.

Between 1995 and 2000 most apples would have been treated with a post-harvest fungicide prior to storage. Since such treatments are now no longer available losses in the current survey would therefore have been expected to be on average higher. Reasons for these low losses could be due to several factors, including fungicide application in late blossom to control Nectria rot, pre-harvest fungicides and better management of fruit at harvest, including use of Smart Fresh (1-MCP) to delay ripening by inhibiting ethylene production.

Although the latter could also increase rotting as ethylene is involved in defence mechanisms in the plant and its inhibition could prevent these being triggered.

As in the earlier surveys, most rotting was caused by brown rot. Brown rot caused by the fungus *Monilinia fructigena*, also causes losses in the orchard pre-harvest which are never recorded and so losses noted after storage probably do not reflect the true importance of this fungus. The fungus is usually introduced into the store as symptomless-infected fruit. The rot then develops in store and spreads by contact to adjacent fruit forming a nest of rots. The rot was well controlled by post-harvest fungicide drenches. Pre-harvest fungicide sprays are rarely effective. The fungus gains entry to the ripening fruits through wounds such as scab or russet cracks or insect holes, especially codling moth stings. Controlling the source of the wounds has usually proved more effective in preventing brown rot. However, careful selection of fruit at harvest has also been shown to reduce brown rot in store by reducing the amount of symptomless infected fruit introduced into the bin.

Nectria rot was also causing significant losses and was the second most important cause of losses in all cultivars. This rot can be reduced by fungicide sprays during late blossom and early fruitlet (Xu & Robinson, 2010). Effective fungicides are limited. Control of Nectria canker is also important. Previous research has also shown that storage temperature has an effect on the incidence of Nectria rot in store with storage at lower temperatures of 1.5-2^{o}C consistently reducing the incidence of Nectria rot compared to storage at higher temperatures of 3.5-4^{o}C. (Berrie *et al*, 2011). This probably explains why cultivars such as Gala (stored at 1.5-2^{o}C), where the incidence of Nectria canker in the orchard is in general high compared to Cox and Bramley (stored at 3.5-4^{o}C) have much lower losses due to rots.

The incidence of Gloeosporium rots was generally low, but accounted for 1-2% of losses in some consignments of Cox in 2009 and up to 2.5% loss in some consignments in 2010. The incidence of Gloeosporium rot in 2009 and 2010 was higher than in 2008 and present in most cultivars except Bramley, which does not appear to be susceptible to this fungus. Gloeosporium rot was the most important cause of losses in stored Cox in the 1960s and 1970s but incidence declined to negligible levels in 1980s and 1990s. Gloeosporium is the most important rot in store in apples in other parts of Europe. It would appear from the survey results over the three years that this rot is increasing in incidence in the UK (Table 25). This could have implications for fungicide control. Currently most growers do not put on specific treatments for control of Gloeosporium. Previous research in the 1960s and 1970s showed that the best spray timing for Gloeosporium rot control was for three sprays starting at about a month pre-harvest. Such treatments would result in significant residues in the fruit. There are two main species of Gloeosporrium – *G. album* and *G. perennans.* Both species are generally found causing rots in the UK but at present the relative incidence of the two species is not known. A third species – *Gloeosporium fructigenum* – was reclassified as *Colletotrichum* spp and is also increasing in incidence but mainly on Bramley and possibly Cameo.

Fungal rots such as Nectria and Gloeosporium are present at harvest as latent infections which subsequently develop as rots in store. Generally they do not appear as rots in store until late December / January and thereafter increase in incidence. Thus the potential losses due to rots will increase the longer the fruit is stored. Currently, both Gala and Braeburn are generally marketed by February but there is a need to extend the storage period to deal with increasing volumes of these two cultivars from new orchard plantings. It is therefore likely that losses due to rots will increase in future.

Other rots such as *Fusarium*, *Botryosphaeria* and *Phomopsis*, present at trace incidence in the 1995-2000 surveys, have increased in incidence.

The incidence of rots in Bramley was generally higher than that in previous surveys. Brown rot was the main cause of losses but of increasing importance was Fusarium rot, mainly associated with core rots. Bramley is stored from September – August and hence any latent infections, such as Nectria or core rots, which develop slowly, have the potential to cause high losses if the fruit is held until August. The survey reported here only contained one fruit sample from August and losses were almost 5%. Fusarium from core rots and brown rot were the main fungi responsible for the losses. However, this sample was from an orchard where the incidence of Nectria rot is low. The current advice to growers is not to long term store fruit from orchards with a high Nectria canker incidence. The increase in incidence of Fusarium rot is of some concern as many species of Fusarium, particularly those causing diseases on cereals, are known to produce mycotoxins. A recent investigation in Slovenia on wet core rots in apples cvs. Gloster, Jonagold and Fuji identified *F. avenaceum* as the main cause of the rots and showed high levels of mycotoxins present in apples with wet core rot (Sorenson et al, 2009). There is a need to identify the *Fusarium* species responsible for rotting in Bramley and investigate their potential as mycotoxin producers.

Losses due to rots in pears were low – around 1%. Botrytis and brown rot were the main cause of losses. In the earlier surveys Botrytis rot accounted for more than 70% of the losses. In the current surveys brown rot is often at a higher incidence. The use of Rovral (iprodione) as a post-harvest drench is still permitted (EAMU) on pears. In addition most pears are now stored at low temperature in controlled atmosphere, which could also account for the lower incidence of Botrytis rot. Botrytis and brown rot are both fungi that gain entry via wounds at or near harvest and therefore have the potential to be controlled by the use of post-harvest drenches with biocontrol agents. Trials are in progress as part of the Sceptre project to identify potential products.

Table 8. Losses due to rots and rot incidence in apples cv. Cox in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other	% Loss estimated
NFF	15 Jan	5 Sep	61.4	9.1	0	13.6	2.3	13.6	0	0	0	0	0	0	2.0
River Farm	20 Jan	?	84.2	0	0	5.3	1.8	1.8	0	0	1.8	3.5	0	1.8	3.0
Chambers	20 Jan	?	45.2	5.8	0	12.5	20.2	15.4	0	0	0	0	0	1.0	0.5
Amsbury	20 Jan	28 Sep	100	0	0	0	0	0	0	0	0	0	0	0	20.0
NFF	21 Jan	4 Sep	26.7	3.3	0	1.7	6.7	51.6	0	0	0	0	0	0	2.5
Neaves	21 Jan	14 Sep	66.7	0	0	18.5	7.4	0	3.7	0	0	3.7	0	0	0.15
River Farm	26 Jan	1 Sep	63.9	0	0	22.2	0	11.1	0	0	0	2.8	0	0	0.5
Neaves	28 Jan	?	79.9	1.4	0	0.7	5.8	9.4	0	0	0	1.4	0	0	3.0
Jan Mean			**66.0**	**2.5**	**0**	**9.3**	**5.5**	**12.9**	**0.5**	**0**	**0.5**	**1.4**	**0**	**0.4**	**4.0**
River Farm	2 Feb	5 Sep	74.1	1.2	0	17.3	0	7.4	0	0	0	0	0	0	3.0
Mansfield	4 Feb	?	12.9	18.8	4.0	1.0	54.5	7.0	0	0	1.0	0	0	1.0	1.0
Chambers	10 Feb	?	73.9	10.1	1.4	2.9	8.7	0	0	0	0	1.4	0	1.4	0.5
Amsbury	10 Feb	29 Sep	24.4	6.7	0	13.3	5.6	50.0	0	0	0	0	0	0	4.0
Mansfield	12 Feb	?	33.3	4.8	0	4.8	14.3	38.2	0	4.8	0	0	0	0	0.1
Neaves	17 Feb	10 Sep	39.7	1.7	0	12.1	31.0	6.9	0	1.7	0	5.2	0	1.7	2.0
Mansfield	17 Feb	14 Sep	66.0	10.6	0	4.3	11.7	3.2	0	0	0	3.2	0	1.1	0.5
NFF	17 Feb	1 Sep	70.8	4.2	0	8.3	13.3	0	0	0	0	3.3	0	0	2.5

Table 9. Losses due to rots and rot incidence in apples cv. Cox in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010 continued

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other	% Loss estimated
River Farm	18 Feb	8 Sep	61.8	2.6	0	9.2	11.8	2.6	0	0	0	5.3	0	6.5	1.5
River Farm	24 Feb	8 Sep	35.9	3.9	0	42.7	5.8	7.8	0	0	0	1.0	0	2.9	2.0
Amsbury	24 Feb	?	0	12.8	0	20.5	35.9	25.6	0	0	0	5.1	0	0	?
Mansfield	25 Feb	?	34.5	9.9	0	11.3	34.5	8.5	0.7	0	0	0.7	0	0	4.0
Feb mean			**43.9**	**7.3**	**0.5**	**12.3**	**18.9**	**13.1**	**0.06**	**0.5**	**0.08**	**2.1**	**0**	**1.2**	**1.9**
Chambers	10 March	?	62.3	7.8	0	7.8	10.2	7.2	0	0	0	4.2	0	0.2	1.25
Mansfield	12 March	7 Sep	13.5	1.4	0	1.4	56.8	23.0	0	0	0	2.7	0	1.4	7.5
Chambers	17 March	?	70.5	16.7	0	9.0	1.3	2.6	0	0	0	0	0	0	1.9
Amsbury	17 March	8 Sep	63.4	2.4	0	15.9	6.1	7.3	0	0	0	4.9	0	0	3.5
March mean			**52.4**	**7.1**	**0**	**8.5**	**18.6**	**10.0**	**0**	**0**	**0**	**3.0**	**0**	**0.4**	**3.5**
Overall mean			**52.7**	**5.6**	**0.2**	**10.7**	**14.4**	**12.5**	**0.2**	**0.3**	**0.1**	**2.0**	**0**	**0.7**	**2.8**
Wye Fruit	19 Feb	?	6.9	2.3	0	0	49.4	40.2	0	0	0	0	0	0	0.5
Wye Fruit	23 March	?	19.1	2.2	0	3.4	6.7	67.4	1.1	0	0	0	0	31.6	0.5
Overall mean			**13.0**	**2.3**	**0**	**1.7**	**28.1**	**53.8**	**0.6**	**0**	**0**	**0**	**0**	**15.8**	**0.5**

Table 10. Losses due to rots and rot incidence in apples cv. Jazz and Braeburn in 2009 assessed during grading at various pack houses in Kent in January-March 2010

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other rot	% Loss estimated
Jazz															
NFF	15 Jan	26 Oct	23.5	29.4	23.5	0	0	0	23.5	0	0	0	0	0	0.1
NFF	21 Jan	22 Oct	8.1	33.9	27.4	21.0	1.6	8.1	0	0	0	0	0	0	0.5
Mansfield	12 March	5 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Mean			**15.8**	**31.7**	**25.5**	**10.5**	**0.8**	**4.1**	**11.8**	**0**	**0**	**0**	**0**	**0**	**0.2**
Braeburn															
Mansfield	14 Jan	?	100	0	0	0	0	0	0	0	0	0	0	0	0.02
Mansfield	21 Jan	?	0	0	0	100	0	0	0	0	0	0	0	0	0.05
Mansfield	28 Jan	18 Oct	0	0	0	0	0	0	0	0	0	0	0	0	0
NFF	28 Jan	26 Oct	57.1	7.9	14.3	14.3	1.6	4.8	0	0	0	0	0	0	0.5
NFF	28 Jan	19 Oct	40.4	32.7	0	23.1	0	1.9	1.9	0	0	0	0	0	0.5
NFF	25 Feb	10 Oct	25.0	6.3	60.4	4.2	4.2	0	0	0	0	0	0	0	0.5
Neaves	12 March	12 Oct	11.1	27.8	5.6	22.2	5.6	22.3	0	0	5.6	0	0	0	0.1
Mean			**38.9**	**12.5**	**13.4**	**27.3**	**1.9**	**4.8**	**0**	**0**	**1.3**	**0**	**0**	**0**	**0.2**

Table 11. Losses due to rots and rot incidence in apples cv. Gala in 2009 assessed during grading at various pack houses in Kent in January-March 2010

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other rot	% Loss estimated
Gala															
The Breach	20 Jan	?	92.9	0	0	0	7.1	0	0	0	0	0	0	0	0.5
The Breach	20 Jan	?	51.4	4.3	0	7.1	37.1	0	0	0	0	0	0	0	1.5
The Breach	26 Jan	16 Oct	68.0	0	2.0	6.0	10.0	6.0	0	0	0	0	0	0	1.0
Amsbury	26 Jan	23 Sep	42.5	0	0	10.0	30.0	2.5	0	0	15.0	0	0	0	0.5
Jan Mean			**63.7**	**1.1**	**0.5**	**5.8**	**21.1**	**2.1**	**0**	**0**	**3.8**	**0**	**0**	**0**	**0.9**
The Breach	2 Feb	23 Oct	52.0	4.1	0	13.3	26.5	3.1	0	0	1.0	0	0	0	0.4
The Breach	10 Feb	?	23.1	21.2	0	13.5	42.3	0	0	0	0	0	0	0	0.1
NFF	12 Feb	19 Sep	39.6	8.3	2.1	16.7	25.0	8.3	0	0	0	0	0	0	1.5
The Breach	18 Feb	?	48.0	0	0	2.7	41.3	2.7	0	2.7	0	0	0	2.7	1.5
The Breach	18 Feb	18 Sep	100.0	0	0	0	0	0	0	0	0	0	0	0	0.1
Amsbury	18 Feb	12 Sep	54.2	4.2	0	4.2	37.5	0	0	0	0	0	0	0	0.1
The Breach	24 Feb	19 Sep	61.3	5.3	0	0	30.7	2.7	0	0	0	0	0	0	0.5
The Breach	25 Feb	18 Sep	56.9	6.2	3.1	10.8	21.5	1.5	0	0	0	0	0	0	1.5
Feb Mean			**54.4**	**6.2**	**0.7**	**7.7**	**28.1**	**2.3**	**0**	**0.3**	**0.1**	**0**	**0**	**0.3**	**0.7**
The Breach	10 March	14 Sep	20.5	2.4	0	4.8	72.3	0	0	0	0	0	0	0	2.0
Amsbury	10 March	17 Sep	30.2	6.3	3.2	11.1	14.3	34.9	0	0	0	0	0	0	0.5
NFF	12 March	?	65.7	2.0	2.0	9.1	17.2	4.0	0	0	0	0	0	0	2.0
March Mean			**38.8**	**3.6**	**1.7**	**8.3**	**34.6**	**13.0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.5**
Overall Mean			**53.8**	**4.3**	**0.8**	**7.3**	**27.5**	**4.4**	**1.1**	**0.2**	**0**	**0**	**0**	**0.2**	**1.0**

Table 12. Losses due to rots and rot incidence in apples cv. Egremont Russet and Cameo in 2009 assessed during grading at various pack houses in Kent in January-March 2010

Pack-house	**Date assessed**	**Date picked**	**Brown rot**	**Botrytis**	**Phytophthora**	**Penicillium**	**Nectria**	**Gloeosporium**	**Colletotrichum**	**Fusarium**	**Mucor**	**Botryosphaeria**	**Phomopsis**	**Other rot**	**% Loss estimated**
Egremont Russet															
Mansfield	14 Jan	9 Sep	81.8	0	0	4.5	13.6	0	0	0	0	0	0	0	0.5
Mansfield	4 Feb	?	83.3	16.7	0	0	0	0	0	0	0	0	0	0	0.5
Mansfield	12 March	10 Sep	41.7	0	0	25.0	25.0	8.3	0	0	0	0	0	0	1.5
Mean			**68.9**	**5.6**	**0**	**9.8**	**12.9**	**2.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0.8**
Cameo															
NFF	15 Jan	30 Sep	15.7	5.7	0	20.0	7.1	42.9	0	8.6	0	0	0	0	1.0

Table 13. Losses due to rots and % rot incidence in apples cv. Bramley's Seedling in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010 (figures for core rots underlined are not included in the rot incidence totals)

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Core rot	Other	% Loss estimated
Mansfield	21 Jan	?	24.1	0	0	27.6	17.2	0	0	20.7	10.3	0	0	**13.8**	0	1.5
Mansfield	28 Jan	?	22.1	0	1.2	38.4	19.8	0	1.2	15.1	0	0	0	**7.0**	0	1.75
Jan mean			**23.1**	**0**	**0.6**	**33.0**	**18.5**	**0**	**0.6**	**17.9**	**5.2**	**0**	**0**	**10.4**	**0**	**1.6**
Chambers	2 Feb	?	65.0	0.8	0	4.1	4.9	0	0	21.1	0	0	4.1	**8.9**	0	2.5
Amsbury	2 Feb	27 Aug	21.9	0	0	22.9	12.4	0	0	38.1	0	0	2.9	**30.5**	1.9	2.5
The Breach	10 Feb	24 Sep	42.4	0	0	23.7	1.7	0	0	25.4	0	0	0	**11.9**	0	2.5
Amsbury	18 Feb	?	70.4	0	0	12.7	2.8	0	2.8	5.6	0	0	2.8	**1.4**	1.0	2.0
Chambers	18 Feb	?	43.5	0	0	8.7	8.7	0	0	30.4	0	0	0	**8.7**	8.7	2.0
Chambers	24 Feb	?	29.2	0	0	7.5	10.0	0	19.2	23.3	0	0	0	**31.7**	10.0	3.5
Amsbury	24 Feb	21 Sep	47.5	0	0	7.5	10.0	0	0	17.5	0	0	10.0	**12.5**	0	0.1
Feb Mean			**45.7**	**0.1**	**0**	**12.4**	**7.2**	**0**	**3.1**	**23.1**	**0**	**0**	**2.8**	**15.1**	**3.1**	**2.2**
River Farm	10 March	8 Sep	41.7	0	0	7.7	9.6	0	8.3	31.4	0	0	1.2	**22.4**	0	4.0
River Farm	17 March	11 Sep	64.8	0	0	9.5	4.8	0.5	2.9	17.1	0	0	0	**11.9**	0	4.0
The Breach	17 March	5 Sep	48.3	0	0	10.8	4.2	0	2.5	20.8	0	0	15.0	**14.2**	0.8	7.5
March mean			**51.6**	**0**	**0**	**9.3**	**6.2**	**0.2**	**4.6**	**23.1**	**0**	**0**	**5.4**	**16.2**	**0.3**	**5.2**
The Breach	6 Aug	?	39.9	0	0	17.3	1.2	0	0	38.2	0	0	0.6	**24.3**	2.9	4.9
Overall mean			**43.1**	**0.06**	**0.09**	**15.3**	**8.3**	**0.04**	**2.8**	**23.4**	**0.8**	**0**	**2.8**	**15.3**	**1.9**	**3.0**

Table 13. Losses due to rots and % rot incidence in apples cv. Bramley's Seedling in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010 – continued (figures for core rots underlined are not included in the rot incidence totals)

Packhouse	**Date assessed**	**Date picked**	**Brown rot**	**Botrytis**	**Phytophthora**	**Penicillium**	**Nectria**	**Gloeosporium**	**Colletotrichum**	**Fusarium**	**Mucor**	**Botryosphaeria**	**Phomopsis**	**Core rot**	**Other**	**% Loss estimated**
Wye Fruit	19 Feb	?	19.0	0	0	46.6	10.3	0	0	5.2	1.7	0	0	**5.2**	12.1	?
Wye Fruit	23 March	?	36.8	0	0	7.9	23.7	0	0	0	0	0	0	**7.9**	23.7	?
Overall mean			**27.9**	**0**	**0**	**27.3**	**17.0**	**0**	**0**	**2.6**	**0.9**	**0**	**0**	**6.6**	**17.9**	**?**

Table 14. Losses due to rots and % rot incidence in pears cv. Conference and Comice in 2009 assessed during grading at various pack houses in Kent in January-March 2010

Pack-house	Date assessed	Date Picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Alternaria	Fusarium	Mucor	Potebniamyces	Phomopsis	Other	% Loss estimated
Conference															
Amsbury	20 Jan	?	24.3	62.2	0	0	0	0	0	0	13.5	0	0	0	1.5
Mansfield	21 Jan	?	50.0	50.0	0	0	0	0	0	0	0	0	0	0	0.1
Chambers	26 Jan	?	14.4	36.5	0	26.0	0	0	0	0	0	1.0	0	22.1	0.5
Mansfield	28 Jan	?	32.7	38.8	0	2.0	2.0	0	6.1	8.2	6.1	0	0	4.1	0.5
Jan Mean			**30.4**	**46.9**	**0**	**7.0**	**0.5**	**0**	**1.5**	**2.1**	**4.9**	**0.3**	**0**	**6.6**	**0.7**
River Farm	10 Feb	7 Sep	50.0	22.7	0	9.1	0	0	18.1	0	0	0	0	0	0.1
Neaves	12 Feb	3 Sep	0	23.4	0	31.9	2.1	4.3	19.1	6.4	10.6	0	0	0	1.5
NFF	12 Feb	7 Sep	21.4	71.4	0	3.6	0	0	3.6	0	0	0	0	0	0.1
Mansfield	12 Feb	?	46.2	38.5	0	15.4	0	0	0	0	0	0	0	0	0.1
Mansfield	17 Feb	30 Aug	26.3	57.9	0	3.9	1.3	0	1.3	3.9	5.3	0	0	0	3.0
NFF	12 Feb	4 Sep	25.5	63.6	0	0	0	0	9.1	0.9	0	0	0	0.9	3.5
Neaves	25 Feb	7 Sep	32.7	30.8	0	23.1	0	0	9.6	0	0	3.8	0	0	0.1
Mansfield	25 Feb	?	52.8	35.2	0	5.6	0	0	1.9	2.8	0	1.9	0	0	1.5
Feb Mean			**31.9**	**42.9**	**0**	**11.6**	**0.4**	**0.5**	**7.8**	**1.8**	**2.0**	**0.7**	**0**	**0.1**	**1.2**
Overall mean			**31.4**	**44.3**	**0**	**10.1**	**0.5**	**0.4**	**5.7**	**1.9**	**3.0**	**0.6**	**0**	**1.9**	**1.0**
Comice															
Mansfield	4 Feb	?	28.6	71.4	0	0	0	0	0	0	0	0	0	0	0.5

Table 15. Losses due to rots and rot incidence in apples cv. Cox in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other	% Loss estimated
Chambers	13 Jan	?	30.4	1.3	0	2.5	53.2	12.7	0	0	0	0	0	0	0.5
Chambers	20 Jan	?	45.7	10.3	0	3.4	21.6	18.1	0	0	0	0	0	0.9	2.2
River Farm	20 Jan	10 Sep	50.7	2.7	2.7	12.0	20.0	0	0	0	8.0	1.3	0	2.7	0.5
Mansfield	21 Jan	19 Sep	57.6	21.2	1.2	15.3	1.2	1.2	0	0	0	1.2	0	1.2	0.5
Jan Mean			**46.1**	**8.9**	**1.0**	**8.3**	**24.0**	**8.0**	**0**	**0**	**2.0**	**0.6**	**0**	**1.2**	**0.9**
The Breach	1 Feb	8 Sep	77.5	8.5	0	0.8	13.2	0	0	0	0	0	0	0	2.0
Chambers	1 Feb	?	51.7	2.6	0	4.3	26.7	13.8	0	0	0	0	0	0.9	2.2
Amsbury	1 Feb	17 Sep	42.3	4.6	6.9	13.1	18.5	13.8	0	0	0.8	0	0	0	1.5
River Farm	1 Feb	15 Sep	63.2	9.4	5.1	8.5	6.8	6.0	0	0	0	0.9	0	0	0.5
Mansfield	10 Feb	17 Sep	52.8	16.7	1.9	13.9	13.9	0	0	0	0	0.9	0	0	1.0
NFF	10 Feb	10 Sep	45.3	8.6	2.3	9.4	27.3	3.9	3.1	0	0	0	0	0	2.5
Mansfield	17 Feb	16 Sep	7.8	2.6	2.6	2.6	83.1	1.3	0	0	0	0	0	0	2.5
Neaves	17 Feb	23 Sep	45.6	1.9	1.0	3.9	27.2	19.4	0	0	1.0	0	0	0	2.5
Chambers	18 Feb	?	68.5	8.2	0	1.4	12.3	9.6	0	0	0	0	0	0	1.5
Mansfield	23 Feb	22 Sep	50.8	3.4	5.1	5.1	33.9	1.7	0	0	0	0	0	0	2.1
Chambers	25 Feb	?	54.6	5.2	0	4.1	16.5	19.6	0	0	0	0	0	0	1.5
Feb Mean			**50.9**	**6.5**	**2.3**	**6.1**	**25.4**	**8.1**	**0.3**	**0**	**0.2**	**0.2**	**0**	**0.1**	**1.8**

Table 15. Losses due to rots and rot incidence in apples cv. Cox in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011 (continued)

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other	% Loss estimated
Mansfield	10 March	10 Sep	29.0	1.6	1.6	6.5	54.8	6.5	0	0	0	0	0	0	3.0
Mansfield	10 March	13 Sep	17.9	1.8	0	3.6	12.5	64.3	0	0	0	0	0	0	4.0
River Farm	11 March	10 Sep	30.9	8.2	9.3	7.2	17.5	18.6	0	0	4.1	4.1	0	0	1.0
Mansfield	17 March	16 Sep	2.8	11.1	1.4	0	34.7	50.0	0	0	0	0	0	0	5.0
River Farm	18 March	9 Sep	11.1	7.2	50.3	2.6	23.5	4.6	0	0	0	0	0	0.7	2.1
Mansfield	25 March	16 Sep	63.9	4.9	0	1.6	23.0	6.6	0	0	0	0	0	0	4.0
Neaves	25 March	16 Sep	26.2	4.8	0	9.5	33.3	26.2	0	0	0	0	0	0	1.0
March mean			**26.0**	**5.7**	**8.9**	**4.4**	**28.3**	**25.3**	**0**	**0**	**0.6**	**0.6**	**0**	**0.1**	**2.9**
Overall mean			**42.1**	**6.7**	**4.2**	**6.0**	**26.1**	**13.5**	**0.1**	**0**	**0.6**	**0.4**	**0**	**0.3**	**2.0**
Herefordshire															
Mansfield (Clive)	21Jan	17 Sep	29.1	25.5	12.7	3.6	14.5	14.5	0	0	0	0	0	0	1.0
Wye Fruit	27 Jan	15 Sep	11.2	12.4	5.6	5.6	15.7	47.2	0	0	0	1.1	0	1.1	2.2
Man of Ross	27 Jan	?	70.2	8.3	4.8	13.1	2.4	1.2	0	0	0	0	0	0	2.3
Overall mean			**36.8**	**15.4**	**7.7**	**7.4**	**10.9**	**21.0**	**0**	**0**	**0**	**0.4**	**0**	**0.4**	**1.8**

Table 16. Losses due to rots and rot incidence in apples cv. Braeburn in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other rot	% Loss estimated
The Breach	20 Jan	21 Oct	35.6	15.6	8.9	6.7	13.3	11.1	0	0	6.7	0	0	2.2	0.2
Amsbury	20 Jan	21 Oct	10.5	73.7	10.5	0	0	5.3	0	0	0	0	0	0	0.1
Neaves	21 Jan	6 Oct	25.0	25.0	0	0	0	0	0	25.0	25.0	0	0	0	0.1
Mansfield	21 Jan	23 Nov	34.1	23.5	23.5	2.4	1.2	0	0	0	15.3	0	0	0	0.1
Jan Mean			**26.3**	**34.5**	**10.7**	**2.3**	**3.6**	**4.1**	**0**	**6.3**	**11.8**	**0**	**0**	**0.6**	**0.1**
Mansfield	3 Feb	10 Nov	3.0	22.7	18.2	28.8	0	1.5	0	0	25.8	0	0	0	1.5
River Farm	11 Feb	29 Oct	12.3	21.1	8.8	29.8	7.0	12.3	0	0	8.8	0	0	0	0.1
Mansfield	23 Feb	20 Oct	22.7	9.1	45.5	9.1	0	4.5	0	0	9.1	0	0	0	0.1
River Farm	25 Feb	15 Oct	36.4	13.6	9.1	13.6	9.1	4.5	0	0	13.6	0	0	0	0.9
Feb Mean			**18.6**	**16.6**	**20.4**	**20.3**	**4.0**	**5.7**	**0**	**0**	**14.3**	**0**	**0**	**0**	**0.7**
Mansfield	3 March	28 Oct	35.1	12.2	12.2	9.5	6.8	10.8	0	0	13.5	0	0	0	0.5
Neaves	3 March	27 Oct	38.5	30.8	0	0	0	30.8	0	0	0	0	0	0	0.2
NFF	3 March	21 Oct	2.1	14.9	25.2	17.0	8.5	29.8	0	0	2.1	0	0	0	0.7
Mansfield	10 March	29 Oct	2.3	3.4	55.2	25.3	3.4	10.3	0	0	0	0	0	0	0.3
Mansfield	10 March	29 Oct	7.4	11.1	44.4	18.5	11.1	0	0	0	7.4	0	0	0	0.1
Mansfield	17 March	15 Oct	3.1	33.3	17.7	11.5	0	34.4	0	0	0	0	0	0	0.5
Mansfield	17 March	25 Oct	4.0	58.7	13.3	12.0	6.7	4.0	0	0	0	0	1.3	0	0.33

Table 16. Losses due to rots and rot incidence in apples cv. Braeburn in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011 (continued)

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytop-hthora	Penicillium	Nectria	Gloeo-sporium	Colleto-trichum	Fusarium	Mucor	Botryo-sphaeria	Phomopsis	Other rot	% Loss estimated
Mansfield	25 March	19 Oct	0	0	90.9	0	0	9.1	0	0	0	0	0	0	0.1
March Mean			**11.6**	**20.6**	**32.4**	**11.7**	**4.6**	**16.2**	**0**	**0**	**2.9**	**0**	**0.2**	**0**	**0.3**
Overall Mean			**17.0**	**23.0**	**24.0**	**11.5**	**4.2**	**10.5**	**0**	**1.6**	**8.0**	**0**	**0.08**	**0.1**	**0.4**
Hereford															
Man of Ross	27 Jan	?	15.6	41.6	3.9	26.0	3.9	9.1	0	0	0	0	0	0	0.13

Table 17. Losses due to rots and rot incidence in apples cv. Jazz in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryo-sphaeria	Phomopsis	Other rot	% Loss estimated
NFF	3 March	9 Oct	4.3	8.5	25.5	1.1	22.3	38.3	0	0	0	0	0	0	0.5
NFF	10 March	14 Oct	10.4	3.0	6.0	7.5	58.2	14.9	0	0	0	0	0	0	0.2
NFF	17 March	8 Oct	0	26.2	0	15.4	32.3	26.2	0	0	0	0	0	0	0.1
Overall Mean			**4.9**	**12.6**	**10.5**	**8.0**	**37.6**	**26.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0.3**
Hereford Jazz	17 Feb	26 Oct	13.5	27.0	21.6	24.3	8.1	5.4	0	0	0	0	0	0	0.1

Table 18. Losses due to rots and rot incidence in apples cv. Gala in 2010 assessed during grading at various pack houses in Kent in January-March 2011

Pack-house	**Date assessed**	**Date picked**	**Brown rot**	**Botrytis**	**Phytophthora**	**Penicillium**	**Nectria**	**Gloeosporium**	**Colletotrichum**	**Fusarium**	**Mucor**	**Botryosphaeria**	**Phomopsis**	**Other rot**	**% Loss estimated**
The Breach	13 Jan	29 Sep	30.6	6.3	43.2	1.8	16.2	0	0	0	0.9	0.9	0	0	1.0
Mansfield	3 Feb	20 Sep	7.8	11.7	7.8	3.9	68.8	0	0	0	0	0	0	0	0.1
NFF	3 Feb	24 Sep	54.2	4.2	0	12.5	4.2	8.3	0	16.7	0	0	0	0	0.25
Mansfield	10 Feb	25 Sep	47.5	11.9	28.8	1.7	6.8	3.4	0	0	0	0	0	0	0.1
The Breach	11 Feb	15 Sep	72.9	7.3	9.4	1.0	6.3	2.1	0	0	1.0	0	0	0	0.5
NFF	17 Feb	?	32.4	9.5	25.7	8.1	21.6	2.7	0	0	0	0	0	0	0.1
The Breach	18 Feb	22 Sep	53.6	5.2	3.1	3.1	32.0	2.1	0	0	0	0	0	1.0	1.0
The Breach	25 Feb	?	21.0	5.7	4.8	1.0	67.6	0	0	0	0	0	0	0	2.5
Feb Mean			**41.3**	**7.9**	**24.2**	**4.5**	**29.6**	**2.7**	**0**	**2.4**	**0.1**	**0**	**0**	**0.1**	**0.7**
Mansfield	3 March	25 Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
Mansfield	3 March	25 Sep	6.0	2.0	49.5	32.3	8.1	1.0	0	1.0	0	0	0	0	2.5
Mansfield	10 March	29 Sep	0	0	6.1	4.1	87.8	0	0	2.0	0	0	0	0	1.0
NFF	10 March	27 Sep	17.6	0	7.8	3.9	70.6	0	0	0	0	0	0	0	0.3
Amsbury	11 March	27 Sep	75.9	0	5.1	0	7.6	0	0	0	11.4	0	0	0	1.0
Mansfield	17 March	28 Sep	28.6	8.6	8.6	2.9	48.6	2.9	0	0	0	0	0	0	0.25
The Breach	18 March	25 Sep	24.6	4.6	6.2	1.5	56.9	1.5	0	0	1.5	0	0	3.0	1.0
Mansfield	25 March	29 Sep	85.3	0	10.5	2.1	1.1	1.1	0	0	0	0	0	0	1.5
NFF	25 March	24 Sep	17.7	5.1	6.3	13.9	50.6	5.1	0	0	0	0	0	1.3	0.7

Table 18. Losses due to rots and rot incidence in apples cv. Gala in 2010 assessed during grading at various pack houses in Kent in January-March 2011 (continued)

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Other rot	% Loss estimated
The Breach	29 March	23 Sep	7.2	2.1	13.4	1.0	74.2	1.0	0	0	0	0	0	1.0	3.0
March Mean			**26.3**	**2.2**	**11.4**	**6.2**	**40.6**	**1.3**	**0**	**0.3**	**1.3**	**0**	**0**	**0.5**	**1.1**
Overall Mean			**32.4**	**4.7**	**13.1**	**5.3**	**34.9**	**1.7**	**0**	**1.1**	**0.8**	**0.05**	**0**	**0.4**	**0.9**

Table 19. Losses due to rots and rot incidence in apples cv. Egremont Russet, Cameo, Ida Red and Jonagored in 2010 assessed during grading at various pack houses in Kent in January-March 2011 (figures for core rots underlined are not included in the rot incidence totals)

Pack-house	Date assessed	Date picked	Brown Rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Core rot	Other rot	% Loss estimated
Egremont Russet															
River Farm	18 Feb	20 Sep	56.1	4.3	0	28.0	1.2	9.8	0	0	0	0	**0**	0.6	5.0
Amsbury	29 March	20 Sep	17.8	0	0	4.7	50.0	27.5	0	0	0	0	**0**	0	3.0
Overall Mean			**37.0**	**2.2**	**0**	**16.4**	**25.6**	**18.7**	**0**	**0**	**0**	**0**	**0**	**0.3**	**4.0**
Cameo															
River Farm	13 Jan	4 Oct	38.5	0	7.7	0	0	0	0	46.2	7.7	0	**46.2**	0	0.1
NFF	21 Jan	14 Oct	20.0	7.5	10.0	22.5	2.5	5.0	0	32.5	0	0	**30.0**	0	0.1
NFF	10 Feb	12 Oct	58.7	4.3	4.3	2.2	0	13.0	0	17.4	0	0	**17.4**	0	1.5
Overall Mean			**39.1**	**3.9**	**7.3**	**8.2**	**0.8**	**6.0**	**0**	**32.0**	**2.6**	**0**	**31.2**	**0**	**0.6**
Ida Red															
Mansfield	17 Feb	20 Oct	2.8	13.9	44.4	8.3	30.6	0	0	0	0	0	0	0	1.0
Jonagored															
Mansfield	10 Feb	11 Oct	31.8	40.9	22.7	4.5	0	0	0	0	0	0	0	0	0.05

Table 20. Losses due to rots and % rot incidence in apples cv. Bramley's Seedling in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011 (figures for core rots underlined are not included in the rot incidence totals)

Pack-house	Date assessed	Date picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Colletotrichum	Fusarium	Mucor	Botryosphaeria	Phomopsis	Core rot	Other	% Loss estimated
Amsbury	13 Jan	3 Sep	73.5	1.0	0	7.8	10.8	0	0	3.9	0	0	1.0	2.9	2.0	1.0
NFF	21 Jan	27 Aug	69.8	2.3	0	9.3	2.3	0	0	1.2	0	0	15.1	1.2	0	0.8
Jan mean			**71.7**	**1.7**	**0**	**8.6**	**6.6**	**0**	**0**	**2.6**	**0**	**0**	**8.1**	**2.1**	**1.0**	**0.9**
Mansfield	3 Feb	6 Sep	33.7	2.0	3.1	3.1	10.2	0	12.2	11.2	3.1	0	20.4	1.0	0	2.5
Mansfield	10 Feb	26 Aug	12.5	7.5	0	42.5	10.0	0	0	25.7	0	0	0	10.0	0	0.1
Chambers	11 Feb	?	70.1	0	0	4.5	4.5	0	0	6.0	0	0	14.9	4.5	0	2.0
Amsbury	11 Feb	8 Sep	72.4	3.4	0	5.7	8.0	0	0	9.2	1.1	0	0	5.7	0	3.0
Mansfield	17 Feb	1 Sep	15.5	0	6.9	25.9	6.9	0	0	8.6	0	0	36.2	8.6	0	1.5
Amsbury	18 Feb	3 Sep	30.8	8.4	0	9.8	11.9	5.6	0	25.2	0	0	8.4	9.1	0	3.5
Amsbury	25 Feb	13 Sep	19.8	0	0	27.9	15.1	0	0	14.0	15.1	0	7.0	4.7	1.2	1.7
Feb Mean			**36.4**	**3.0**	**1.4**	**17.1**	**9.5**	**0.8**	**1.7**	**14.3**	**2.8**	**0**	**12.4**	**6.2**	**0.2**	**2.0**
Mansfield	3 March	20 Sep	12.3	1.8	1.8	12.3	42.1	0	0	26.3	0	0	3.5	7.0	0	2.0
The Breach	11 March	9 Sep	54.9	0	0	5.5	1.1	0	0	16.5	0	0	22.0	2.2	0	5.5
The Breach	11 March	10 Sep	90.0	0	0	5.0	5.0	0	0	0	0	0	0	0	0	3.0
Mansfield	17 March	2 Sep	33.3	22.2	0	0	0	0	0	0	0	0	22.2	22.2	22.2	1.0
NFF	17 March	23 Aug	60.0	0	0	20.0	0	0	0	20.0	0	0	0	20.0	0	1.0
Amsbury	18 March	6 Sep	37.3	0	0	6.7	41.0	0	0	11.2	0	0	3.7	9.0	0	2.2
Mansfield	25 March	10 Sep	36.4	0	0	9.1	6.1	0	0	48.5	0	0	0	6.1	0	1.7
March mean			**46.3**	**3.4**	**0.3**	**8.4**	**13.6**	**0**	**0**	**17.5**	**0**	**0**	**7.3**	**9.5**	**3.2**	**2.3**
Overall mean			**45.1**	**3.0**	**0.7**	**12.2**	**10.9**	**0.4**	**0.8**	**14.2**	**1.2**	**0**	**9.7**	**7.1**	**1.6**	**2.0**

Table 21. Losses due to rots and % rot incidence in pears cv. Conference and Comice in 2010 assessed during grading at various pack houses in Kent in January-March 2011

Pack-house	Date assessed	Date Picked	Brown rot	Botrytis	Phytophthora	Penicillium	Nectria	Gloeosporium	Alternaria	Fusarium	Mucor	Potebniamyces	Phomopsis	Other	% Loss estimated
Conference															
NFF	3 Feb	10 Sep	26.3	30.3	0	17.1	9.2	0	3.9	0	7.9	5.3	0	0	1.0
Neaves	3 Feb	?	29.7	37.5	0	7.8	17.2	0	0	0	7.8	0	0	0	0.2
Mansfield	3 Feb	9 Sep	14.3	28.6	0	28.6	0	0	0	0	28.6	0	0	0	0.1
Mansfield	10 Feb	6 Sep	59.0	36.1	0	1.2	1.2	0	2.4	0	0	0	0	0	1.0
Neaves	10 Feb	10 Sep	50.0	32.1	0	14.3	3.6	0	0	0	0	0	0	0	0.5
Mansfield	17 Feb	?	33.3	45.8	0	12.5	1.0	0	0	0	7.3	0	0	0	1.5
Feb Mean			**35.4**	**35.1**	**0**	**13.6**	**5.4**	**0**	**3.2**	**0**	**8.6**	**0.9**	**0**	**0**	**0.7**
Neaves	10 March	7 Sep	45.1	19.5	0	8.5	8.3	0	6.2	0	4.9	2.4	0	6.0	3.0
NFF	25 March	8 Sep	35.6	57.8	0	4.4	2.2	0	0	0	0	0	0	0	3.3
River Farm	29 March	6 Sep	24.5	14.3	0	4.1	6.1	0	0	0	51.0	0	0	0	0.1
March Mean			**35.1**	**30.5**	**0**	**5.7**	**5.5**	**0**	**2.1**	**0**	**18.6**	**0.8**	**0**	**2.0**	**2.1**
Overall Mean			**35.3**	**33.6**	**0**	**10.9**	**5.4**	**0**	**1.4**	**0**	**11.9**	**0.9**	**0**	**0.7**	**1.2**
Comice															
NFF	10 Feb	9 Oct	7.7	76.9	0	0	3.8	11.5	0	0	0	0	0	0	5.0

Results and Discussion - Control of storage rots

Treatments

The dates treatments were applied are shown in Table 22. Treatments were all applied on the same day.

Weather

In 2010, the risk of rotting was moderate with wetter conditions during early fruit development in May and June compared to 2009 (Table 7). Rainfall was exceptionally high in August, September and October giving a high risk of phytophthora rot for most of the harvest period (Table 6). Unfortunately on May 11 during blossom there was a late frost (-0.7^{o}C) recorded at which temperatures remained below zero for several hours overnight resulting in frosted blooms and poor fruit set. The poor fruit set resulted in low fruit numbers in plots in the middle of the tree rows which were most exposed in the centre of the orchard and higher fruit numbers in plots at the ends of the rows where the trees were sheltered by the windbreaks.

Orchard rots

The incidence of *Nectria* eye rot in the orchard was very low and not recorded. For pre-harvest brown rot (Table 24) there was an indication of a treatment effect. No individual treatment had any significant effect on brown rot compared to the untreated control but comparing time of treatment (p=0.026) indicating that the treatments applied pre-harvest appeared to give a significant reduction in brown rot in the orchard. These effects were not carried over into the incidence of brown rot in store (Table 25). This result is unusual as in general, from previous work fungicides applied pre-harvest have very little effect on the incidence of brown rot. Usually the best results are obtained from controlling the insects or scab that cause the damage that provides entry points for the brown rot.

Assessment of storage rots

Fruit was harvested on 16 September and stored until March 2011. The rots present in each bin were assessed separately. The bin was first weighed and then tipped on to a sorting table and the rots removed identified and the number and weight of each rot type present recorded. Rot incidence was expressed as percentage rots by weight for each bin.

In general the incidence of storage rots was relatively low with just over 3% rotting in total in untreated plots (Table 25). Most of the rotting was due to brown rot (2.0 %), followed by

Nectria rot (0.6%) in untreated plots. Botrytis, Penicillium, Gloeosporium, Phomposis, Botryosphaeria and Colletotrichum rots were also present but at negligible levels. Overall there was no significant effect of treatment on the incidence of any of the rots in store.

Recent work has shown that Nectria infection of fruit mainly occurs during late blossom and petal fall (Xu & Robinson, 2010). Rainfall during this period was low and not favourable for fruit infection (Table 23). Hence insufficient rotting was recorded after storage for meaningful conclusions to be drawn.

Table 22. Treatment application dates in 2010

Growth stage and planned spray schedule	Spray application date
Late bloom	14 May
10 days later	25 May
28 days pre-harvest	19 August
14 days pre-harvest	2 September

Table 23. Rainfall and rain days recorded before and after the treatment periods in 2010

Treatment timing/spray date	Rainfall (mm) in 14 days before treatment	No. of rain days in 14 days before treatment	Rainfall (mm) in 14 days after treatment	No. of rain days in 14 days after treatment
14 May	22.0	8	11.4	5
25 May	8.6	4	26.0	7
19 August	22.6	8	59.2	8
2 September	59.2	8	28.8	11

Table 24. Mean % losses (angular transformed) due to brown rot (pre-harvest) in Cox apples in orchard TL109 following treatment with various fungicide programmes applied at blossom and / or pre-harvest in 2010. Figures in brackets are back transformed means data

Treatment	% fruit infected with brown rot at harvest
1 Untreated	15.0 (6.7)
2 Captan / Bellis blossom only	15.3 (7.0)
3 Captan / Bellis pre-harvest only	7.5 (1.7)
4 Captan / Bellis blossom + pre-harvest	6.3 (1.2)
5 Captan / Bellis blossom only selective picking at harvest	12.9 (5.0)
F Prob	0.197
SED (8)	4.31
LSD (P=0.05)	9.94

Table 25. Mean % losses (angular transformed) due to various rots in Cox apples in orchard TL109 following treatment with various fungicide programmes applied at blossom and / or pre-harvest in 2010. Fruit was stored at 3.5°C in controlled atmosphere conditions for six months. Figures in brackets are back transformed means data

Treatment	Brown rot	*Botrytis*	*Penicillium*	*Nectria*	*Gloeo-sporium*	*Phomopsis*	*Botryo-sphaeria*	*Colleto-trichum*	Total rots
1 Untreated	8.2 (2.0)	1.9 (0.1)	1.0 (0.03)	4.5 (0.6)	(0.02)(	(0.10)	(0.04)	(0.1)	10.2 (3.1)
2 Captan / Bellis blossom only	7.5 (1.7)	1.7 (0.09)	1.1 (0.03)	2.2 (0.2)	0	0	(0.14)	(0.34)	9.3 (2.6)
3 Captan / Bellis pre-harvest only	7.2 (1.6)	2.4 (0.18)	1.6 (0.08)	3.5 (0.4)	(0.03)	0	0	0	9.0 (2.4)
4 Captan / Bellis blossom + pre-harvest	5.9 (1.1)	1.2 (0.05)	2.1 (0.13)	2.7 (0.2)	0	0	(0.18)	(0.08)	7.8 (1.8)
5 Captan / Bellis blossom only selective picking at harvest	9.9 (3.0)	2.6 (0.21)	1.1 (0.04)	2.1 (0.1)	(0.26)	0	0	(0.11)	11.7 (4.1)
F Prob	0.401	0.914	0.936	0.455					0.383
SED (8)	1.924	1.622	1.549	1.387					1.875
LSD (P=0.05)	4.437	3.741	3.572	3.199					4.323

Overall project conclusions

Rot survey

- The losses due to rots for all the cultivars over the three years are summarised in Tables 26-28
- Actual losses in Cox due to rots were low to moderate on average 1.8-2.8 over the three years of the survey. The overall range of losses from the three years was 0.1-20%, indicating that actual losses due to rots were very variable depending on orchard site
- Most losses were due to brown rot (*Monilinia fructigena*) which accounted for up to 50% of the rots. *Nectria* accounted for about 20% of losses with *Botrytis* and *Gloeosporium* also important and Phytophthora important in some samples in 2008 and 2010 when rainfall was significant pre-harvest
- *Colletotrichum, Fusarium, Botryosphaeria*, *Phomopsis* and *Mucor* were recorded at low incidence
- Losses in Egremont Russet were similar to those in Cox and ranged from 0.8-4 % over the three years
- Losses due to rots in Gala were low (1% or less). Brown rot and *Nectria* were the main fungi responsible with *Phytophthora* important in 2008 and 2010 when rainfall was significant pre-harvest. *Gloeosporium*, *Colletotrichum, Fusarium, Botryosphaeria*, and *Mucor* were recorded at low incidence
- In Braeburn and Jazz, harvested in October losses due to rots were negligible (0.1-0.9%). On average most losses were due to brown rot and *Botrytis*. *Phytophthora* was also important in all three years as weather conditions for apples harvested in October were generally wet. *Penicillium, Nectria, Gloeosporium, Fusarium* and *Mucor* were also recorded
- In Bramley losses due to rots ranged on average from 1.6-3%. As with the other cultivars, on average, most of the losses (over 40%) were accounted for by brown rot. *Fusarium* was also important. Much of the *Fusarium* was present as cheek rots which appeared to have originated from the core. *Botrytis, Penicillium, Nectria,* and *Phomopsis* were also present
- The risk of Phytophthora rot was significant for all cultivars in 2010 and for cultivars picked in October in all three years. The risk is reflected in the number of apple samples in which Phytophthora rot was present (Table 29)

- The incidence of Gloeosporium rot (Table 30) increased in all cultivars, apart from Bramley, over the three years of the survey. In most cases, although the rot was present it was not causing significant losses. However, in some samples of Cox it accounted for 1-2% of losses in 2009 and up to 2.5% loss in some consignments in 2010. Gloeosporium rot is obviously increasing in importance and may need specific control measures to be applied
- Losses due to rots in Conference and Comice were on average around 1%. Over three quarters of this rotting was accounted for by *Botrytis* and brown rot. The incidence of other rots was very low

Control of storage rots

- The incidence of storage rots was low in both years with around 2-3% rotting in total in untreated plots. Therefore it is difficult to draw any meaningful conclusions from the trial regarding the efficacy of early season sprays versus pre-harvest sprays for control of storage rots
- In 2009 overall there was significantly more rotting in untreated plots compared to treated plots
- Treatments 3 (pre-harvest sprays only) and 4 (blossom and pre-harvest sprays) had significantly less rots in total than the untreated
- The main rots recorded were brown rot, *Botrytis*, *Penicillium*, *Nectria*, *Phomopsis*, *Botryosphaeria* and *Colletotrichum*
- In general most rotting was recorded in the untreated plots apart from *Penicillium*
- Overall significantly less rotting was recorded in treated plots compared to untreated plots for *Nectria*, *Phomopsis* and *Botryosphaeria* but the incidence of rots was too low for differences between individual treatments to be identified
- There were no significant effects of treatments on brown rot, *Botrytis*, *Penicillium* or *Colletotrichum*
- In 2010 a late frost in blossom resulted in poor fruit set and low numbers of apples at harvest. The incidence of rots in store was low and none of the treatments had any significant effects
- No individual treatment had any significant effect on brown rot in the orchard pre-harvest but overall the treatments applied pre-harvest appeared to give a significant

reduction in brown rot in the orchard. These effects were not carried over into the brown rot in store

Table 26. Summary of losses due to rots and % rot incidence in various apple cultivars in 2008 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2009

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Bramley (Kent)	Bramley (Herefordshire)
Brown rot	32.2	18.3	20.4	41.0	33.3	47.3	42.3	8.0
Botrytis	15.0	9.3	10.1	14.9	30.7	3.0	3.3	0
Phytophthora	1.8	5.3	20.2	2.6	0.3	0	1.6	0
Penicillium	8.2	1.7	3.3	14.3	6.7	13.7	13.7	1.0
Nectria	28.1	11.0	22.6	6.9	6.0	22.3	13.2	12.0
Gloeosporium	12.2	48.3	0	0.8	3.0	12.7	0	0
Colletotrichum	1.2	0	0	0	0	0	0.5	49.0
Fusarium	0.4	0	1.8	2.5	0	1.0	12.4	30.0
Mucor	0.8	0	1.5	4.6	0	0	0.5	0
Botryosphaeria	0.3	0.3	0	0	0	0	0.3	0
Phomopsis	0.1	6.0	0	0	0	0	7.2	0
Other	0	0	0	0	0	0	0.1	0
No. of samples	23	3	5	8	5	3	11	1
Mean Loss	1.8	<1.0	<0.5	0.9	0.1	1.5	1.6	?
Range	<0.5-5.5	<1.0	<0.5-1.0	0-4.8	0-<1.0	1.0-2.0	<1.0-4.0	

Table 27. Summary of losses due to rots and % rot incidence in various apple cultivars in 2009 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2010

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Cameo	Bramley (Kent)	Bramley (Herefordshire)
Brown rot	52.7	13.0	53.8	38.9	15.8	68.9	15.7	43.1	27.9
Botrytis	5.6	2.3	4.3	12.5	31.7	5.6	5.7	0.06	0
Phytophthora	0.2	0	0.8	13.4	25.5	0	0	0.09	0
Penicillium	10.7	1.7	7.3	27.3	10.5	9.8	20.0	15.3	27.3
Nectria	14.4	28.1	27.5	1.9	0.8	12.9	7.1	8.3	17.0
Gloeosporium	12.5	53.8	4.4	4.8	4.1	2.8	42.9	0.04	0
Colletotrichum	0.2	0.6	1.1	0	11.8	0	0	2.8	0
Fusarium	0.3	0	0.2	0	0	0	8.6	23.4	2.6
Mucor	0.1	0	0	1.3	0	0	0	0.8	0.9
Botryosphaeria	2.0	0	0	0	0	0	0	0	0
Phomopsis	0	0	0	0	0	0	0	2.8	0
Other	0.7	15.8	0.2	0	0	0	0	1.9	17.9
No. of samples	24	2	15	7	3	3	1	13	2
Mean Loss	2.8	0.5	1.0	0.2	0.2	0.8	1.0	3.0	?
Range	0.1-20.0	0.5	0.1-2.0	0-0.5	0.01-0.5	0.5-1.5	1.0	0.1-7.5	

Table 28. Summary of losses due to rots and % rot incidence in various apple cultivars in 2010 assessed during grading at various pack houses in Kent and Herefordshire in January-March 2011

Fungal rot	Cox (Kent)	Cox (Hereford)	Gala	Braeburn	Jazz	Egremont Russet	Ida Red	Jonagored	Cameo	Bramley
Brown rot	42.1	36.8	32.4	17.0	4.9	37.0	2.8	31.8	39.1	45.1
Botrytis	6.7	15.4	4.7	23.0	12.6	2.2	13.9	40.9	3.9	3.0
Phytophthora	4.2	7.7	13.1	24.0	10.5	0	44.4	22.7	7.3	0.7
Penicillium	6.0	7.4	5.3	11.5	8.0	16.4	8.3	4.5	8.2	12.2
Nectria	26.1	10.9	34.9	4.2	37.6	25.6	30.6	0	0.8	10.9
Gloeosporium	13.5	21.0	1.7	10.5	26.5	18.7	0	0	6.0	0.4
Colletotrichum	0.1	0	0	0	0	0	0	0	0	0.8
Fusarium	0	0	1.1	1.6	0	0	0	0	32.0	14.2
Mucor	0.6	0	0.8	8.0	0	0	0	0	2.6	1.2
Botryosphaeria	0.4	0.4	0.05	0	0	0	0	0	0	0
Phomopsis	0	0	0	0.08	0	0	0	0	0	9.7
Other	0.3	0.4	0.4	0.1	0	0.3	0	0	0	1.6
No. of samples	22	3	18	16	3	2	1	1	3	16
Mean Loss	2.0	1.8	0.9	0.4	0.3	4.0	1.0	0.05	0.6	2.0
Range	0.5-4.0	1.0-2.3	0.1-3.0	0.1-1.5	0.1-0.5	3.0-5.0	-	-	0.1-1.5	0.1-5.5

Table 29. Risk of Phytophthora rot in 2008, 2009 and 2010 – rainfall in 15 days pre-harvest, >20 mm = risk

Harvest date	Rain in 15 days pre-harvest		
	2008	**2009**	**2010**
1 September	15.6	3.6	59.4
5 September	29.8	10.4	59.4
10 September	42.0	9.8	22.0
15 September	42.6	25.6	28.8
20 September	15.8	16.4	29.2
25 September	4.4	17.0	9.0
30 September	8.2	0.8	23.6
5 October	25.2	8.4	65.6
10 October	28.0	37.8	63.6
15 October	25.4	38.2	47.4
20 October	18.6	34.8	10.6
31 October	28.8	9.2	24.4
% apple samples with Phytophthora	44	19	66

Table 30. Percentage of apple samples assessed in which Gloeosporium rots were present in rot surveys 2008-2010

Cultivar	2008	2009	2010
Cox	77	85	88
Gala	0	60	61
Braeburn	13	43	88
Jazz	20	33	100
Cameo	-	100	67
Egremont Russet	0	33	100
Total % of apple* samples in survey with Gloeosporium	**47**	**67**	**79**

*****Excludes Bramley as this cultivar appears to have very low susceptibility to Gloeosporium

Knowledge and Technology Transfer

The results of the rot survey were reported at the EMRA / Marden Fruit Show Society in March 2010, March 2011 and March 2012. The results will also be presented at the BIFGA Technical Day in January 2013. They have also been reported in HDC Top Fruit Review.

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Appendix

Table 31. Plot data for post-harvest rots and pre-harvest brown rot for TL109 in 2010

Apple TL109 Spray timing for rot control HDC TF193 2010						Weight in Kg								% pre-harvest
Plot	**Block**	**Treat-ment**	**Fruit Wt**	**Rot Wt**	**Brown rot**	**Botrytis**	**Penicillium**	**Nectria**	**Gloeo.**	**Colleto.**	**Botryosp.**	**Phomops.**		**Brown rot**
1	1	2	228.5	6.1	3.6	0.2	0.1	1.1	0	1	0.4	0		5.8
4	1	5	101	4.3	3.1	0.4	0	0.35	0.25	0	0	0		4
7	1	4	216.5	3.1	2.5	0	0	0.2	0	0.5	0	0		5.7
10	1	3	197	3.65	1.75	1.2	0.15	0.4	0	0	0	0		4.2
13	1	1	155	5.2	3.4	0.3	0.4	1	0.1	0.1	0	0		11.8
2	2	1	85	4.3	2.9	0.25	0	0.8	0	0.2	0.1	0.25		4.7
5	2	2	70.5	1.25	1.1	0.25	0	0	0	0	0	0		3.6
8	2	5	94	2.1	1.2	0	0.3	0.25	0	0.3	0	0		4.2
11	2	4	95	1.65	1.1	0.4	0.1	0.1	0	0	0.1	0		0.8
14	2	3	109.5	2.7	1.4	0.25	0.35	0.45	0.1	0	0	0		3.4
3	3	4	34	0.8	0.3	0	0.2	0.2	0	0	0.15	0		0
6	3	3	46.5	1.4	1.35	0	0	0.25	0	0	0	0		0
9	3	1	62	0.9	0.55	0	0	0.2	0	0	0	0		4.7
12	3	2	87.5	3.1	1.7	0	0.1	0.2	0	0.5	0.2	0		13
15	3	5	37	2.3	1.9	0.2	0	0	0.2	0	0	0		6.9