FOOD STANDARDS AGENCY

PESTICIDE RESIDUE MINIMISATION

CROP GUIDE

PEARS

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November 2006

Contents

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Every effort is made to ensure that the information provided in these guides is accurate. The information contained within the guides was correct to the best of the author's knowledge up to March 2006. No legal responsibility is accepted for any errors, omissions or misleading statements.

The guide offers broad approaches to be explored further. They are not intended to be used as detailed protocols and it would be advisable for users to consider the guidance in relation to an integrated crop management system.

Up-to-date information on pesticide regulations is available on the Pesticides Safety Directorate's website (www.pesticides.gov.uk). However, approvals and MRLs are subject to change over time and the users of the guide are reminded that it is their responsibility to ensure that any chemical intended for use by them is approved for use at the time of intended application. The user is reminded to carefully read the label attached to any chemical product and follow the instructions regarding application.

Products are mentioned as examples of those that contain particular active ingredients and no endorsement is intended.

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Preface

Why choose pears for pesticide residue minimisation?

The FSA has a policy of pesticide residue minimisation because it recognises that people want residues reduced further than the current safe levels. Therefore the crop guides have not been produced because of any food safety concerns but with the aim of meeting people's choice in the food they buy. Further information on the rationale for the crop guides and on the safety of pesticides can be found in the General Introduction.

In producing the crop guides the FSA focussed on UK production because it is more practicable, in the first instance, to apply guidance at home than abroad. Pears show some similarities in pest and disease control with apples (the subject of a parallel guide) and monitoring shows that each year some of the crop contains pesticide residues, albeit at safe levels.

Much work has been done by those involved in the UK food industry to keep pesticide residues to a minimum. Many of the measures recommended in this guide have already being adopted by growers. The FSA hopes to build on this body of knowledge, to help to maintain the momentum to keep residues to a minimum.

FSA Pesticide Residue Minimisation

Crop Guide – Pears

1. Introduction

1.1 Crop description

The cultivated pear belongs to the genus *Pyrus*, which appears to have arisen from three centres of diversity: a Chinese centre, with forms of *Pyrus pyrifolia* and *Pyrus ussuriensis* with Asian pears having been domesticated from *P. pyrifolia*; a centre in the Caucasus Mountains and Asia Minor from where the domesticated forms and hybrids of *Pyrus communis* arose; and a Central Asian centre where *Pyrus communis* and its hybrids occur. Pear fruits have been cultivated for thousands of years and gathered from the wild before that.

Nowadays, pears are grown in orchards with known varieties being grown on rootstocks which have been selected for their agronomic qualities, such as size control, tolerance of soil conditions and pest and disease tolerance. Varieties are selected for fruit quality, eating attributes, storage potential and agronomic traits, such as yield, fruit size distribution, and tolerance to pest, disease and disorders. Whilst there are a range of varieties that are characteristic of particular fruit growing areas of the world, increasingly the market is dominated by those grown in the major production areas. This enables marketing organisations to source fruit to supply customers over most of the year from a combination of UK and overseas orchards.

Orchards have an economic life of 20 to 25 years. Pear trees can however have a much longer life, sometimes exceeding 100 years. Orchards are often surrounded by windbreaks, which provide protection from strong winds and minimise drift from sprays applied for crop protection purposes. Trees are grown in strips of bare earth, maintained with the help of herbicides, with grass alleyways between the tree rows. Often weeds are allowed to develop later in the season within the row in an attempt to reduce rain splash from the ground reaching the fruit. Whilst early UK varieties may be marketed immediately after picking, most are stored in cold stores prior to marketing. Over-winter storage has been practised for hundreds of years using simple structures and clamps. However, advances in storage technology since the 1950's have resulted in the use of refrigerated cold stores and in some cases this is combined with the atmospheric control of levels of oxygen and carbon dioxide. This allows fruit to be held in good condition for prolonged periods. Some cultivars are capable of being stored in these conditions for almost a complete year e.g. Conference.

1.2 Uses and markets

Dessert and perry pears are grown in the UK but no distinct cooking pears are grown. The major variety is Conference with limited volumes of Comice and Concorde. Other varieties are primarily grown as pollinators. There is little development of new varieties of pear in the UK, although new varieties are likely to become part of the UK market in the near future from imported sources. Perry represents a very minor part of the total market for pears, being much less significant than the part cider plays in the apple market.

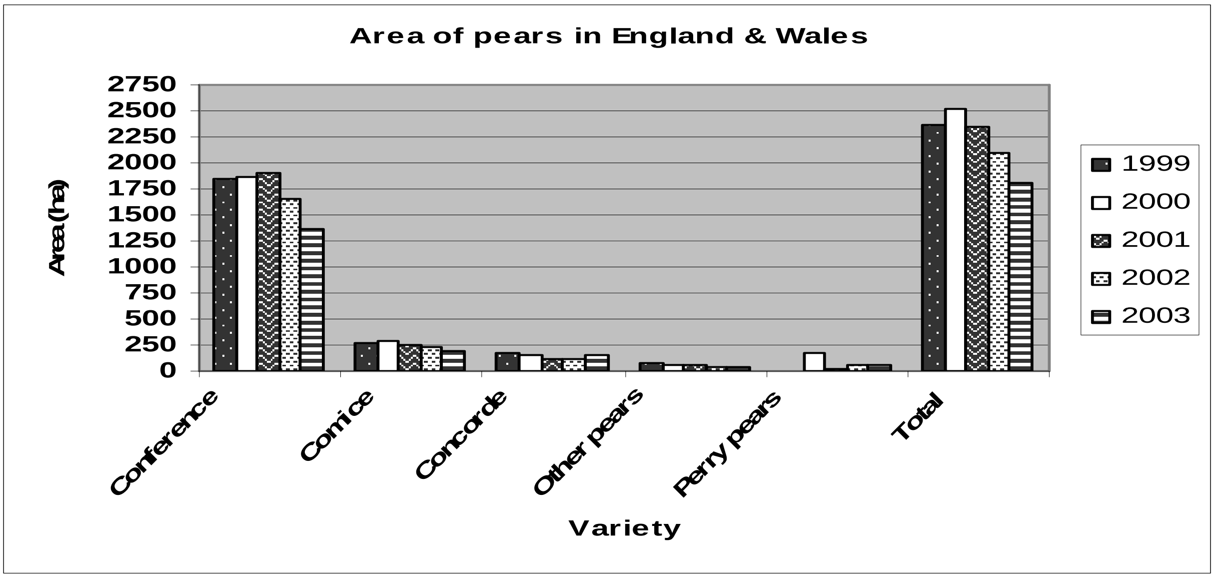
Conference pears from UK orchards tend to be available from September to May, with Comice from October to February, and Concorde from November to January. Limited volumes of Williams are available in September and October.

Few pears are used for juice and only a small volume is processed. Most processors use imported fruit.

1.3 Area grown in the UK, volume produced and value

The total orchard area in England and Wales in 2003 was 17,671 ha of which 10.2% was pears (including perry pears) compared with apples, which represented 44% of the total national orchard area.

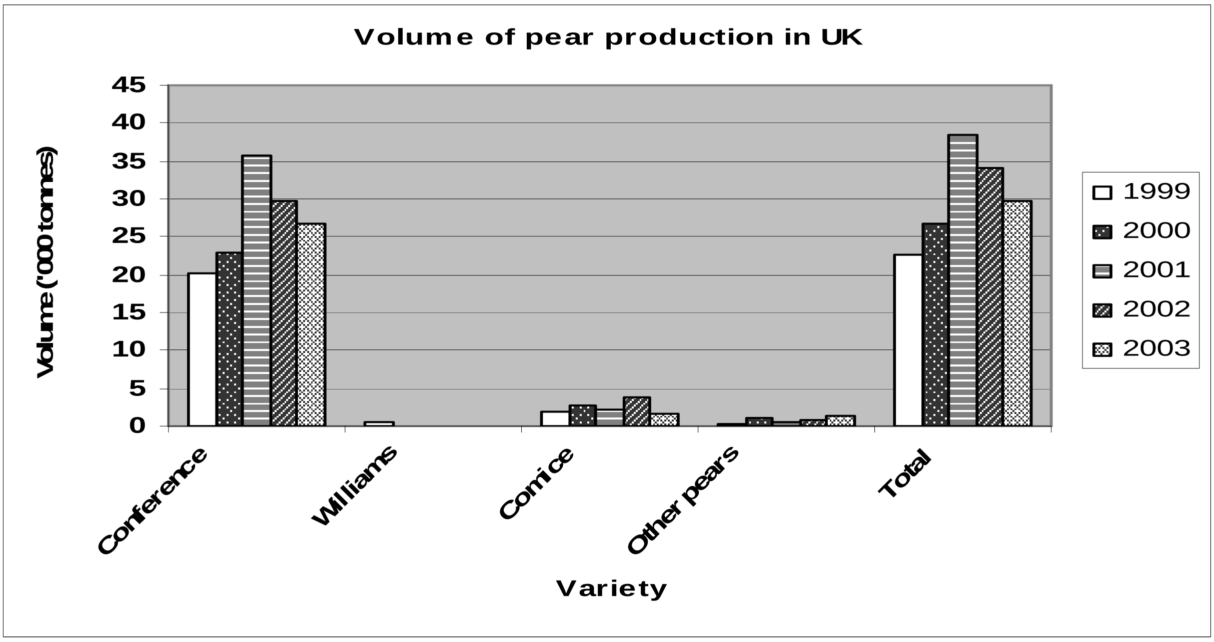
Figure 1. Area of pears grown in England and Wales (ha)



Source: Defra - Orchard Fruit Survey, July 2003

The major variety is Conference, occupying nearly 76% of the total pear area. The pear area is declining with a reduction of some 15% in the dessert pear area from 2002 to 2003.

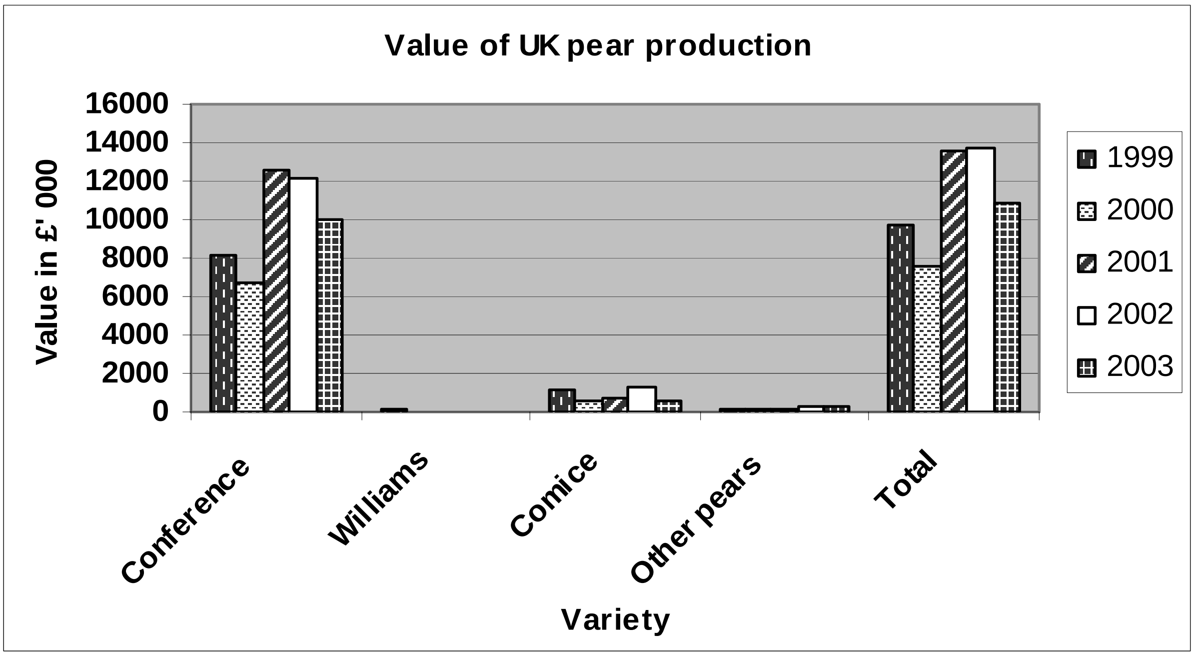
Figure 2. Volume of pear production in UK ('000 tonnes)



Source: Defra - Basic Horticultural Statistics for the UK, 2004

Variation in the volume of fruit produced year on year reflects not only the changes in the areas being grown but also the variable yield per hectare from year to year. This is influenced primarily by the weather during the blossom period.

Figure 3. Value of UK pear production (£'000)



Source: Defra, Basic Horticultural Statistics for the UK, 2004

The value of the UK pear crop also varies year on year depending upon world trading conditions and the volume of crop in the UK and elsewhere. The pear crop in the rest of Europe, especially Belgium and the Netherlands, can have a significant impact on prices in the UK.

In 1993, it was estimated that 23.8% of the total supply of pears on the UK home market came from UK orchards. This proportion had risen slightly by 2002, with an estimated 24.2% of the market supplied from UK production (Defra, Basic Horticultural Statistics, 2004). This indicates that UK production is at least "holding its own" against imported pears. Very small volumes of pear fruit are exported each year from the UK. In 2003 for example, some 3,000 tonnes were recorded but some of these may have been re-exports.

1.4 Volume imported and value

Imported pears include the major varieties such as Conference, Comice and Williams, but some 30 additional varieties are available at different times in the year. A recent feature of the market has been the introduction of coloured fruit, which are yellow or have a red "blush".

Table 1. Volume and value of imported pears into the UK 2003

Country of origin	**Volume (tonnes)**	**Value (£'000)**
Netherlands	32047	45544
South Africa	11962	21522
Belgium	8588	14493
Italy	7759	10803
Portugal	5058	8726
Germany	1742	2729
France	2349	3725
Argentina	1062	2094
Spain	1783	2941
New Zealand	416	689
China	878	2261
USA	581	896
Chile	270	456
Irish Republic	197	333
Australia	186	256
Turkey	176	269
Brazil	49	103
Canada	50	74
Uruguay	36	80
Singapore	31	67
Israel	9	17
South Korea	7	6
Zimbabwe	2	4
Austria	2	4
Greece	2	4
Total	75,244	118,098

(Source: HM Revenue & Customs 2004)

The Netherlands and South Africa dominate the imported pear market. South African fruit is marketed in the February to July/August period, whilst the bulk of Dutch fruit is available during the UK season from September to April. Italian and Portuguese fruit is often marketed in UK in the late summer to fill a natural gap in market supply.

2. Pesticide use on pears

2.1 Problems requiring the use of pesticides

The key pest and disease problems of pears, which may require the use of pesticides, are listed in Table 2. Problems are rated for importance according to their effect on crop yield and also for the occurrence of residues that might arise from the use of a pesticide to control the problem.

Table 2: Key pests and disease problems in pears requiring the use of pesticides and their relative importance to the crop and pesticide residues (***= high; **= medium; *= low ; -= no importance because associated pesticides not found or not sought)

Problem	**Species name**	**Importance**		**Description**
		Crop	**Residues #**	
Orchard pests				
Pear sucker	*Cacopsylla pyricola*	***	**	This key pest attacks the crop throughout the growing season and severely debilitates trees due to sucking sap. The pest also transmits pear decline, a phytoplasma disease. Honeydew excreted by the sucker contaminates foliage and fruits directly and results in sooty mould growth. Can occur close to harvest.
Pear rust mite	*Epitrimerus piri*	***	*	Causes russeting at the calyx end of the fruit.
Aphids including pear bedstraw aphid	*Dysaphis pyri*	***	*	Causes severe leaf curl.
Codling moth	*Cydia pomonella*	***	***	These pests cause direct damage to the fruit.
Winter moth	*Operophtera brumata*	***	*	
Common green capsid	*Lygocoris pabulinus*	**/ *	*	
Summer fruit tortrix moth	*Adoxophyses orana*	**	*	
Fruit tree tortrix moth	*Archips podana*	**	*	
Pear leaf midge	*Dasineura pyri*	*/ *	*	Causes reduced photosynthetic leaf area and yield loss, especially in young orchards.
Pear leaf blister mite	*Phytoptus pyri*	*	*	Causes blisters on leaves which may lead to premature leaf and fruit fall.
Pear leaf blister moth	*Leucoptera malifoliella*	*	*	Attacks leaves only.
Pear midge	*Contarinia pyrivora*	*	*	Midge larvae infest and eat the inside of fruit, affected fruit become spherical and drop prematurely
Pear slug sawfly	*Caliroa cerasi*	*	*	Larvae feed on the upper surface of leaves, which may check tree growth.

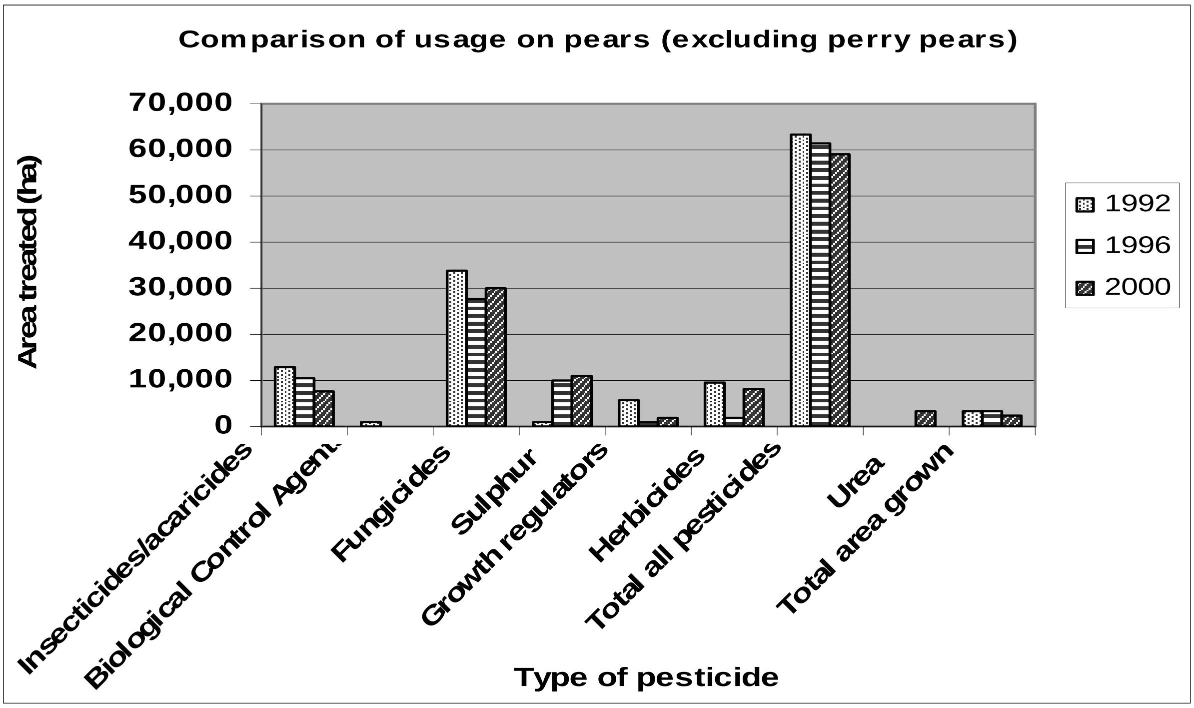
Orchard diseases				
Pear scab	*Venturia pirina*	***	***	All parts of the tree are attacked - defoliation causes yield losses, and scabs occur on fruit. N.B. Wood scab is an important source of inoculum in pear.
Canker	*Nectria galligena*	***	**	This fungus causes cankers and dieback on trees and also a fruit rot in store.
Bacterial blossom wilt	*Pseudomonas syringae pv syringae*	***	-	Blossoms, leaves and fruit may be attacked.
Blossom wilt	*Monilinia laxa f.sp. mali*	*	*	Causes loss of blossoms. Rare in main commercial varieties.
Fireblight	*Erwinia amylovora*	**/ *	-	Bacteria cause blossom wilt and loss of fruit-bearing shoots. Can kill mature trees and there are very limited control options.
Sooty blotch & fly speck	*Gloeodes pomigena & Schizothyrium pomi*	*/ *	*	The symptoms are superficial blemishes which cause down-grading of fruit.
Powdery mildew	*Podosphaera leucotricha*	*	*	Reduces photosynthetic efficiency, can cause reduction in fruit size and russet, in severe cases loss of leaves and blossoms. Only a problem on Comice and Concorde.
Silver leaf	*Chondrostereum purpureum*	*	-	Causes silvering of the foliage and shoot loss.
Armillaria root rot	Armillaria spp	*	-	Causes root rotting, and tree death.
Storage diseases				
Botrytis rot	*Botrytis cinerea*	***	***	Fruit rots mainly as a result of wound infection or as calyx end rot from infection. Major rot of pears
Brown rot	*Monilinia fructigena*	***	***	Rot infects fruit through wounds caused in the orchard.
Penicillium rot	*Penicillium expansum*	***	*	This rot occurs as a secondary invader of other rots and damage.
Nectria rot	*Nectria galligena*	*/ *	**	Causes a flattened brown/black rot around the calyx.
Phytophthora rot	*Phytophthora cactorum & P. syringae*	*/ *	*	Symptomless infected fruit initiate rotting, which then spreads in store.
Mucor rot	*Mucor piriformis*	*/ *	-	The wound rot invades through damage to the fruit.
Gloeosporium rot	*Gloeosporium spp*	*	*	Infection remains latent in fruit, developing as a rot later in store.
Others				
Growth regulators		**	-	Used to control tree growth and fruit set.

Pest and disease pressure varies considerably from year to year and this affects the relative importance of the problem and the likely risk of residues arising from pesticide treatment.

2.2 Pesticide use, volume by type and trends over last 10 years

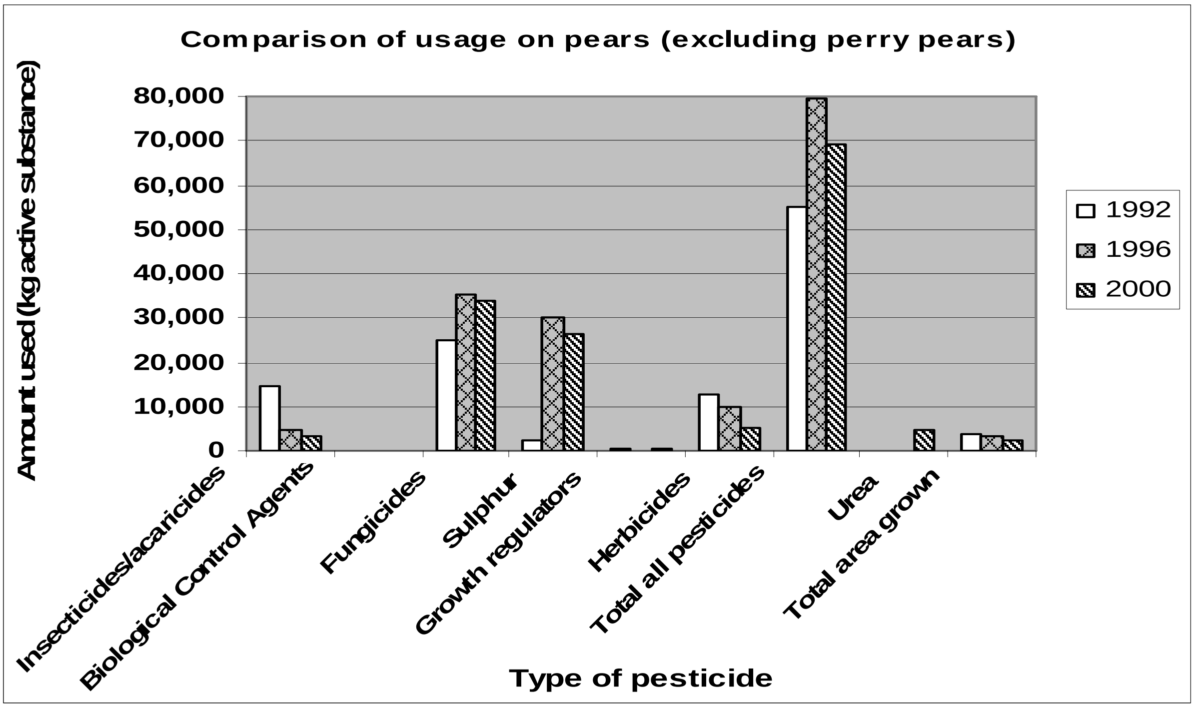
Details of pesticides currently approved for use on pears in the UK are available on the Pesticides Safety Directorate (PSD) website (https://secure.pesticides.gov.uk/pestreg/ and https://secure.pesticides.gov.uk/offlabels/search.asp). Defra and the Scottish Executive Environment and Rural Affairs Department (SEERAD) survey the use of pesticides on pears every four years. The survey data are published in the Pesticide Usage Survey Reports, and these are available on the Central Science Laboratory (CSL) website (www.csl.gov.uk/science/organ/pvm/puskm/reports.cfm). Information on the use of pesticides in the growing pear crop can be found in Pesticide Usage Survey Reports – Orchards and Fruit Stores in Great Britain. Comparative data for 1992, 1996 and 2000 are presented. Anecdotal information from the industry indicates that there has been a significant reduction in the use of post-harvest drenches since 2004. A summary of the usage of pesticides on top fruit crops grown in Great Britain from 1992 to 2000 (spray hectares & kg of active substances applied) is given in Figures 4 & 5.

Figure 4. Comparison of usage on pears (excluding perry pears) by area treated (ha), 1992, 1996 and 2000



Source: Defra, Pesticide Usage Survey Reports, 115 – 1996, 142 – 1996, 172 - 2000

Figure 5. Comparison of usage on pears (excluding perry pears) by amount used (kg active substance), 1992, 1996 and 2000



Source: Defra, Pesticide Usage Survey Reports, 115 – 1996, 142 – 1996, 172 – 2000

The area of pear growing declined from 3,533 ha in 1992 to 2,555 ha in 2000. Although the total area treated has declined, the number of treatments and the quantity of pesticide applied to pears has not. On average, each hectare of pears was treated 18, 19 and 23 times in 1992, 1996 and 2000 respectively, and the average weight of pesticides applied per hectare of pears was 15.6, 24.6 and 27.1 kg for 1992, 1996 and 2000 respectively. The increase was mainly in the use of fungicides. The weight of insecticides/acaricides applied declined dramatically between 1992 and 1996 because of the reduced use of tar oil winter washes.

Fungicides accounted for 50.7% of the total area treated and 49.2% of the weight applied in 2000. The three most extensively used fungicides were captan, dithianon and mancozeb, and fungicides were mostly applied for scab and mildew control. The use of sulphur accounted for 18.7% of the area treated and 38% of the weight applied. Acaricides and insecticides accounted for 13% of the area treated and 4.5% of the weight applied, with chlorpyrifos, fenoxycarb, cypermethrin and pirimiphos-methyl the most commonly used active substances.

Table 3. Comparison of pesticide used on pears prior to storage – amount of fruit treated (tonnes) in 1992, 1996, 2000

Active substance	**1992**	**1996**	**2000**
Antioxidant			
Diphenylamine	-	169	-
Fungicides			
Benomyl	4,853	-	-
Captan	-	110	-
Carbendazim	1,273	12,360	9,879
Carbendazim/metalaxyl	4,892	110	4,650
Iprodione	-	20,026	16,014
Thiophanate-methyl	909	-	-
Vinclozolin	196	-	-
All fungicides	12,121	32,606	30,542
Untreated	17,131	9,621	8,680
Tonnage of fruit stored	27,546	32,554	26,296

Source: Defra, Pesticide Usage Survey Reports, 115 – 1996, 142 – 1996, 172 - 2000

Iprodione and carbendazim were the main fungicides applied for the prevention and treatment of storage rots in pears in 2000.

3. Pesticide residues on pears

3.1 Pesticide residue survey data

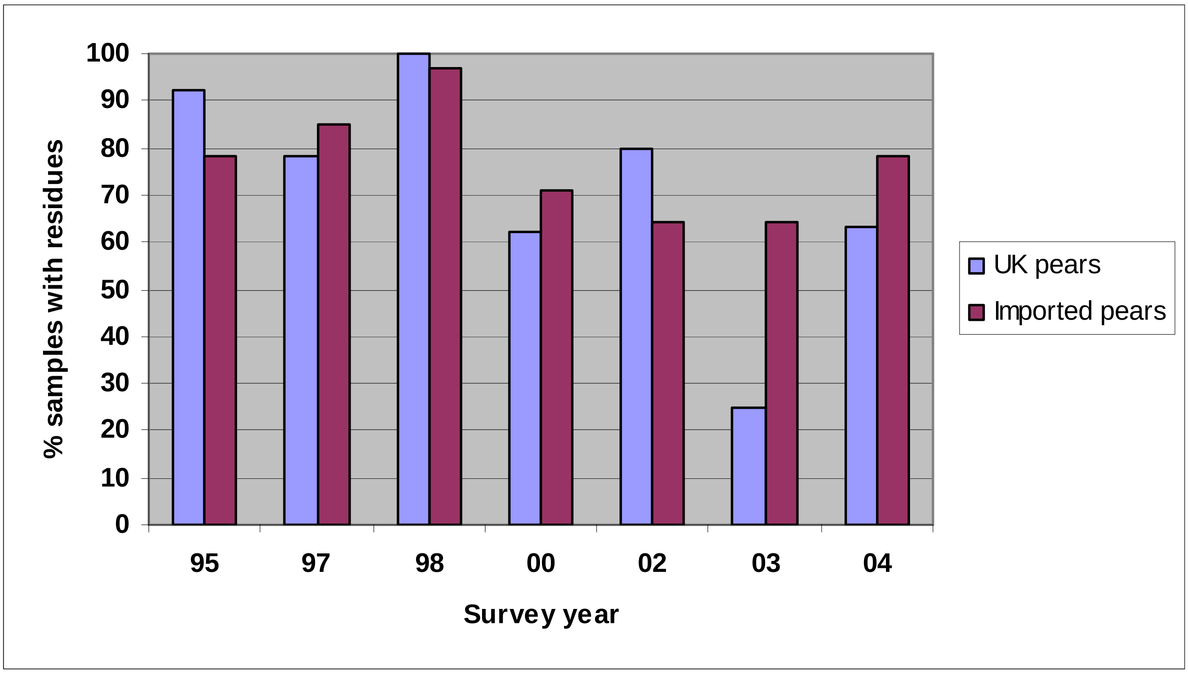
Data on pesticide residues in pears have been taken from the annual reports of the Working Party on Pesticide Residues (WPPR) from 1995 to 1999, and then from the Pesticide Residue Committee (PRC) quarterly survey reports from 2000 to 2004 (www.pesticides.gov.uk/prc_home.asp). Pears were monitored in eight of the ten years between 1995 and 2004, but full surveys were only done in seven years. Details of the pesticide residues sought and found in the surveys between 1994 and 2004 are listed in Appendix A.

The number of pesticides sought in the standard surveys over this period has varied from 54 to 119 active substances per year. The PRC choose which pesticides to look for based on information from the Pesticide Usage Surveys, the likely occurrence of a residue appearing based on degradation data and time of application, and the availability of a cost-effective analytical test. The use of pesticides on pears grown overseas and imported into the UK will also influence the residues sought. Most of the main fungicides and insecticides applied to pears are sought as residues in the recent PRC surveys, but fenoxycarb and amitraz have not been sought. Chlorpyrifos is the main insecticide applied to pears, and was sought in recent survey years including 2004, but not in 2003.

3.2 Pesticide residue trends

In the six main sampling years between 1995 and 2004, 136 UK and 598 imported samples of pears were tested for pesticide residues, reflecting the dominance of imported pears in the UK market (Appendix B). Overall, residues were found in 87 (64%) and 422 (71%) of UK and imported pears respectively. The yearly percentages are presented in Figure 6, and these range from 25 % to 100 % of samples with residues in individual years. This reflects the seasonal approach to pesticide use which depends on weather conditions, and the incidence of pest and disease problems. The occurrence of residues was lowest in 2003 for UK pears, with 25 % of samples containing residues. The lowest residue year for imported pears was 2002 with 64 % of samples with residues. It is difficult to determine whether there is a decline in residue occurrence in pears from the WPPR/PRC data, because the numbers of samples tested and the residues sought have not been consistent either within or between years.

Figure 6. UK and imported pear samples containing pesticide residues 1995-2004 (%)



(Source: WPPR/PRC survey data)

MRL exceedances

A total of 16 MRL exceedances for chlormequat only were recorded on pear samples over the 10 survey years reported here (1.9% of the total samples taken). These were found in three UK and 13 imported pear samples taken in 1998 and 1999, as detailed in Table 4.

Table 4. MRL exceedances in UK and imported pears 1998-1999 (mg/kg)
(Source: WPPR survey data)

Pesticide	Year	MRL*	Residue found	Country of origin
Chlormequat	1998	3	4.9	UK
Chormequat	1998	3	3.2	Belgium
Chlormequat	1998	3	3.8, 4.5, 5.2, 11	The Netherlands
Chlormequat	1999	3	5.6,10	UK
Chlormequat	1999	3	3.2, 3.5, 5.3, 16	Belgium
Chlormequat	1999	3	3.7, 4.1, 4.4	The Netherlands
Chlormequat	1999	3	8.8	Spain

* MRL at the time of sampling. MRL from 2002 onwards 0.5mg/kg

Chlormequat is a plant growth regulator which is used to control growth in pears, reducing extension growth and encouraging fruit bud development and thus significant yield increases. It is not approved for use in the UK on top fruit, but was until recently approved in some other EU countries. Chlormequat residues were found on UK pears in 1997, 1998, 1999, 2000 and 2002, indicating non-approved use of this pesticide, cross-contamination, or incorrectly assigned country of origin. It has been found on imported pears in each of the pear survey years since 1997.

The highest residue detected in a composite sample of pears was 16 mg/kg. The highest theoretical residue level in a single unit of pear within this sample, calculated by applying the appropriate factor of 7 to this would be 112 mg/kg. The acute risk assessment suggests that it is possible that a toddler consuming a whole pear weighing about 150g which contains residues at the highest theoretical calculated residue for an individual unit may experience a mild stomach upset (Annual Report WPPR, 1999).

No chlormequat residues were found in UK pear samples in 2003 and 2004 but they are still being detected in imported pears at levels below the 0.5mg/kg MRL.

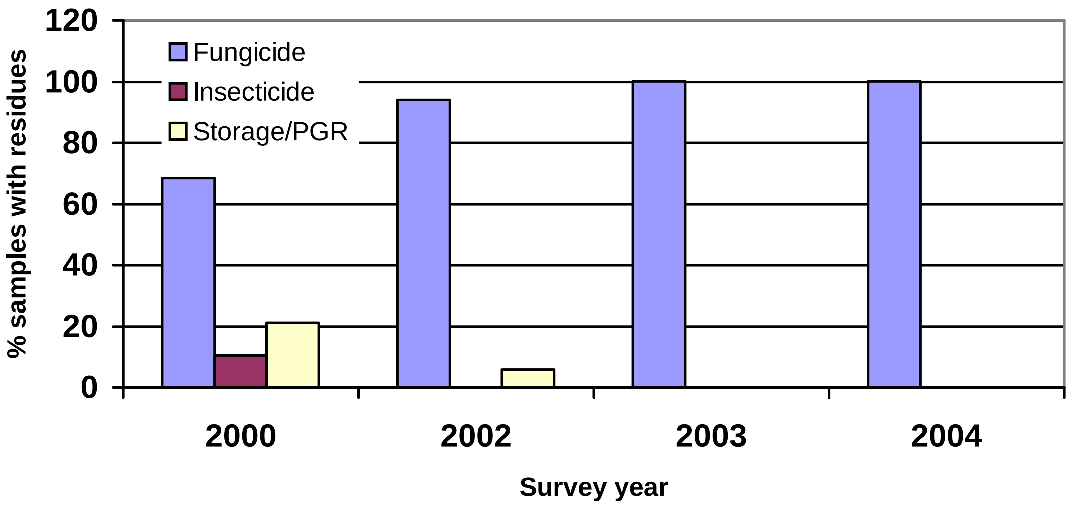
3.2.1 UK-produced pears

The most commonly occurring pesticide residues (i.e. found on >10% of samples tested), on UK pears in the 2004 PRC survey, were the fungicides, carbendazim, captan, iprodione and dithiocarbamates (Appendix B). Tolyfluanid and metalaxyl were also found at lower frequencies. The 2000 Pesticide Usage Survey shows that captan was the most frequently used fungicide on pears in orchards. Carbendazim is mostly used to prevent storage rots. However, the most commonly applied storage fungicide was iprodione in the 2000 survey. Residues of this fungicide exceeded 10% of samples in 2002 and 2004 but only one sample was detected in 2003.

In total in 2004, residues of six pesticides were found on UK grown pear samples, and these were all fungicides. Over three years of survey data (2002-2004), fungicide residues were the most commonly occurring residue type (Figure 7). Insecticides, acaricides and plant growth regulators (PGRs) did not appear as major residue problems in UK pears in 2003 and 2004 (Figure 7). However, the growth regulator chlormequat was detected in five of the seven survey years, and there were three MRL exceedances as described above.

Residues of chlormequat in UK pears are a cause of concern to the industry as this growth regulator has not been used in UK for many years. It is a widely held view in the industry that one of the few explanations for this may be a failure of the sampling procedure to accurately identify country of origin at the sampling point.

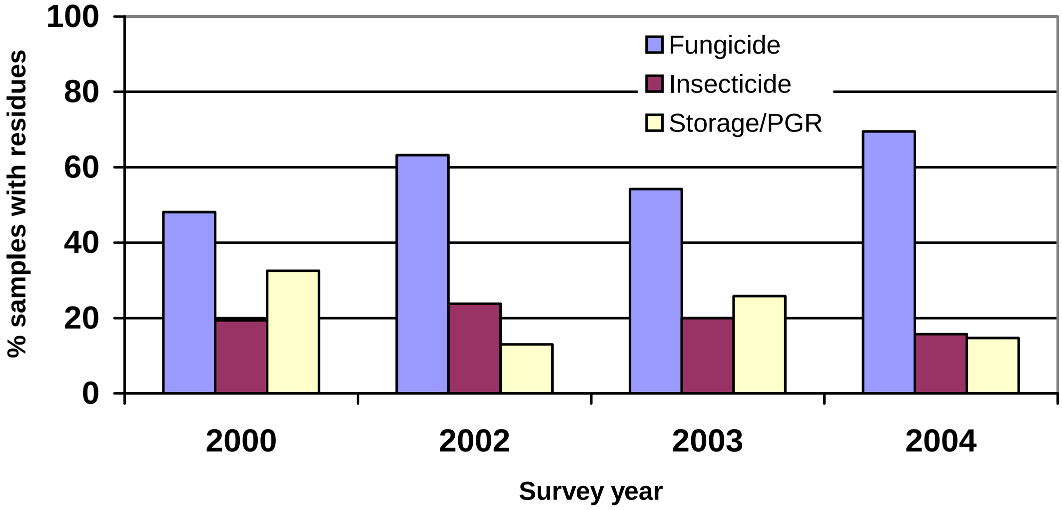
Figure 7. Type of pesticide residue found on UK pear samples (2000, 2002-2004) (% of residues found) (Source: PRC survey data)



3.2.2 Imported pears

The most commonly occurring (>10%) pesticide residues, on imported pears in 2004, were carbendazim, tolyfluanid, captan, diphenylamine, dithiocarbamates, phosmet (Appendix B). Overall, residues of 17 pesticides were found on the imported samples in 2004. Nine of the pesticides found were fungicides, six were insecticides and acaricides, one PGR and one storage chemical.

Figure 8. Type of pesticide residue found on imported pear samples (2000, 2002 -2004) (% of residues found) (Source: PRC survey data)



Fungicide residues were the most frequently occurring residue type in all three years for imported pears, but the proportion of samples with residues of insecticides/acaricides and storage chemicals/PGRs was much higher than on the UK produce.

There were 13 MRL exceedances of the plant growth regulator chlormequat on imported pears in 1998-9, as detailed in Table 4.

4. Approaches to reducing pesticide residues

4.1 General approaches and policies to reduce use and residues

To reduce pesticide use and minimise residues conventional pear growers follow the principles of Integrated Crop Management (ICM). ICM is a cropping strategy in which growers aim to conserve and enhance the environment whilst producing safe and wholesome food economically. ICM recognises that profitability is vital to the success and sustainability of any farmer/grower business.

ICM is built on sound existing knowledge and good agronomy practices and is regularly updated to take account of new research findings. Knowledge of pest, disease and weed biology and environmental awareness is vital. Integrated Pest Management (IPM) is a part of ICM and involves developing pest control strategies based on environmental control, bio-control and the use of physical and chemical control agents. IPM relies on representative and diligent crop monitoring carried out at regular intervals.

A recommended protocol for practising IPM in pear production is contained within the Defra Best Practice Guide for UK Pear Production (2003).

4.2 Assurance schemes

Assured Produce Scheme (APS) – www.assuredproduce.co.uk
UK pear growers were in the vanguard of developing assured produce protocols with their own GroAct scheme, instigated by English Apples and Pears Ltd. This has now been integrated within the Assured Produce Scheme with which the majority of commercial pear growers in the UK are registered. The crop protocol for pears promotes ICM practice and includes advice on pesticide use reduction and minimisation of residues. Assured Produce is currently developing a specific residue minimisation protocol for pears.

4.3 Decision support systems

Decision support systems (DSS's) are available for a number of pests and diseases in pear but are not as widely developed as those for apple. The most commonly used DSS is based on pheromone trapping to monitor insect levels to determine when the threshold for spraying is reached – the threshold might not occur in some seasons. Also, they can determine the time of egg laying for some pests, and with daily temperature records, can calculate the subsequent hatching of the pests. This results in more effective pesticide application. Assessments of risk for many diseases are also available to growers, which can help determine the need for treatments to be applied.

There are a number of DSS available for pest disease prediction based on weather data including the PESTMAN and ADEM systems developed by HRI East Malling. However, ADEM was developed on apple and has not been validated on pears where there may be differences in the behaviour of scab. Other DSS models exist in other pear growing regions of the world although the number is less than those available for apples. The uptake of these systems has been limited by the direct costs for automatic weather stations, software costs and the indirect costs of maintaining the weather station and running the programmes. Some Defra and APRC funded work at East Malling did show both cost and pesticide savings could be achieved in apple in some seasons by adopting these systems. It is, however, unlikely that significant uptake will occur unless there is validation on pear and the approach is made more accessible to growers and the systems are simple to use. This might occur by means of a "bureau" system where the operation of the programme is carried out for growers who receive advice from the bureau without the need to master the underlying science and computer technology. Some consultants and agronomist from agrochemical suppliers operate services of this type for their clients.

5. Approaches for specific problems related to residues

The Defra '*Best Practice Guide for UK Pear Production'* set out best practice at the time of its publication in 2003. The approach advocated by the guide is to, build up the levels of the natural predators of pests within orchards, to use pesticides which will not adversely affect predator levels, and to apply pesticides only when there is significant risk of damage and when the pests are most susceptible. This has had a significant effect on the occurrence of insecticide residues which are rarely found in PRC surveys. The main residues found are from the use of fungicides. There has also been a trend within the industry to reduce the rates of pesticide use where possible, and more recently to apply appropriate pesticides earlier rather than later in the cycle of crop development.

(Pear growth stages and a Pest and Disease Action Calendar are detailed in Appendices C and D.)

Fungicide residues found in UK pears in 2002, 2003 and 2004 are grouped into the following categories, according to the risk of occurrence:

High frequency – found in each of the three years

- Captan
- Carbendazim
- Iprodione
- Dithiocarbamates

Medium to low frequency

- Tolyfluanid

5.1 Approaches to reduce high frequency residues

5.1.1 Captan

Captan provides a cost effective control for scab and is useful in a resistance management strategy providing an alternative to fungicides from other groups. It also gives partial control of sooty blotch and fly speck. When used pre-harvest it will give useful control of rotting diseases, *Nectria, Gloeosporium, Phytophthora* and *Botrytis*.

Approaches to minimise captan residues
Effective control of scab is achieved by starting fungicide applications early in the season. To reduce captan use, more use would need to be made of inorganic fungicides, copper and sulphur. Copper could be used at pre-bud burst stage, followed by dithianon at bud burst (both will aid canker control, see carbendazim) with sulphur used for the later part of the spray programme. Sulphur is however only partially effective against pear scab so early control is essential. Utilising the demethylation-inhibiting (DMI) fungicides (which have high risk of resistance developing) together with tolyfluanid for a relatively short period earlier in the season would provide some control, but there is evidence of reduced sensitivity to DMI fungicides in the scab pathogen population. Thiram may also have a place in programmes (see later comments). It would also be crucial to use good orchard hygiene practice with urea sprays post-harvest but before leaf fall, to encourage leaf rotting and efficient maceration of orchard litter post-leaf fall and pre-bud burst. Wood scab must be pruned out during the winter and prunings well macerated.

5.1.2 Carbendazim

The use of carbendazim has declined as resistant isolates of the scab pathogen and *Gloeosporium* have become more widespread, but it is still used because it helps control canker infection. It is particularly useful having both protectant and sporulation suppressive properties against *Nectria* canker for which it remains the most effective treatment. New fungicides are becoming available e.g. tolyfluanid, which have been shown to give some control of pear canker but not as good as carbendazim. *Nectria* rot is a relatively minor problem in storage compared to *Botrytis* rot.

Approaches to minimise carbendazim residues
Greater emphasis on cultural controls will be required to minimise carbendazim usage. Pruning in winter and summer is required, paying particular attention to removal of any cankered shoots and branches, coupled with efficient pulverising of prunings and orchard litter to facilitate as rapid a breakdown as possible.

It may be necessary to work through an orchard three times between petal fall and harvest to cut out cankers on new growth to reduce infection, especially in badly infected orchards. The incorporation of copper applied at 10% and 50% leaf fall and again at pre-bud burst can help achieve some control. Use of one application of carbendazim at petal fall should not result in detectable residues at harvest, alternatively applications of dithianon at flowering and tolyfluanid at petal fall can be used. An alternative treatment for post-harvest control of *Nectria* fruit rot is required - at present, applying the rot risk assessment tool developed for apples is the best that can be attempted.

5.1.3 Iprodione

Iprodione has Specific Off-Label Approval (SOLA) for post-harvest use for the control of *Botrytis*, the most common rotting disease found on pears in storage, and is very effective.

Approaches to minimise iprodione residues
Botrytis can infect at blossom period through to petal fall and sprays at this period can help control levels, e.g. tolyfluanid. Pre-harvest orchard sprays of captan, thiram, tolyfluanid, and boscalid+pyraclostrobin can have a limited effect on *Botrytis*. In experiments, the application of chlorine (100–120ppm free chlorine) as calcium hypochlorite has proved to give some control of rotting in Comice pears but its use is not common practice.

Work on bio-control agents has shown potential for controlling rots, especially an antagonistic yeast (Yield Plus). Results have been variable but do show promise. Its use would require UK approval. However, this may not be commercially viable given the relatively small market of UK pear production. Although effective in large-scale trials it did not achieve the same level of control as iprodione use but nevertheless, it may be commercially acceptable. There may be other chemicals (GRAS methods – generally recognised as safe) that could be evaluated and some of this work is likely to be undertaken as part of the EU Project ISAFRUIT.

Careful management of the picking and post harvest handling operations as well as avoiding physical damage to the fruit is essential, as much of the *Botrytis* infections can be linked to damage to fruit during this period. Hygiene in the orchard will also help. Bins into which fruit is picked should be cleaned before harvest by physical removal of debris followed by use of a suitable disinfectant e.g. Jet 5. This is best carried out in the pack house immediately after fruit is unloaded.

5.1.4 Dithiocarbamates

Both thiram and mancozeb have a low resistance risk profile and provide cost-effective fungicides to incorporate within a resistance management strategy. Thiram is used for scab control with activity against *Botrytis* and *Gloeosporium* rots. Much brown rot can result after bird damage. Thiram is also a good bird deterrent. Mancozeb is used against scab with some suppression of mites and some incidental control of pear sucker.

Approaches to minimise dithiocarbamate residues
Although alternatives to these fungicides are available they are still useful if used sparingly early in the season as part of a resistance management strategy. These products are often used instead of captan. The use of sulphur will also aid control of rust mite.

5.2 Approaches to minimise medium to low frequency residues

5.2.1 Tolyfluanid

Tolyfluanid is used for scab control and also has activity against *Nectria* eye-rot, *Botrytis, Gloeosporium* and *Phytophthora* when applied pre-harvest. There is also an indication of some incidental suppression of rust mite, red spider mite, pear blister mite and pear sucker. Tolylfluanid also appears to have some activity against the tree canker pathogen.

Tolyfluanid together with other new products in development, e.g. boscalid+pyraclostrobin, has the potential to control post-harvest diseases from orchard applications.

Approaches to minimise tolyfluanid residues
Research findings and commercial experience on the best timing for application are suggesting it may be possible to eliminate detectable residues by manipulation of timing. Recent research on apple at EMR indicates that late season application does not adversely affect the residue profile for this product and this may also hold for pears. The use of boscalid + pyraclostrobin on pears has recently been approved and provides an alternative to tolyfluanid.

5.3 Fungicide resistance in pears

Fungicide use in pear production can be intensive and the range of fungicides available for effective disease control is often limited to a few fungicide groups. This increases the risk that fungal strains, which are resistant or less sensitive to certain fungicides, may arise leading to reduced control or control failure.

Fungal diseases which readily develop strains resistant to fungicides include *Botrytis cinerea*, pear scab (*Venturia pirina*), *Penicillium expansum,* and *Gloeosporium* sp.

There is an increased risk that fungal pathogens will become resistant or less sensitive to those fungicides that have a single site mode of action. Fungicides used on pears having a single site mode of action are listed in Table 5.

Table 5. Fungicides at risk from fungal resistance

Fungicide group	Fungicides	Resistance type
benzimidazole	carbendazim	resistant/sensitive
DMI	e.g. myclobutanil	reduced sensitivity
guanidine	dodine	resistant/sensitive
dicarboximide	iprodione	resistant/sensitive
phenylamide	metalaxyl, metalaxyl-M	resistant/sensitive
hydroxypyrimidine	Bupirimate	reduced sensitivity

Where fungi develop **reduced sensitivity** those fungicides may still be partially effective. Where fungi, such as *Botrytis,* become **resistant** to a fungicide, such as carbendazim, these strains are completely resistant and will not be controlled by the fungicide or any other with a similar mode of action.

The risks of fungicide resistance for pear diseases are detailed below.

Table 6. Summary of main pear diseases and fungicide resistance

Fungal disease	**Resistance identified**	**Identified fungicides, resistance type (incidence)**
Pear scab	Yes	• dodine - resistant/sensitive (WS) • carbendazim - resistant/sensitive (WS) • DMI - reduced sensitivity
Nectria canker	None	
Silver leaf	None	
Sooty blotch	None	
Fly speck	None	
		•
Gloeosporium rot	Yes	• carbendazim - resistant/sensitive (WS)
Penicillium rot	Yes	• carbendazim - resistant/sensitive (WS)
Botrytis rot	Yes	• carbendazim - resistant/sensitive (WS) • iprodione - resistant/sensitive (rare)
Phytophthora rot	Yes	• metalaxyl - reduced sensitivity (rare)
Brown rot	None	
Botryosphaeria	None	
Fusarium	Unknown	

Key: WS = widespread

6. Research

6.1 Recent research

Research on pears is primarily funded by Defra and the Horticultural Development Council (HDC), with some other funding from the Biotechnology and Biological Sciences Research Council (BBSRC). A significant part of the HDC portfolio (and previously the APRC) has addressed the availability of pesticides for specific problems and has resulted in a Specific Off-Label Approvals programme to meet growers' immediate needs. The HDC has recently undertaken a Gap-Analysis of pesticide availability and the implications of this for the horticulture industry in the UK. Other work has covered the breeding and assessment of new varieties, rootstock evaluation and fruit storage work.

In comparison with apples, relatively little work has been funded directly on pears. This reflects the smaller area of pear production in the UK. There are, however, considerable similarities in many of the pest and disease problems between the two crops, and information obtained in respect of apples can often be adapted to pear production.

Given the relatively small UK pear industry, it is essential that results from pear research programmes in other parts of the world are evaluated for the UK situation. Also, some work carried out on apples can be directly extrapolated to pears.

6.2 Gaps in knowledge and research needs

There is a need to test the effect of alternative pesticide strategies on pesticide residues otherwise one residue problem may be exchanged for another.

Nectria canker remains one of the major problems in pear production. It is essential that work on apples is structured in a way which will also benefit pear production. However, there may be significant differences in epidemiology between pear and apple and it could be misleading to simply "read across" from work on apple to pear, hence the need for pear to be separately considered. Scab can appear late in the season and is often associated with wood scab in pear and this relationship needs to be more fully understood. New chemistry and timing of application is urgently needed to counter the threat of *Nectria* in pear orchards.

There is little or no readily available information on the degradation characteristics of pesticides used in pear production. Neither growers nor their advisors are in a position to build this information into their decision making processes when considering the need for control of specific pests and diseases. Such information could become an important tool for minimising pesticide residues, with pesticide degradation profiles and half-life characteristics being especially useful. The development of the concept of Residue Interval (RI) analogous to the current Harvest Interval (HI) could also be a useful advisory tool. The RI would be the period required to elapse between the last application of a pesticide and the presence of residues in fruit below the Limit of Determination (LOD). This would need further research. Of course, LODs might become lower and thus the RI might need adjusting accordingly.

The whole area of biopesticide use and availability is relatively under researched in respect to fruit crops in the UK. In pear the biological control of post-harvest rotting caused by *Botrytis* and *Penicillium* is probably the best approach for the future. It will be important to link in with those groups elsewhere in the world working in this area. These offer real alternatives to conventional pesticides and, in theory, meet many of the policy aims of moving towards more sustainable crop production systems. Initially, trials evaluating commercially available bio-control agent formulations from other parts of the fruit growing world would be very useful with the focus on treating fruit in bulk. More research work is urgently required to identify other potential organisms and commercial products and to determine how best to use them in practice.

The commercialisation of these control agents is difficult because registration costs are relatively high compared to the potential commercial returns for use on “minor” crops. This issue is currently being addressed by the EU Steering Group on Minor Uses, which was set up to co-ordinate the work of the Technical Group on Minor Uses and to look at procedures, finance and strategic issues to do with minor uses. A literature review of the available options for the use of barriers and deterrents in orchard pest and disease control would also be useful. Recent changes to the registration system have been introduced by the Pesticides Safety Directorate which are aimed at addressing this issue.

The role of plant nutrition and its interaction to susceptibility to pest and disease needs investigation together with an understanding of systemically acquired resistance. The introduction of a number of nutritional based plant stimulants in recent years has focussed action on this area in other crop situations. These, together with other approaches, may lead to the development of sustainable pest and disease management strategies.

There is enormous scope for improvements in pesticide application technology in fruit crops aimed at more effectively reaching the target organisms and minimising use of pesticide as well as reducing drift.

Breeding new varieties of pear is not as advanced, especially in terms of seeking pest and disease resistance, as it is in apple. Funding a programme in the UK may be difficult given the size of the industry and the costs and long-term nature of breeding for resistance. Awareness of breeding programmes in other parts of the world and accessing these as quickly as possible may help.

7. Knowledge/Technology transfer initiatives

Knowledge transfer is largely undertaken for the pear industry by the Horticultural Development Council (HDC), which has taken over the activities of the Apple and Pear Research Council (APRC). Defra also funds some knowledge transfer activities, such as the Best Practice Guide for Pears, either alone or in partnership with the HDC.

Some of the grower-producer organisations undertake a limited amount of knowledge transfer activity as part of their operational programmes, when stimulated by marketing organisations in response to customers' requirements or commercial pressures. Consultants, advisors and agronomists from suppliers all provide information and assistance to growers.

A major initiative has been the Defra funded '*The Best Practice Guide for UK Pear Production*', published in 2003 as a hard copy sent to all HDC levy payers and to consultants and advisers. A fuller version of the Guide was prepared on CD and is being made available to all pear growers who request a copy, but this is primarily aimed at consultants, advisers and technologists who assist growers. It is not always appreciated how much consultants and technical sales staff influence pesticide choice and use.

7.1 Ongoing activities

There have been few recent knowledge transfer initiatives specific to pears, other than the East Malling Research Association (EMRA) members' days, where work on pears has been featured. The HDC arranged a Pear Research Day at East Malling Research (EMR) in September 2004.

Professional fruit consultants, through their continued professional development activities, also ensure that the latest developments and techniques are brought to the attention of the fruit growing community.

Assured Produce is incorporating information aimed at minimising pesticide residues into the Crop Protocol for apples.

7.2 Required activities

- Review the Defra Pear Best Practice Guide and develop a sustainable means of updating this useful tool for the industry. This is most likely to be achieved by utilising a CD format or website, rather than producing a printed hard copy for all growers (Defra/HDC).
- Hold workshops on the management and enhancement of natural enemies in pear orchards. This could also cover apple orchards to present a comprehensive picture to growers (Defra/HDC).
- Hold workshops and/or produce factsheets on using improved pesticide application techniques.
- Hold workshops and/or produce factsheets on improving hygiene in pear production.
- EMRA Members Day "Towards Achieving Zero (below detection level) Pesticide Residues in UK Pears" would be timely (EMR/EMRA).
- Implementation of decision support systems. Ways of making information and benefits available to growers, which do not require growers to be familiar with the underlying technology nor expose them to high costs. Some consultancy organisations are providing this type of service. Improvements in models are needed however.
- Interactive seminars involving both research workers and consultants/agronomists should be developed to improve interchange of information and aid rapid dissemination of R&D findings to the industry. It is essential that independent agronomists and those employed by service companies are included in this invitation.

7.3 Pesticide availability

The Pan European policy developments, including mutual recognition provisions, offer hope to minor crop producers, such as pear growers, that new solutions to problems, whether by new chemistry from conventional pesticides or from new biopesticides, could be available to them. These provisions must be used as the UK pear industry is marginal in commercial terms for many products and agrochemical companies can often only justify introducing new pesticides in a European context given costs of registration. In future therefore, it is likely that the UK will need to look to products developed for the larger Dutch, Belgium and Italian pear industries.

8. Conclusions

The pear industry has made substantial progress in reducing its use of pesticides in recent years in response to pressure from its customers. There is a willingness within the industry to continue to reduce pesticide inputs wherever possible. There is however concern over potential losses in storage to fungal rots.

Much can be achieved by the application of currently available knowledge. But it must be noted that there will inevitably be seasons where high pest and disease pressure from certain organisms will necessitate interventions with pesticides that may not be needed in most seasons. There is little or no information on the degradation characteristics of pesticides used by pear growers that is readily available. Neither growers nor their advisors are in a position to build this information into their decision making processes when considering the need to control pests and diseases in the light of risks and weather, whilst aiming towards minimal pesticide residues. More information in this area from agrochemical companies could be very beneficial, with pesticide degradation profiles and half-life characteristics being especially useful. The development of the concept of a Residue Interval (RI) analogous to the current Harvest Interval (HI) could be a useful advisory tool. The RI would be the period required to elapse between last application of a pesticide to give the presence of residues in fruit below the level of detection.

The move away from broad spectrum pesticides to those with more targeted activity against specific pests and diseases over recent years has resulted in some minor pests and diseases emerging as problems and this trend is likely to continue. These organisms have previously been controlled by the broader spectrum pesticides. Changes in weather patterns are also likely to influence pest and disease pressure.

8.1 Key actions to minimise pesticide residues on pears

Pear Variety	Variety development offers the potential to exploit genetic resistance to pest and disease but this is a long-term solution with between 5 to 10 years required to introduce a variety into the market place.
Orchard Hygiene	Remove diseased and damaged wood and fruit, macerate prunings and other litter. Apply urea to encourage rapid breakdown of debris. Apply pest and disease control measures where possible between harvest and flowering.
Agronomic Practice	Develop strategies to encourage the build up of natural enemies and predators, and introduce biological control options as soon as they become available. Use pesticides as early in the crop growth cycle as possible to achieve early control of a pest or disease and to allow the maximum period for degradation of pesticide residues. Use the most benign (least likely to result in residue issues) pesticide that is effective for control and which has the most appropriate degradation and residue profile. Use the most appropriate application rate of pesticide for the pest or disease concerned. If a lower rate of pesticide is used this should not compromise effective control of the target pest/disease or risking build up of resistance to the pesticide. This approach should always be based on a comprehensive understanding of the target organism and be based on the principles of sound science. Adopt optimum pesticide application techniques, such as pesticide application_rate adjustment to the crop environment (PACE). Continue to use regular monitoring and introduce improved decision support systems when available to establish the need to spray and to improve the timing of application. Produce a residue reduction plan for orchard operations. Ensure good picking and harvest practice to minimise potential for damage and subsequent disease infection.
Key residues and actions (*** = high, ** = medium importance)	
Captan *****	**Scope for residue minimisation – short to medium term** ***Pear scab*** Residues resulting from the use of captan to control pear scab could be minimised by combining a mixture of orchard

	hygiene measures, fungicide timing and the use of other chemicals including dithianon, myclobutanil, tolyfluanid, copper, sulphur and urea. Using fungicides like systhane and tolyfluanid early in the season followed by low rate applications of sulphur between petal fall and harvest will minimise the possibility of captan residues, but minor diseases such as sooty blotch and fly speck may become more prominent. ***Post-harvest storage rots*** Crop and store hygiene measures can be used to reduce the incidence of storage rots, combined with the Apple Rot Risk assessment to treat, market or store fruit (see the apple plan for details), will all help minimise residues of captan.
Carbendazim *******	**Scope to minimise residues – medium term** ***Pear canker*** Greater emphasis on cultural controls will be required to minimise carbendazim usage. Pruning in summer and winter to remove cankered shoots and branches, coupled with efficient pulverising of prunings and orchard litter is required. The incorporation of copper applied at 10% and 50% leaf fall and again at pre-bud burst will help achieve some control. Use of one application of carbendazim at petal fall should not result in detectable residues at harvest, alternatively dithianon during flowering and tolyfluanid at petal fall can be used. ***Post-harvest storage rots*** An alternative treatment to carbendazim for post-harvest control of *Nectria* rot is required, as at present applying the rot risk assessment tool developed for apple is the best that can be attempted.
Iprodione *******	**Scope to reduce residues – medium term** ***Botrytis storage rot*** Only fruit going into long-term storage should be treated. Consider blossom/petal fall sprays of tolyfluanid to control infection. The pre-harvest orchard sprays of captan, thiram, tolyfluanid or boscalid+pyraclostrobin have an effect on Botrytis. Application of chlorine (100–120ppm free chlorine) as calcium hypochlorite could be considered for Comice pears. Work on bio-control agents has shown potential for controlling rots, especially an antagonistic yeast (Yield Plus) but results have been variable and its use would require UK approval. Careful management of the picking and post harvest handling operations is essential as rots found in store can be linked to damage to fruit during this period. Storage bins should be cleaned and disinfected before harvest.
Dithiocarbamates *******	**Scope to reduce residues – short term** Alternatives are available to these fungicides but they may still be useful if used sparingly early in the season as part of a resistance management strategy. These products are often used instead of captan.

Tolyfluanid ******	**Scope to reduce residues – short term** Tolyfluanid is increasing being used to replace other fungicides which result in residues. Research and experience suggest it may be possible to eliminate detectable residues of tolyfluanid by applying the fungicide earlier in the season. Information on residue degradation would be particularly useful for this fungicide.
Medium to long-term proposals	Biological control measures in use in other parts of the world need to be identified and then evaluated in the UK. An evaluation of the EMR Strategy to minimise residues on apples for use on pears. A review of the Defra Best Practice Guide for UK Pear Production is required to take account of residue issues, and a means of routine updating for this Guide via CD or a website is needed. Information on pesticide residue degradation would enable growers and advisors to plan their crop protection plans to minimise residues more effectively.
Advice	A Crop Walkers' Guide to identify key pear diseases and pests would help growers recognise and monitor problems. Factsheets on management of natural enemies in pear orchards, pesticide application techniques and improving hygiene in pear production are required.
Training	Knowledge transfer workshops to help growers develop orchard pesticide residue reduction plans would lead to a more co-ordinated approach to minimising residues.

Acknowledgements

We are grateful to those in the top fruit industry involved in various discussions at the start of this project, and in particular to Dr Angela Berrie and Jerry Cross of East Malling Research for helpful discussion of various issues.

Glossary of terms – (This glossary applies to all 5 crop guides)

Acceptable Daily Intake (ADI):- the estimated amount of a substance that can be consumed every day for a lifetime by humans without presenting a significant risk to their health, based on current scientific evidence.

Active ingredient:- Synonym for active substance.

Active substance:- Any substance or micro-organism, including a virus, that has a general or specific action: against harmful organisms; or on plants, parts of plants or plant products. Active substances are usually formulated with other materials in a pesticide product.

BASIS:- An independent registration, standards, certification and training organisation (serving pesticide, fertiliser, horticulture, forestry and other relevant interests), working with and through industry organisations to implement relevant sections of 'The Food and Environment Protection Act 1985' and other legislative and industry Code of Practice requirements.

Bio-control or Biological Control Agent (BCA):- Biological control of pests by use of other organisms.

Conservation Grade:- Conservation Grade farming is a system which encourages biodiversity and ensures a sound environmental provenance for food production (www. Conservationgrade.co.uk).

Desiccants:- Products used to dry out unwanted plant material.

Diatomaceous earth:- Fine hygroscopic clay material used for controlling grain storage pests.

Disease:- A condition causing damage to a plant usually by a fungal or viral infection.

DMI:- demethylation inhibitors, group of fungicides, affect a particular biochemical step in the production of ergosterol.

Early potatoes:- Crops harvested before 31 July.

Fungicides: - Chemical substances that kill or inhibit the growth of fungal pathogens affecting plants.

Good Agricultural Practice (GAP):- The way products should be used according to the statutory conditions of approval, which are stated on the label.

HACCP: - **H**azard **A**nalysis & **C**ritical **C**ontrol **P**oints. A system, which identifies, evaluates and controls hazards which are significant for food safety.

Hagberg Falling Number (HFN): – a measure of bread making quality. Values of >250 seconds are required by millers.

Harvest Interval (HI): The time which must elapse between the final treatment with an individual pesticide and the harvest of the crop, as detailed on the pesticide label.

Haulm:- Potato foliage.

Herbicide:- A pesticide used to control unwanted vegetation (weed killer). A chemical that kills plants, sometimes designed to kill specific weeds.

Insecticide:- A pesticide used to control unwanted insects.

Integrated Crop Management (ICM):- ICM is a method of farming that balances the requirements of running a profitable business with responsibility and sensitivity to the environment. It includes practices that avoid waste, enhance energy efficiency and minimise pollution. ICM combines the best of modern technology with some basic principles of good farming practice and is a whole farm, long-term strategy including:
the use of crop rotations;

- appropriate cultivation techniques;
- careful choice of seed varieties;
- minimum reliance on artificial inputs such as fertilisers, pesticides and fossil fuels;
- maintenance of the landscape;
- enhancement of wildlife habitats.

Limit of Determination (LOD):- The limit of determination is the lowest concentration of a pesticide residue or contaminant that can be routinely identified and quantitatively measured in a specified food, agricultural commodity or animal feed with an acceptable degree of certainty by the method of analysis. It is also known as the Limit of Quantification (LOQ).

Lodging:- Term used to describe crops that are flattened by wind and rain.

Maximum Residue Level (MRL):- A legal limit for the maximum amount of residue that will be left on a food when a pesticide is applied according to instructions based on good agricultural practice. The MRL is a maximum legal level based on what would be expected if the pesticide was used correctly, it is not a safety limit. MRLs are intended primarily as a check that good agricultural practice is being followed and to assist international trade in produce treated with pesticides. MRLs are not safety limits and exposure to residues in excess of an MRL does not automatically imply a hazard to health.

In cases where there are no UK or EC MRLs, the acceptability of residues may be judged against Codex Maximum Residue Levels (**CAC MRL**). These limits give an indication of the likely residue that should occur in edible crops.

MBC:- Group of fungicides, methylbenzimidazole carbamates, the active component of carbendazim and thiophanate-methyl.

Molluscicide:- A pesticide used to control unwanted slugs and snails.

Nematicide:- A pesticide used to control harmful nematodes.

Pest:- Any organism harmful to plants or to wood or other plant products, any undesired plant and any harmful creature.

Pesticide:- Any substance, preparation or organism prepared or used for controlling any pest. A pesticide product consists of one or more active substances co-formulated with other materials. Formulated pesticides exist in many forms, such as solid granules, powders or liquids. Sometimes called a plant protection product.

Pesticide Usage Survey Group (PUSG):- The group that regularly surveys the UK use of agricultural pesticides. It is based at the Central Science Laboratory.

Pheromone:- A chemical substance secreted by an animal which influences the behaviour of others of its species.

Plant Growth Regulator (PGR):- A substance that has a marked and specific effect on plant growth, without killing the plant.

Plant Protection Product:- An active substance or preparation containing one or more active substances, formulated as it is supplied to the user, intended to:

- protect plants or plant products against all harmful organisms or prevent the action of such organisms;
- influence the life processes of plants other than as a nutrient (e.g. as a growth regulator);
- preserve plant products, in so far as such substances or products are not subject to the provisions of Community law on preservatives;
- destroy unwanted plants;
- destroy parts of plants or check or prevent the undesired growth of plants.

Sometimes used as a synonym for 'pesticide', but not in the strict legal sense.

QoI: – Class of fungicides that work by inhibiting mitochondrial respiration by binding at the Qo site of cytochrome b

Sclerotia:- Also known as fungal resting bodies. Pathogenic fungal sclerotia are able to survive long periods in the absence of the host plant.

SOLA (Specific Off-Label Approval):- For many reasons, label recommendations of approved pesticides do not cover the control of every problem which may arise. This is particularly true for crops that are grown on a comparatively small scale in the UK as well as for sporadic pests and diseases. It is for this reason that the extrapolations presented in the Long Term Arrangements for Extension of Use have been developed. If these do not address particular needs growers or their representatives may apply to PSD for a specific off-label approval (SOLA). Such approvals are only granted after consumer, operator, bystander and environmental safety have been assessed and found acceptable.

Sprout suppressant:- A chemical or treatment that inhibits dormancy break and growth of potatoes during the storage period.

Steep:- Barley is soaked or 'steeped' in water to stimulate the embryo in the grain to grow to begin the malting process.

Trap cropping:- The planting of a potato crop to encourage the hatching of PCN and invasion of the roots. The trap crop is subsequently sacrificed before the PCN matures and in this way populations are reduced.

Volunteer potatoes:- Self-set potatoes from a commercial crop growing as weeds in other crops.

Ware potatoes:- Crops grown for human consumption either before or after processing (excludes seed potatoes grown for planting).

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Department of Environment, Food & Rural Affairs (Defra)
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www.defra.gov.uk

Food Standards Agency (FSA)
Aviation House, 125 Kingsway, London WC2B 6NH. Tel 0207 276 8000
www.food.gov.uk

LEAF (Linking Farming And Environment)
The National Agricultural Centre, Stoneleigh Park, Warwickshire CV8 2LZ
www.leafmarque.co.uk

Organic Farmers & Growers
Elim Centre, Lancaster Rd, Shrewsbury, Shropshire SY1 3LE. Tel 0845 3305122
www.efsis.com/htm/en/subp4page5.php

Pesticide Residues Committee (PRC)
Mallard House, Kings Pool, 3 Peasholme Green, York YO1 7PX. Tel 10904 445775
www.pesticides.gov.uk/prc_home.asp

Pesticides Safety Directorate (PSD)
Mallard House, Kings Pool, Peasholme Green, York YO1 2PX. Tel 01904 640500
www.pesticides.gov.uk

Soil Association
Bristol House, 40-56 Victoria Street, Bristol BS1 6BY. Tel 0117 3145000
www.soilassociation.org/farmassurance

APPENDIX A. Pesticide residues sought on UK and imported pears in WPPR/PRC surveys 1995-2004 (See footnote below table for key to abbreviations)

Pesticide active substance	**1995**	**1997**	**1998**	**1999**	**2000**	**2002**	**2003**	**2004**
Acephate	Y	Y	Y	-	-	Y	Y	Y
Aldicarb	-	-	-	-	-	Y	-	-
Azinphos-ethyl	-	Y	-	-	Y	-	-	-
Azinphos-methyl	Y	Y	Y	-	**F**	**F**	**F**	**F**
Azoxystrobin	-	-	-	-	-	Y	Y	Y
Bendiocarb	Y	Y	Y	-	Y	Y	-	-
Bifenthrin	Y	Y	Y	-	-	Y	Y	Y
Biphenyl	Y	Y	Y	-	-	-	Y	Y
Bromopropylate	**F**	Y	**F**	-	-	**F**	**F**	Y
Bupirimate	Y	Y	Y	-	-	Y	Y	Y
Buprofezin	Y	Y	Y	-	-	Y	-	-
Butocarboxim	-	Y	-	-	Y	Y	-	-
Captan	**F**	Y	**F**	-	-	**F**	**F**	**F**
Carbaryl	Y	**F**	**F**	-	**F**	**F**	Y	Y
Carbendazim	**F**	**F**	**F**	-	**F**	**F**	**F**	**F**
Carbofuran	-	Y	-	-	Y	Y	-	-
Chlorfenvinphos	Y	Y	Y	-	Y	Y	-	
Chlormequat	-	**F**	**F**	**F**	**F**	**F**	**F**	**F**
Chlorothalonil	Y	Y	Y	-	-	**F**	Y	Y
Chlorpropham	Y	Y	-	-	-	-	-	-
Chlorpyrifos	Y	Y	Y	-	**F**	**F**	**-**	Y
Chlorpyrifos-methyl	Y	Y	Y	-	**F**	Y	Y	Y
Chlozolinate	Y	Y	Y	-	-	Y	-	-
Cyfluthrin	Y	Y	Y	-	-	Y	-	-
Cyhalothrin, lambda	Y	Y	Y	-	-	Y	-	-
Cypermethrin	Y	Y	Y	-	-	Y	-	-
DDT	Y	Y	Y	-	-	Y	-	-
Deltamethrin	Y	Y	Y	-	-	Y	Y	Y
Demeton-s-methyl	-	-	-	-	-	Y	-	-
Diazinon	Y	Y	Y	-	Y	**F**	Y	Y
Dichlofluanid	**F**	Y	Y	-	-	Y	Y	Y
Dichlorvos	Y	Y	Y	-	-	Y	-	-
Dichloran	Y	Y	Y	-	-	Y	Y	-
Dicofol	**F**	Y	Y	-	-	**F**	**F**	Y
Dicrotophos	-	Y	-	-	Y	Y	-	-
Diethofencarb	-	**F**	-	-	**F**	**F**	-	-
Dimethoate	**F**	**F**	**F**	-	**F**	**F**	Y	Y
Dinocap	-	-	-	-	Y	-	-	-
Dioxabenzophos	-	Y	-	-	Y	Y	-	-
Diphenylamine	**F**	**F**	**F**	-	-	-	**F**	**F**
Dithianon	-	-	-	-	Y	Y	Y	Y
Dithiocarbamates	**F**	**F**	**F**	-	**F**	**F**	**F**	**F**
Dodine	-	-	-	-	**F**	Y	**F**	**F**
Endosulfan	Y	Y	Y	-	-	Y	-	Y
EPN	-	Y	-	-	Y	Y	-	-
Ethiofencarb	-	Y	-	-	-	Y	-	-
Ethion	Y	Y	Y	-	Y	Y	Y	Y
Ethofumesate	Y	Y	Y	-	-	Y	-	-
Ethoprophos	Y	Y	Y	-	-	-	-	-
Ethoxyquin	**F**	**F**	**F**	-	-	-	-	-
Etriadiazole	Y	Y	Y	-	-	-	-	-
Etrimfos	Y	Y	Y	-	Y	Y	-	-
Fenbuconazole	-	-	-	-	-	-	-	Y
Fenhexamid	-	-	-	-	-	-	-	Y
Fenitrothion	Y	Y	**F**	-	Y	Y	Y	Y
Fenpropathrin	Y	Y	Y	-	-	Y	-	-

Cont'd	**1995**	**1997**	**1998**	**1999**	**2000**	**2002**	**2003**	**2004**
Fenpropidin	Y	Y	Y	-	-	-	-	-
Fenpropimorph	Y	Y	Y	-	-	Y	-	-
Fenvalerate	Y	Y	Y	-	-	-	-	-
Flucythrinate	-	Y	-	-	-	-	-	
Flurochloridone	Y	Y	Y	-	-	Y	-	-
Flusilazole	Y	Y	Y	-	-	Y	-	-
Folpet	-	-	-	-		**F**	**F**	**F**
Fonofos	Y	Y	Y	-	Y	Y	-	-
Formothion	-	Y	-	-	Y	Y	-	-
Fosthiazate	-	-	-	-	-	-	Y	Y
Furalaxyl	Y	Y	Y	-	-	Y	-	-
Furathiocarb	-	Y	-	-	-	Y	-	-
Gamma HCH	Y	Y	Y	-	-	Y	-	-
Heptenophos	Y	Y	Y	-	Y	Y	-	-
Hexachlorobenzene	Y	Y	Y	-	-	Y	-	-
Imazalil	Y	**F**	**F**	-	-	**F**	**F**	**F**
Iodofenphos	-	-	Y	-	-	-	-	-
Iprodione	Y	**F**	**F**	-	-	**F**	**F**	**F**
Isazophos	-	Y	-	-	Y	Y	-	-
Isofenphos	Y	Y	-	-	Y	Y	-	-
Isoprocarb	-	Y	-	-	Y	Y	-	-
Kresoxyim-methyl	-	-	-	-	-	Y	Y	Y
Malathion	Y	Y	Y	-	**F**	Y	Y	Y
Mecarbam	-	Y	Y	-	Y	Y	Y	Y
Mephosfolan	-	Y	-	-	Y	Y	-	-
Metalaxyl	**F**	Y	**F**	-	-	Y	Y	Y
Methamidophos	Y	Y	Y	-	-	Y	Y	Y
Methidathion	-	Y	Y	-	-	**F**	Y	Y
Methiocarb	-	Y	Y	-	Y	-	-	-
Methomyl	-	Y	-	-	Y	Y	-	-
Metolcarb	-	Y	-	-	Y	Y	-	-
Mevinphos	-	Y	-	-	Y	Y	-	-
Monocrotophos	Y	Y	Y	-	-	Y	Y	Y
Myclobutanil	Y	Y	Y	-	-	-	-	Y
Naled	-	Y	-	-	Y	Y	-	-
Napropamide	Y	Y	Y	-	-	-	-	-
Nicotine	Y	Y	Y	-	-	-	-	-
Nitrophal-isopropyl	Y	Y	Y	-	-	Y	-	-
Ofurace	Y	Y	Y	-	-	Y	-	-
Omethoate	Y	**F**	Y	-	-	Y	Y	Y
Oxadixyl	Y	Y	Y	-	-	Y	-	-
Oxamyl	-	Y	-	-	Y	Y	-	-
Paclobutrazol	Y	Y	Y	-	-	Y	Y	Y
Parathion	Y	Y	Y	-	Y	Y	Y	Y
Parathion-methyl	Y	Y	Y	-	Y	Y	-	Y
Penconazole	Y	Y	Y	-	-	Y	-	-
Pendimethalin	Y	Y	Y	-	-	Y	-	-
Permethrin	Y	Y	Y	-	-	Y	Y	Y
Phenthoate	Y	Y	Y	-	Y	Y	-	-
Phorate	-	-	-	-	-	Y	-	-
Phosalone	**F**	**F**	**F**	-	**F**	**F**	Y	Y
Phosmet	**F**	**F**	**F**	-	**F**	**F**	**F**	**F**
Phosphamidon	-	Y	-	-	Y	Y	-	-
Pirimicarb	Y	**F**	Y	-	Y	Y	Y	Y
Pirimiphos-ethyl	Y	Y	Y	-	Y	Y	Y	Y
Pirimiphos-methyl	Y	Y	Y	-	Y	Y	Y	Y
Procymidone	Y	**F**	**F**	-	-	**F**	**F**	**F**
Profenofos	Y	Y	Y	-	Y	Y	-	-
Prometryn	Y	Y	Y	-	-	Y	-	-
Propamocarb	-	Y	Y	-	-	-	-	-
Propanil	Y	Y	Y	-	-	Y	-	-
Propargite	Y	Y	Y	-	-	Y	**F**	Y

Cont'd	**1995**	**1997**	**1998**	**1999**	**2000**	**2002**	**2003**	**2004**
Propiconazole	Y	Y	Y	-	-	Y	-	-
Propoxur	Y	Y	Y	-	Y	Y	-	-
Propyzamide	Y	Y	Y	-	-	Y	-	-
Prothiofos	-	Y	Y	-	Y	Y	-	-
Pyrazophos	Y	Y	Y	-	Y	Y	-	-
Pyridaphenthion	Y	Y	Y	-	Y	Y	-	-
Pyrimethanil	-	-	-	-	-	Y	-	Y
Quinalphos	Y	Y	Y	-	Y	Y	-	-
Quinomethionate	Y	Y	Y	-	-	-	-	-
Quintozene	Y	Y	Y	-	-	Y	-	-
Simazine	Y	Y	Y	-	-	-	-	-
Tebuconazole	Y	Y	Y	-	-	**F**	Y	Y
Tebufenpyrad	-	-	-	-	Y	Y	-	Y
Tecnazene	Y	Y	Y	-	-	Y	-	-
Tetrachlorvinphos	Y	Y	Y	-	Y	Y	-	-
Tetradifon	Y	Y	Y	-	-	Y	Y	Y
Thiabendazole	**F**	Y	**F**	-	-	**F**	**F**	Y
Thiodicarb	-	Y	-	-	-	-	-	-
Thiophanate-methyl	Y	Y	-	-	Y	-	-	-
Tolclofos-methyl	Y	Y	Y	-	Y	Y	-	-
Tolyfluanid	**F**	**F**	**F**	-	-	**F**	**F**	**F**
Triazamate	-	-	-	-	-	-	-	Y
Triazophos	Y	Y	Y	-	Y	Y	Y	Y
Trifloxystrobin	-	-	-	-	-	Y	Y	Y
Trifluralin	Y	Y	Y	-	-	Y	-	-
Vinclozolin	**F**	Y	Y	-	-	Y	Y	Y
Total residues sought	100	127	104	1	59	119	54	62

(NB. Not all residues are sought on all samples taken in any one year.)

Key to symbols and abbreviations:

- = pesticide not sought
Y = pesticide sought but not found
F = pesticide above the Limit of Detection (LOD) found

APPENDIX B. Pesticide residues found in pears from WPPR/PRC surveys 1995-2004, number of samples with residues (range of residues found mg/kg) – (See page 40 for the key to the abbreviations in these tables.)

UK pears

Pesticide residue	**1995**	**1997**	**1998**	**1999**	**2000**	**2002**	**2003**	**2004**
Total samples	13	27	5	13	21	15	28	27
No. samples with no residues detected	1	6	0	10	8	3	21	10
% samples with no residues detected	7.7	22.2	0	76.9	38.1	20	75	37
Bromopropylate (A) (CAC MRL=2)	2 (0.2-1)	Nil	Nil	-	-	Nil	Nil	Nil
Captan (F) (MRL=3)	2 (0.1-0.2)	2 (0.3-0.4)	2 (0.06-0.4)	-	-	3 (0.06-0.3)	4 (0.06-0.3)	6 (0.02-0.2)
Carbaryl (I) (MRL=5)	Nil	Nil	Nil	-	1 (0.1)	Nil	Nil	Nil
Carbendazim (F) (MRL=2)	2 (0.5-0.9)	15 (0.06-1)	3 (0.1-0.4)	-	12 (0.2-0.6)	1 (0.1)	3 (0.2-0.3)	8 (0.05-0.5)
Chlormequat (PGR) (MRL=0.3)	-	8 (0.06-15)#	4* (0.07-4.9)	3** (1.6-10)	4 (0.09-0.3)	1 (0.1)	Nil	Nil
Chlorpyrifos (I) (MRL=0.5)	Nil	Nil	Nil	-	1 (0.03)	Nil	-	Nil
Diphenylamine (SP) (MRL=5)	Nil	6 (0.01-0.07)	Nil	-	-	-	Nil	Nil
Dithiocarbamates (F) (MRL=3)	3 (0.1-0.2)	7 (0.1-0.5)	3 (0.05-0.2)	-	1 (0.3)	4 (0.07-0.1)	1 (0.3)	4 (0.05-0.07)
Iprodione (F) (MRL=10)	5 (0.6-4.1)	9 (0.3-3.6)	3 (0.08-0.5)	-	-	6 (0.6-2.3)	1 (1)	5 (0.07-2.6)
Metalaxyl (F) (MRL=1)	1 (0.1)	Nil	Nil	-	-	Nil	Nil	1 (0.06)
Phosalone (I) (MRL=2)	1 (0.2)	Nil	Nil	-	Nil	Nil	Nil	Nil
Pirimicarb (I) (CAC MRL=1)	Nil	1 (0.06)	Nil	-	Nil	Nil	Nil	Nil
Tolyfluanid (F) (CAC MRL=5)	2 (0.08)	2 (0.5-0.8)	1 (0.1-0.2)	-	-	2 (0.2-0.3)	3 (0.1-0.2)	2 (0.06-0.1)
Vinclozolin (F) (CAC MRL=1)	1 (0.05)	Nil	Nil	-	-	Nil	Nil	Nil
MRL Exceedances	Nil	Nil	1	2	Nil	Nil	Nil	Nil

Imported pears

Pesticide residue	1995	1997	1998	1999	2000	2002	2003	2004
Total samples	32	27	36	77	112	59	218	114
No. samples with no residues detected	7	4	1	34	33	27	79	25
% samples with no residues detected	21.9	14.8	2.8	44.2	29.5	45.8	36.2	21.9
Azinphos-methyl (I) (MRL=1)	Nil	Nil	2 (0.09-0.1)	-	4 (0.06-0.2)	1 (0.08)	17 (0.05-0.1)	7 (0.05-0.1)
Bromopropylate (A) (CAC MRL=2)	4 (0.2-1.5)	Nil	4 (0.1-0.2)	-	-	2 (0.2)	4 (0.05-0.1)	Nil
Captan (F) (MRL=3)	8 (0.05-0.7)	4 (0.08-0.2)	2 (0.06-0.4)	-	-	29 (0.06-1.6)	19 (0.06-1.8)	24 (0.02-0.7)
Carbaryl (I) (MRL=5)	Nil	1 (0.09)	Nil	-	4 (0.01-0.07)	1 (0.1)	2 (0.08-0.1)	1 (0.03)
Carbendazim (F) (MRL=2)	1 (0.4)	12 (0.05-0.5)	10 (0.1-0.8)	-	33 (0.1-1.4)	6 (0.05-0.2)	28 (0.06-0.6)	36 (0.06-0.6)
Chlormequat (PGR) (MRL=0.3)	-	13 (0.05-12)	21***** (0.05-11)	43*x8 (0.06-16)	52 (0.05-3)	25 (0.05-0.5)	42 (0.05-0.5)	8 (0.05-0.08)
Chlorothalonil (F) (MRL=1)	Nil	Nil	Nil	-	-	4 (0.05-0.1)	Nil	Nil
Chlorpyrifos (I) (MRL=0.5)	Nil	Nil	Nil	-	2 (0.05-0.07)	3 (0.06-0.09)	-	2 (0.02-0.03)
Chlorpyrifos-methyl (I) (MRL=0.5)	Nil	Nil	Nil	-	1 (0.01)	Nil	Nil	Nil
Diazinon (I) (MRL=0.5)	Nil	Nil	Nil	-	Nil	2 (0.02-0.03)	Nil	Nil
Dichlofluanid (F) (MRL=5)	1 (0.2)	Nil	Nil	-	-	Nil	Nil	Nil
Dicofol (A) (MRL=1)	3 (0.1-0.3)	Nil	Nil	-	-	1 (0.2)	1 (0.07)	Nil
Diethofencarb (F)	-	-	-	-	13 (0.05-0.4)	3 (0.06-0.4)	Nil	Nil
Dimethoate (I) (MRL=0.02)	3 (0.06-0.1)	2 (0.07-0.09)	2 (0.07-0.1)	-	1 (0.06)	7 (0.02-0.07)	Nil	Nil
Diphenylamine (SP) (MRL=5)	4 (0.07-2.5)	8 (0.01-1.2)	5 (0.3-2.4)	-	-	-	16 (0.06-1.7)	21 (0.05-1.3)
Dithianon (F) (CAC MRL=5)	-	-	-	-	Nil	Nil	2 (0.05-0.1)	Nil
Dithiocarbamates (F) (MRL=3)	15 (0.1-1.7)	8 (0.2-1)	22 (0.05-2)	-	26 (0.1-2.3)	29 (0.06-0.1)	22 (0.1-0.9)	19 (0.05-0.6)

Imported pears continued

Pesticide residue	1995	1997	1998	1999	2000	2002	2003	2004
Dodine (F) (CAC MRL=5)	-	-	-	-	5 (0.2-0.4)	Nil	1 (0.5)	4 (0.05-0.2)
Ethoxyquin (F) (CAC MRL=3)	4 (0.06-0.3)	4 (0.1-0.5)	1 (0.3)	-	-	-	-	-
Fenitrothion (I) (MRL=0.5)	Nil	Nil	1 (0.05)	-	Nil	Nil	2 (0.03-0.04)	Nil
Folpet (F)	-	-	-	-	-	11 (0.08-2.1)	2 (0.2-0.9)	8 (0.03-1)
Imazalil (F) (MRL=5)	3 (0.1-0.6)	4 (0.3-1.5)	3 (0.03-0.6)	-	-	8 (0.1-1.1)	3 (0.3-1)	9 (0.1-1.4)
Iprodione (F) (MRL=10)	Nil	3 (0.5-0.8)	Nil	-	-	5 90.08-1)	2 (0.1-0.8)	4 (0.1-0.4)
Lambda cyhalothrin (I) (MRL=0.1)	Nil	Nil	Nil	-	-	1 (0.02)	-	-
Malathion (I) (MRL=0.5)	Nil	Nil	Nil	-	2 (0.07-0.1)	Nil	1 (0.07)	1 (0.04)
Methidathion (MRL=0.3)	-	Nil	Nil	-	-	1 (0.3)	Nil	Nil
Phosalone (I) (MRL=2)	3 (0.07-0.4)	2 (0.2-0.5)	3 (0.06-0.6)	-	9 (0.01-0.1)	2 (0.07-0.2)	Nil	Nil
Phosmet (I) (CAC MRL=10)	4 (0.08-0.3)	3 (0.1-0.4)	3 (0.02-0.1)	-	8 (0.05-0.5)	25 (0.05-0.6)	16 (0.04-0.3)	19 (0.02-0.1)
Pirimicarb (I) (CAC MRL=1)	Nil	Nil	Nil	-	Nil	Nil	1 (0.09)	1 (0.02)
Procymidone (MRL=1)	Nil	1 (0.2)	2 (0.09-0.1)	-	-	7 (0.03-0.9)	5 (0.03-0.1)	1 (0.09)
Propargite (A) (CAC MRL=5)	Nil	Nil	Nil	-	Nil	Nil	1 (0.4)	Nil
Tebuconazole (F)	Nil	Nil	Nil	-	Nil	1 (0.1)	Nil	Nil
Thiabendazole (F) (MRL=5)	2 (0.3-0.5)	Nil	2 (0.6-1.1)	-	-	5 (0.3-0.6)	13 (0.2-3.5)	1 (1.2)
Tolyfluanid (F) (CAC MRL=5)	3 (0.2-0.7)	5 (0.05-0.6)	5 (0.05-0.7)	-	-	14 (0.09-0.3)	25 (0.05-1.4)	31 (0.05-0.4)
Vinclozolin (F) (CAC MRL=1)	1 (0.07)	Nil	Nil	-	-	Nil	Nil	Nil
MRL exceedances	Nil	Nil	5	8	Nil	Nil	Nil	Nil

Key to symbols and abbreviations:

MRLs shown are the most recent values presented in the latest PRC survey report for apples. Where an MRL exceedance is recorded it relates to the MRL which was current at the time the survey was conducted.
- = pesticide not sought
nil = residue not found
* = one MRL exceedance found
** = two MRL exceedances found
***= three MRL exceedances found

Pesticide types:
A = acaricide; F = fungicide; I = insecticide; PGR = plant growth regulator; SP = scald prevention; SS = sprout suppressant (e.g. tecnazene used on stored potato crops and occasionally occurring as a contaminant on apples)

APPENDIX C. BBCH Phenological Growth Stages for Apples and Pears (Meier *et al*.,1994)

Code	Description
Principal growth stage 0: Sprouting /Bud development	
00	Dormancy: leaf buds and the thicker inflorescence buds closed and covered by dark brown scales
01	Beginning of leaf bud swelling: buds visibly swollen, bud scales elongated, with light coloured patches
03	End of leaf bud swelling: bud scales light coloured with some parts densely covered by hairs
07	Beginning of bud break: first green leaf tips just visible
09	Green leaf tips about 5 mm above bud scales
Principal growth stage 1: Leaf development	
10	Mouse-ear stage: Green leaf tips 10 mm above the bud scales; first leaves separating
11	First leaves unfolded (others still unfolding)
15	More leaves unfolded, not yet at full size
19	First leaves fully expanded
Principal growth stage 3: Shoot development (from terminal bud)	
31	Beginning of shoot growth: axes of developing shoots visible
32	Shoots about 20% of final length
33	Shoots about 30% of final length
3-	Stages continuous till
39	Shoots about 90% of final length
Principal growth stage 5: inflorescence emergence	
51	Inflorescence buds swelling: bud scales elongated, with light coloured patches
52	End of bud swelling: light coloured bud scales visible with parts densely covered by hairs
53	Bud burst: green leaf tips enclosing flowers visible
54	Mouse-ear stage: green leaf tips 10 mm above bud scales; first leaves separating
55	Flower buds visible (still closed)
56	Green bud stage: single flowers separating (still closed)
57	Pink bud stage: flower petals elongating; sepals slightly open; petals just visible
59	Most flowers with petals forming a hollow ball
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: about 10% of flowers open
62	About 20% of flowers open
63	About 30% of flowers open
64	About 40% of flowers open
65	Full flowering: at least 50% of flowers open, first petals failing
67	Flowers fading: majority of petals fallen
69	End of flowering: all petals fallen

Growth Stages and Identification Keys for Apples & Pears (continued)

Code	Description
Principal growth stage 7: Development of fruit	
71	Fruit size up to 10 mm; fruit fall after flowering
72	Fruit size up to 20 mm
73	Second fruit fall
74	Fruit diameter up to 40 mm; fruit erect (T-stage: underside of fruit and stalk forming a T)
75	Fruit about half final size
76	Fruit about 60% final size
77	Fruit about 70% final size
78	Fruit about 80% final size
79	Fruit about 90% final size
Principal growth stage 8: Maturity of fruit and seed	
81	Beginning of ripening: first appearance of cultivar-specific colour
85	Advanced ripening: increase in intensity of cultivar-specific colour
87	Fruit ripe for picking
89	Fruit ripe for consumption: fruit have typical taste and firmness
Principal growth stage 9: Senescence, beginning of dormancy	
91	Shoot growth completed; terminal bud developed; foliage still fully green
92	Leaves begin to discolour
93	Beginning of leaf fall
95	50% of leaves discoloured
97	All leaves fallen
99	Harvested Product

APPENDIX D. Pear Pest and Disease Action Calendar

Growth stage	Check list of Integrated Pest and Disease Management tasks
Dormant period	
	Service and calibrate weather station. Start temperature records from 1 January.
	In the middle of the dormant period, assess overwintering populations of aphid eggs on shoots and scale insects on bark by visual inspection. Earmark orchards with damaging populations of any of these pests for treatment at the appropriate time.
	Inspect whole orchard for fireblight cankers. Remove and burn infected branches or whole trees if necessary.
	Remove badly cankered branches, wood scab shoots, root stock sucker growths (which may harbour capsid eggs and mildew) during winter pruning.
	In the late dormant period (February), assess overwintering populations of adult pear sucker by beating. If high numbers of pear sucker are present (>> 1/beat) there is a greater risk of serious pear sucker attacks in the growing period. An early season spray of a recommended synthetic pyrethroid insecticide can be considered to kill adults before egg laying commences. This should not be applied until the migration of pear sucker adults into the orchard from other orchards and trees is complete.
	Check whether any leaf litter is left in the orchard by the end of February, as this may be a source of scab inoculum. Macerate thoroughly well before bud burst to aid biodegradation.
	Stock check pesticide store.
Just pre bud-swell	
	Consider a pre-bud-burst spray of a copper fungicide, especially where canker and scab were bad the previous season. This may give some control of overwintering scab and protect against *Nectria* canker and will reduce populations of bacteria (*Pseudomonas syringae pv syringae*) that cause bacterial blossom wilt.
Bud-swell	
	Start weather station records of leaf wetness, humidity and rainfall. Run disease forecasting (e.g. ADEM) and pest life cycle (e.g. PESTMAN) computer models at least weekly and before spray rounds are applied.
	Start programme of fungicide sprays for scab control promptly. Choice of fungicide and spray interval will depend on varietal susceptibility, scab levels the previous season including late season infection of leaves and the amount of leaf litter present.
Bud-burst	
	Continue sprays for scab to maintain good protection at this sensitive stage
Early green bud	
	Check whole orchard for branches that have failed to leaf out indicating probable fireblight infection. Remove infected branches or whole trees if necessary before blossom.
	Monitor numbers of pear leaf blister mites and the occurrence of blisters on rosette leaves and of pear rust mite on outer rosette leaves. If blister mite or damage is extensive apply a recommended acaricide or include Elvaron Multi at the full rate for the next 2-3 spray rounds. If threshold numbers of pear rust mite (5 mites per outer leaf) are exceeded, apply a recommended acaricide or include Elvaron Multi at full dose or sulphur at reduced (25-33%) rate in next 3-4 spray rounds
	Continue sprays for scab to maintain good protection at this sensitive stage
Green bud	
	Conduct pre-blossom pest assessment for pear midge adults (especially where the pest occurred the precious year) in warm, still conditions. Apply first spray of a pyrethroid if adults seen and repeat as necessary. Also assess aphids, winter and tortrix moth caterpillars, pear sucker, capsids, rust mite and other minor pests. Apply other pre-blossom insecticide sprays as necessary.
	Continue sprays for scab to maintain good protection at this sensitive stage

White bud	
	Check truss leaves for scab until early June. Early detection of a potential problem is essential.
	Apply the first spray of mildew fungicide in pear orchards which contain susceptible varieties (e.g. Comice or Concord). Include a mildew fungicide in each spray application for scab until at least three sprays after petal fall.
	Repeat pre-blossom assessment for pear midge adults in warm, still conditions. Apply pyrethroid spray if necessary. If not done at green bud, conduct pre-blossom pest assessment for aphids, winter and tortrix moth caterpillars, pear sucker, capsids, rust mite and other minor pests. Apply pre-blossom insecticide spray if necessary.
First flower	
	After frost, check whole orchard for presence of frosted blossoms infected by fireblight. Remove and burn infected branches or whole trees if necessary.
	Continue spray programme for scab and mildew as necessary
Full bloom	
	After frost, check whole orchard for presence of frosted blossoms infected by fireblight. Remove and burn infected branches or whole trees if necessary.
	Continue spray programme for scab and mildew as necessary, but try to avoid spraying fungicides at this critical time if possible
Late blossom	
	Continue spray programme for scab and mildew as necessary
	Conduct late blossom pest assessment for pear bedstraw aphid, other aphids, winter moth and other early caterpillars, rust mite and capsid.
End of blossom	
	Continue spray programme for scab and mildew as necessary.
	Start regular programme of monitoring for pear sucker and anthocorid predators. Apply preventive spray of insecticide if eggs are numerous. Apply curative spray of insecticide if numbers of nymphs are above threshold or if there is significant honeydew contamination of fruits and anthocorid predators are not sufficiently numerous to prevent further population increase or damage
	Apply a post blossom spray of insecticide(s) if required for capsid, sawfly, winter moth, clouded drab moth, tortrix caterpillars, pear bedstraw aphid or other pests.
	Apply acaricide spray for rust mite or if necessary
	If required, apply fenoxycarb (Insegar) for summer fruit tortrix moth and pear sucker once the risk to bees has ceased. This product should not be needed for tortrix moth control if methoxyfenozide (Runner) is to be or has already been applied, though there may still be a need to use it at this time or later for pear sucker or other pests.
	Set out pheromone traps for codling, fruit tree tortrix moth and summer fruit tortrix moth. Record the catch of moths of each species at least weekly.
Early June	
	Fortnightly for the rest of the season, and following fireblight warnings, check whole orchard for presence of shoot die back or blossom death caused by fireblight. Remove and burn infected branches or whole trees if necessary.
	Check orchard thoroughly for signs of scab on leaves or fruitlets and for wood scab. Continue sprays as necessary if scab is present, or if the weather is very wet or if scab problems occurred last year
	Continue regular programme of monitoring for pear sucker and anthocorid predators. Apply preventive spray of insecticide if eggs are numerous. Apply curative spray of insecticide if numbers of nymphs are above threshold or if there is significant honeydew contamination of fruits and anthocorid predators are not sufficiently numerous to prevent further population increase or damage.
	Conduct early June pest assessment for pear sucker, pear bedstraw aphid, pear sucker, clouded drab moth, pear leaf blister mite damage and rust mite.
	If Blastobasis was present last year or infestation is suspected, conduct beat samples for adults at fortnightly intervals throughout June or July. Insecticidal treatment should be considered if the pest is detected.
	Calculate daily egg development amounts for summer fruit tortrix using maximum

	and minimum air temperatures and look up table provided. Apply egg hatch spray of methoxyfenozide (Runner) or *Bacillus thuringiensis* (Dipel) when sum reaches 90-100%. Repeat sprays to maintain protection through egg hatch period. This action should not be necessary if methoxyfenozide (Runner) or fenoxycarb (Insegar) earlier.
	Continue weekly monitoring of pheromone traps for codling and tortrix moths. If diflubenzuron (Dimilin) is to be used for control of codling or fruit tree tortrix moth, then a spray should be applied as soon as the threshold pheromone trap catch is exceeded.
Late June	
	Continue sprays for scab only if necessary
	Continue fortnightly fireblight inspection, especially where fireblight has been found.
	Look for signs of die back on extension growth caused by canker. Cut out and burn.
	Continue regular programme of monitoring for pear sucker and anthocorid predators. Apply preventive spray of insecticide if eggs are numerous. Apply curative spray of insecticide if numbers of nymphs are above threshold or if there is significant honeydew contamination of fruits and anthocorid predators are not sufficiently numerous to prevent further population increase or damage.
	Conduct late June pest assessment for other pests including green apple aphid, tortrix moth caterpillars and rust mite. Apply control treatments as necessary.
	Continue weekly monitoring of pheromone traps for codling and tortrix moths. If diflubenzuron (Dimilin) is to be used for control of codling or fruit tree tortrix moth, then a spray should be applied as soon as the threshold pheromone trap catch is exceeded.
	Continue regular beat sampling for Blastobasis if necessary. Apply chlorpyrifos or another suitable insecticide if pest is detected.
July-August	
	Continue sprays for scab only if necessary
	Continue fortnightly fireblight inspection, especially where fireblight has been found.
	Conduct late July-mid August pest assessment for green apple aphid, tortrix moth caterpillars, pear leaf blister mite, rust mite and other pests. Apply control treatments as necessary.
	Continue regular programme of monitoring for pear sucker and anthocorid predators. Apply preventive spray of insecticide if eggs are numerous. Apply curative spray of insecticide if numbers of nymphs are above threshold or if there is significant honeydew contamination of fruits and anthocorid predators are not sufficiently numerous to prevent further population increase or damage.
Pre-harvest	
	Apply a spray of Thianosan (thiram) 2-3 weeks before harvest. This will give some protection against rots and will also deter birds.
	Conduct rot risk assessment in each orchard. Determine best way of minimising losses due to rots with minimal use of post harvest fungicide treatments.
Harvest	
	Train pickers to be vigilant for pest and disease blemishes to fruit and record the causes of significant losses in each orchard.
	Drench fruit in fungicide to prevent Botrytis and Brown rot where fruit is to be stored beyond December.
Post harvest	
	If apple bud weevil (*Anthonomus piri*) is known to occur locally, monitor populations of weevil adults using beating method if pest was present previous season and inspect buds for signs of infestation or damage. Apply a spray of chlorpyrifos in good conditions if the pest is detected
	In orchards with a high level of scab, apply a spray of 5% urea post picking and before appreciable leaf fall. This will help aid microbial breakdown of the leaves bearing scab perithecia and prevent the overwintering stage of scab developing.
Leaf fall	

	To protect leaf scars from canker infection, apply a copper spray the start of leaf fall and again at 50% leaf fall.
	Soon after leaf fall, inspect orchard for trees which still have leaves attached to whole limbs or branches indicating probable fireblight infection. Remove and burn infected branches or whole trees if necessary
Grading	
	Train grading staff to be vigilant for pest and disease blemishes to fruit and fungal rots and record the causes and extent (% incidence) of losses due to each cause in each orchard.
Dormant period	
	Start at the top again.

APPENDIX E. Selected recent and ongoing research projects

Further information on Defra funded projects can be found on the Defra website. It should be noted that results of HDC funded projects are available to levy payers. Many of the projects outlined in the Apple Action Plan may contain approaches which could be applied to pear. The lower level of R&D activity on pears reflects the relative importance of this crop in the UK compared to apples.

Recent Research

<u>Integrated control of new storage rot problems in apple and pears (HH2118STF) Defra.</u>

Three year project (1998-2001) looked at rots which have become seen more frequently over recent seasons and identified the changes which had given rise to them. The key factor in the increase in levels had been the management practice of pulverising pruning in situ rather than removing them from the orchard. This had allowed these organisms to build up on rotting plant tissue.

<u>Improving pesticide spraying techniques for tree crops. (PA1721) Defra.</u>

One year project (2000-2001) reviewed the methods of expressing pesticide dose and discussed. This also provided the preparatory work to enable PA1732 (see below) to develop PACE.

<u>Pesticide application rate adjustment to the crop environment (PACE) for fruit spraying with an axial fan sprayer. (PA1732) Defra.</u>

This three year project ((2001 to 2004) developed an approach to assessing tree size and matching spray volume to the tree size. This methodology could when developed further help to optimise pesticide application and apply the minimum of pesticide required to achieve control of pests.

<u>TF108 Review of biological control of apple and pear pests in the UK. HDC.</u>

This review, concluded in 1997 provided a basis for targeted research and development as well as areas for immediate use.

Ongoing Research

<u>Further development of pesticide dose adjustment to crop environment (PACE) for fruit spraying with broadcast sprays. (PS2002) Defra</u>

This three year project (2004 to 2007) develops the work carried out within project PA1732 into commercial apple orchards extending the information base looking at a wider range of tree forms and situations.

<u>Pear: Evaluation of non-fungicide treatments for the control of *Botrytis cinerea* on stored pears (var. Conference). HDC Project.</u>
Evaluating the potential of biological control by antagonistic organisms on Botrytis in store. If successful and approval can be obtained for the biological control agent this work could eliminate the need for post harvest fungicidal drench on pears.