Grower Summary

TF 193

Apple - Sustainable management of storage rots

Final 2012

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

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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.