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The effects of leaf litter treatments, post-harvest urea and omission of early season fungicide sprays on the overwintering of apple scab on Bramley's Seedling grown in a maritime environment

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The theory that orchards with zero or low levels of apple scab post harvest do not need scab protection at the start of the next growing season was evaluated under Irish conditions. In addition, a range of post-harvest orchard sanitation practices (application of urea to rot overwintering leaves, mowing the orchard or total leaf removal in February) were also evaluated. Due to the high summer rainfall in Ireland (compared to all other European apple growing areas) and the severe susceptibility of the apple cultivar Bramley's Seedling to scab (*Venturia inaequalis*), neither clean orchards in the autumn nor sanitation practices were sufficient to eliminate the requirement for full fungicide protection programmes at the start of the following growing season. Post harvest applications of urea proved difficult due to late harvesting of pollinator fruit for the juice market and wet weather. Total removal of leaf litter from plots prior to the commencement of growth did not significantly reduce disease incidence. Regardless of orchard cleanliness in autumn, missing the first fungicide application in the spring always reduced yield.

Keywords: leaf litter; mowing; mulching; urea; *Venturia inaequalis*

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Introduction

Bramley's Seedling, a culinary cultivar, is the major apple variety grown commercially in Ireland, occupying an area of ca. 1700 ha, most of which is in Co. Armagh. Since 2001, annual production has ranged from 25 to 50 thousand tonnes and the value of the crop at the farm gate ranged from £GB3.2 to £GB7.3 million (Anonymous, 2007) depending on level of supply. Apple scab, caused by the fungal pathogen *Venturia inaequalis*, is the most serious disease limiting production; in most years its development is favoured by the mild, wet Irish climate (average 1100 mm of rainfall each year). In the spring, infection is initiated mainly by ascospores released from diseased apple leaves surviving in orchard debris (Hirst and Stedman, 1962a,b), although conidia or mycelia which overwinter in diseased wood, shoots or buds, may also contribute to the primary inoculum (Holb, Heijne and Jeger, 2004b). Under suitable environmental conditions, the developing leaves and flower buds are infected and the disease becomes epidemic with repeated cycles of conidial production and infection. Severe foliar scab may result in premature leaf fall and the decreased photosynthetic area reduces the trees' productivity. At the same time, developing fruit may be infected and rendered unmarketable due to scab lesions. In Ireland, a full spring-summer fungicide spray programme, which may comprise as many as 15 applications between March and August, is required to achieve scab control; if the disease is not controlled, the crop may be completely unmarketable (average 80% reduction in Co. Armagh). Before the introduction of fungicides, growers had to rely on orchard hygiene to lessen the impact of disease. Now, with pressure to reduce reliance on fungicides, these techniques are regaining importance.

Burchill *et al.* (1965) first showed that application of 5% urea to English orchards in the autumn completely suppressed ascospore production the following spring. Burchill (1968) treated Bramley's Seedling trees at two sites in Kent with a postharvest, pre-leaf fall application of 5% urea; scab lesions on blossom-spur leaves were reduced by 59% and 46%, respectively, the following spring compared to the untreated control. Similarly, in France a 5% urea spray applied to severely scabbed (> 30% foliar scab) Golden Delicious and Starking Delicious trees after harvest but before leaf fall, reduced scab the following spring (Bassino and Blanc, 1975).

Despite the effectiveness of urea in reducing ascospore survival, the need for spring-summer fungicide applications could not be eliminated. By the 1970s, commercial apple growers had ready access to a wide range of fungicides which were much less toxic than earlier compounds and scab management generally relied on routine application of these throughout the growing season, with little emphasis on the benefits of orchard hygiene (MacHardy, 1994).

In recent years, however, there has been increasing emphasis on the development of integrated pest management strategies in the fruit industry (MacHardy, 2000) with the intention of reducing agrochemical usage (to improve the financial returns from fruit production and to satisfy customer requirements for high quality fruit produced with minimal use of agrochemicals). The techniques involved may include growing disease resistant cultivars, removal of alternate hosts (where relevant) and cultural and sanitation measures (Berrie and Cross, 2000). In the case of apple production in Ireland, scab control presents the greatest challenge for integrated pest management. In theory, better targeting of fungicide applications, which may potentially reduce the number of applications, can be achieved by using weather-based disease forecasting systems. However, in field trials over four seasons in New Zealand, Beresford and Manktelow (1994) found that scab was consistently greater in treatments where fungicide use was reduced by timing sprays using weather information and concluded that, because of the increased costs of harvesting and grading scabby fruit, there was little economic incentive for growers to reduce fungicide use. Berrie and Xu (2003), using the Adem™ disease prediction system, reported better disease control with integrated fruit production systems combined with strategic spraying. However, such systems have proved to be of limited value under Irish conditions where regular rainfall is a constant factor during the growing season and full spray programmes are usually indicated by forecasting systems: thus, over three seasons only one spray was saved using the Adem™ system (Mac an tSaoir, 2001).

Interest in combining orchard hygiene measures with reduced fungicide applications in integrated scab management in Northern Ireland was rekindled by the work of MacHardy and co-workers on the potential ascospore dose. The concept of estimating the potential of the ascospore source is not new and was first proposed by Hirst and Stedman (1961, 1962a), but had not been developed into a system which could be used to modify the spring–summer fungicide programme. Gadoury and MacHardy (1986) developed a method for quantifying the potential ascospore dose (PAD), which they defined as the total seasonal production of ascospores per square meter of orchard floor, by estimating the disease incidence and severity just before leaf fall and the leaf litter density at bud break. MacHardy, Gadoury and Rosenberger (1993) demonstrated that at sites where PAD was low, the first fungicide application could be delayed without impairing scab control. Subsequently, Sutton, MacHardy and Lord (2000) showed that shredding leaf litter or treating it with urea could reduce PAD. However, the temperate, maritime, island climate of Ireland is very different from that of the Eastern United States, where MacHardy validated the use of PAD to delay fungicide application. Aylor (1998) considered the aerobiology of apple scab and commented that an abandoned orchard (1 ha) with high levels of scab could cause infections in a managed orchard 2 to 5 km distant. In the Netherlands, Holb, Heijne and Jeger (2004b) demonstrated that there was a risk of early scab epidemics initiated by overwintered conidia in orchards where there had been a high incidence of apple scab in the preceding season.

It was therefore important to evaluate the impact on scab control of a range of approaches aimed at reducing pesticide usage under Irish conditions. To that end, treatments, including mowing and urea application, that were intended to reduce the overwintering of ascospores in leaf litter were investigated over a 4-year period. At the same time, the effect on scab control of omitting early fungicide sprays was evaluated in the absence of any hygiene treatments in a well managed orchard.

Materials and Methods

A series of experiments designed to evaluate MacHardy's theory on orchard hygiene and potential fungicide reduction was undertaken, as explained below, during the period 2001 to 2004, inclusive.

The experiments were all undertaken on medium to heavy loam, at the Agri-Food and Biosciences Institute Horticulture Centre, Loughgall, Co. Armagh

BT61 8JP (Ordinance Survey map reference 7°37'W, 54°34'N). All experimental plots were surrounded by Alder wind breaks. In all experiments, scab assessments were undertaken in June, July, August, at harvest (September) and post harvest (Late October/Early November) using the European and Mediterranean Plant Protection Organisation (EPPO) protocol PP1/5(3). Yield parameters (harvested weight, drops weight, total weight per plot (harvested and dropped combined), weight and size grading of 50 apples) were recorded at harvest. The percentage of the fruit that was clean and above 70 mm was recorded as 'percent marketable'. Experimental design for each experiment is described in the relevant section.

To keep variability to a minimum the apple scab protection programme was standard across all treatments over the 4 years of the experiments. The programme comprised a tank-mix of fenbuconazole (50 g/ha as 'Indar 5EW' 50 g/L, Landseer) and dithianon (300 g/ha as 'Dithianon Flowable', 705 g/L, BASF). This combination had given excellent scab control in agrochemical evaluation trials (Mac an tSaoir, unpublished). Sprays (14 applications/season) were applied at high volume using appropriate sprayers (see below) at 10-day intervals from bud-break (within the first two weeks of April).

The effect of leaf litter treatment on spring infection levels

The experimental design consisted of two blocks with the four treatments randomly applied to each. Plots of apple, cv. Bramley's Seedling, on M9 rootstocks (planted in 1995 at a spacing of 3 m × 4 m, 32 trees per plot) were treated by either mowing the alleyways once, mowing twice (using a Votex orchard mower –2 m span), total leaf removal by hand or untreated before bud burst. The mowing operations (either a single pass or a double pass) took place in February each year as wet winter weather always prevented mowing any earlier. Leaf removal took place at the same time as mowing. Visual assessments of leaf litter presence in February showed that an average of 90% of surviving litter was trapped in the grass alleyways i.e. most of the leaves which had fallen onto the 2 m herbicide strip under the trees were blown onto the grass. The treatments were randomised each year. A Berthoud air assisted sprayer at 1000 L/ha was used to apply all treatments during the experiments. The plots were left unsprayed until green cluster (i.e. missed the first three sprays) in order to allow any potential treatment effects to develop. Disease levels and yield were subsequently assessed as described earlier. Yield was recorded on a full plot basis (32 trees) and orchard scab assessments were recorded on the four central trees.

The effect of missing early sprays on subsequent scab development

This experiment was conducted in the agrochemical evaluation orchard which consisted of Bramley's Seedling trees on M26 rootstock (planted in November 1983) in a fully randomised block design with nine plots randomly arranged in each of four blocks. Each of the 36 plots contained two assessed trees surrounded on all sides by shared, single-row guard trees. The trees were planted 4.3 m apart within rows with 6 m between rows. Tree height was managed in line with local practice to maintain a height of *c*. 3.5 m with a canopy width of *ca.* 2.5 m.

Four plots in each block were used for evaluating the following treatments: missing the first spray (M1), missing the first two sprays (M2), missing the first three sprays (M3), and the full scab-protection programme (M0). Each year the treatments were moved to different plots. Standard agrochemical protection programmes (described earlier) were used with the chemicals being applied to the trees using hand-held lances. Each treatment was applied to the point of run-off. Disease levels during the season and plot yield parameters at harvest were recorded according to EPPO guidelines [PP1/5 (3)].

The effect of urea on rate of leaf fall and decomposition

Over four seasons, two concentrations of urea (Net Urea 46%, Sefton Fertiliser Ltd.) were applied post harvest at 5% leaf fall (on 20/11/01, 6/11/02, 7/11/03 and 26/10/04) to mature, open-centred Bramley's Seedling trees (on M26 rootstock, planted at 3 m × 4 m, 1983) using lances (at 23.9 kg/1,000 L and 47.9 kg/1,000 L (= full rate)). There were four trees surrounded by guard rows per plot and four replicates of each treatment. Leaf fall was monitored by placing apple bins midway between the central two trees in the plot. At weekly intervals (weeks 1 to 5) fallen leaves were removed from the bins and counted. In addition, nylon bags of 50 leaves, dipped in the same concentrations of urea, were placed on the orchard floor and the rate of leaf rotting was measured by reduction in dry matter (determined after oven drying at 80 °C for 4 days). Initial attempts at monitoring leaf rotting on the ground failed as it was impossible to sample without removing soil with the leaf debris. The use of nylon mesh bags alleviated this problem.

Statistical analysis

All experiments were statistically analysed using the Genstat programme (Payne *et al*., 2008). The data for all experiments were analysed routinely with and without transformation (angular transformation). In all cases, the probability plot of the residuals of untransformed data was not a straight line, so only transformed data are presented.

Results

Meteorological conditions

The results reported here were affected by two major weather events during the course of the trials. The average (90 years) rainfall for Loughgall is 1100 mm. The year 2001, with 663 mm rainfall, was relatively dry. In 2002, there was a hard frost over 15–16 April when temperature dropped to −1.8 °C for two days and severely damaged the flowers, which was followed by an exceptionally wet May (132 mm compared to 90-year average of 70 mm; Figure 1). The combination of these extreme weather conditions resulted in almost total crop failure. Although 2003, with 712 mm rainfall, was quite dry, pollination was affected by very heavy continuous rain (110 mm) during the blossom period, followed by excessive rain in June and July. These extended wet periods resulted in prolonged apple scab infection periods (Table 1) which, combined with poor pollination, caused significantly reduced yield.

In contrast, 2004 at 810 mm rainfall and a warm, dry blossom period was relatively 'normal'. With two abnormal seasons out of four, it proved very difficult to identify significant trends within the data. The flowering period (May) coincided with severe scab pressure in 2001, 2002 and 2003 (Table 1). Both 2002 and 2003 had extensive periods of wet weather (Figure 1) when the disease was thriving and spraying was impossible. Low disease pressure during flowering only happened in 2004. Revised Mills tables (MacHardy and Gadoury, 1989) predict when weather

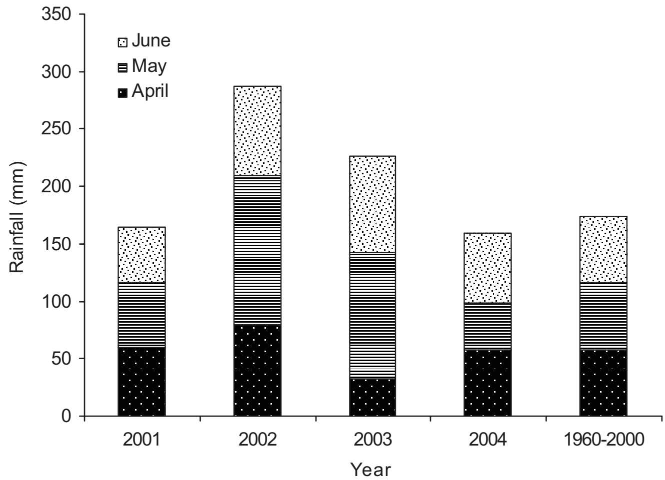

Figure 1. Rainfall (mm) at Loughgall from 2001 to 2004 inclusive with 40-year mean for April, May and June.

Table 1. Scab infection periods and number of infection days, for 2001 to 2004 based on Revised Mills infection tables[a]

Year	April		May		June	
	Periods	Days	Periods	Days	Periods	Days
2001	4	10	4	7	3	5
2002	3	7	3	13	3	6
2003	5	5	2	10	3	4
2004	3	5	0	0	1	1

[a] Mills tables do not indicate severity of infection.

conditions are conducive to spore release but do not predict the levels of spore release. However, extended periods of wet weather prevent fungicide applications to the crop and with only a short period of kickback activity available with some fungicides, the potential for disease establishment increases significantly.

The effect of leaf litter treatment on spring infection levels

Over the four growing seasons, removal or mowing leaf litter had no significant effect on the development of scab or cropping in any year (Table 2). Whilst total removal of leaf litter did produce the highest average yield and the lowest amount of fruit lost to scab, benefits were not significant.

The results presented confirm the importance of leaf litter and its removal in the overall disease management scenario. Averaged over four seasons, total leaf litter removal gave the highest yield and the lowest percentage fruit which was unmarketable due to scab. The leaf scab and fruitlet scab figures demonstrate the indigenous disease pressure in an intensive apple growing region and also the difficulty in controlling scab once it has become established in an orchard. The fact that total leaf removal did not significantly reduce apple scab damage is also indicative of the indigenous disease pressure.

The effect of missing early season fungicide applications

The effects of missing out early season protection are shown in Table 3 and Figure 2. In 2001 and 2002, unsprayed controls were included and compared with these, all other treatments had a significant

Table 2. The effect of leaf litter on apple scab development between 2001 and 2004 (all treatments missed the first three sprays)

Variable	Treatment[a]				LSD[b] (P=0.05)
	Control	Mow	Mow × 2	Removal	
Fruitlet scab – June (%)	24.9	13.8	25.2	17.4	13.82
Leaf scab – June (%)	10.4	9.8	13.5	10.3	3.57
Leaf scab – July (%)	10.2	10.2	12.9	10.7	2.55
Leaf scab – August (%)	12.9	13.1	14.6	13.3	2.36
Leaf scab at harvest (%)	37.6	38.2	36.4	36.0	6.11
Fruit unmarketable due to scab (%)	22.3	21.8	20.0	17.9	6.74
Total yield per plot (kg)	234.4	247.1	229.8	260.9	32.84
Weight picked (kg)	215.0	226.3	208.9	239.4	31.61

[a] Mow = the grass and leaf litter were cut with one pass of a standard 3 m Votex orchard mower; Mow × 2 signifies that a second pass immediately followed the first.
[b] None of the differences were statistically significant.

Table 3. The effect of spray programme on disease and yield development for the years 2001 to 2004

Treatment[a]	Fruitlet scab (%) June	Leaf scab (%)				Total yield (kg)	Marketable yield (%)
		June	July	August	Oct./Nov.		
M0	12.0	1.9	7.4	18.9	37.5	130.1	76.3
M1	17.1	3.3	8.2	21.7	39.1	113.4	75.1
M2	21.5	6.3	11.5	23.9	43.6	91.4	61.6
M3	33.6	5.4	11.6	23.5	35.7	83.5	53.6
s.e.	5.3	0.9	1.6	2.4	2.5	7.8	4.3
F-test		*				**	*
LSD (P=0.05)	16.78	2.87	5.00	7.60	12.09	24.82	13.71

[a] M0 = full spray programme; M1 = first spray omitted; M2 = first 2 sprays omitted; M3 = first 3 sprays omitted.

effect. In addition, unsprayed plots created an increasing disease infection inoculum which potentially could influence neighbouring plots. Therefore this treatment was removed in 2003 and 2004. Average data from these treatments is included in Figure 2 and illustrates the absolute necessity to control *Venturia inaequalis* on a susceptible cultivar (Bramley) in a maritime climate.

Overall the results demonstrated that even missing only the first spray will have adverse consequences for the grower. Fruitlet scab (recorded in June) showed a consistent (though not significant) increase as sprays were missed. Leaf scab did increase significantly over the same period. The resumption of spraying reduced scab levels on the trees. However, the fruitlet scab damage subsequently developed into a significant reduction in both total yield and marketable yield (Table 3 and Figure 2). When scab levels on fruitlets and leaves, early, mid and late season were averaged over the four years of the trial (Figure 2) it was clear that missing sprays early in the season was not a practical method of saving on chemical application.

Use of Urea

None of the differences for this experiment were significant. It proved impossible to achieve optimum timings for urea application in these trials, since applications had to be delayed until after the

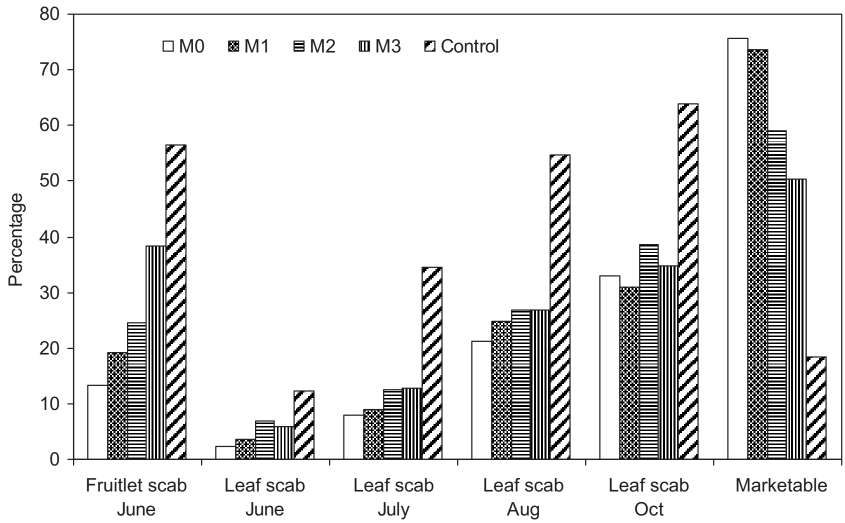

Figure 2. The effect of full spray programme (M0) compared to missing first (M1), first two (M2) or first three (M3) sprays, respectively on mean incidence of fruitlet and leaf scab and percent marketable weight over 4 years (2001 to 2004). The control figure represents the mean of the unsprayed trees (2001 to 2002).

pollinators had been harvested for juice and usually by then leaf drop had started. Consequently neither the use of urea nor the rate used increased leaf fall (Table 4). Attempts to monitor leaf degradation due to use of urea were unsuccessful. Averaged over two seasons, dry matter decreased by 45% between November and March. However, total surviving dry matter (which mostly consists of un-degraded xylem) is not a useful measurement in the context of apple scab development, which depends on the area of intact leaf lamina, a parameter which could not easily be monitored, hence these data are not presented.

Discussion

From the literature cited in the introduction, it is evident that ascospores produced in fallen apple leaves and released in the spring are the most important source of

Table 4. Effect of urea on leaf defoliation (%) averaged over 2001 to 2004

Observation week[a]	Urea application rate[b]			Mean	LSD[c] (P=0.05)
	None	Half rate	Full rate		
Week 1	50.5	51.3	52.1	51.3	4.26
Week 2	29.2	27.2	28.7	28.4	4.32
Week 3	14.6	15.0	14.7	14.8	1.80
Week 4	13.1	10.7	12.2	12.0	4.12
Week 5	10.5	9.4	9.0	9.7	2.28

[a] Post treatment.
[b] Urea concentration: Half rate = 23.9 kg/1,000 L water; Full rate = 47.8 kg/1,000 L water.
[c] None of the differences were statistically significant.

inoculum and initiate new infections on recently developed leaves. Any treatment which can remove leaves from the orchard floor will thus reduce inoculum, resulting in less scab. All of the published research was, however, undertaken in countries and areas where continental climatic conditions predominate. The results reported here illustrate the major differences which a maritime climate bring to the issue of scab control, particularly the year round availability of moisture. The mean annual rainfall at Loughgall is 1100 mm (compared to 750 mm in Kent, England). Therefore there is always a strong chance of infection during the growing season if viable spores are present. Holb (2006) made reference to the fact that scab spores can travel from poorly managed areas into otherwise clean areas, thus re-establishing infection. Loughgall is at the centre of the largest apple growing area in Ireland and thus re-infection is always a risk. However, even though there are no poorly maintained orchards within the immediate environs of the institute, there was still sufficient inoculum present to ensure significant disease pressure. Indeed, the industry practice of ceasing spraying for scab control in mid Summer contributes significantly to the development of post harvest scab under Irish maritime conditions (in three seasons out of four, large scab inocula were present at the end of the season).

Shredding leaves, use of urea or inoculation with biocontrol agents, such as *Micosphaeropsis ochracea* or *Athelia bombacina*, all significantly reduced ascospore production in Canadian orchards (Vincent, Rancourt and Carisse, 2004). Urea and leaf shredding were the most effective treatments giving 92.1 and 85.2% reductions in ascospore production, respectively (Vincent, Rancourt and Carisse, 2004). Similar reductions in overwintering ascospore inoculum of *Pleospora allii* (*Stemphylium vesicarium*), the cause of brown spot of pear, were achieved using leaf shredding or removal (Liorente, Vilardell and Montesinos, 2006). Only partial reductions were recorded following the application of the biocontrol agent, *Trichoderma* sp., and chemical treatments with copper or urea were ineffective in reducing ascospore production (Liorente, Vilardell and Montesinos, 2006). In the study described in this paper, no measurements were made, following mechanical or chemical treatment, of total numbers of ascospores produced. However, the very large reduction in intact leaves on the orchard floor would have resulted in less tissue in which ascospores could develop with subsequently fewer released in the spring.

The finding that total leaf removal from plots only slightly reduced infection levels supports the observations of Aylor (1998) on the transfer of infection from one orchard to another. The high levels of disease in the orchards post harvest add to the potential of early season infection as predicted by Holb *et al.* (2004a) and this is further supported by the data reported here where missing just the first spray significantly increased fruit scab incidence.

When urea was applied to leaf litter in orchards in northwest United States of America in November, at approximately 95% leaf-fall, the number of ascospores counted in spore traps was reduced by 50%. This increased to 60% when the urea was applied in April, prior to bud-break (Sutton, MacHardy and Lord, 2000). In Ireland, Bramley's Seedlings have a tendency to retain their leaves for prolonged periods and in some years a significant number are still attached in late December. This makes the timing of effective urea applications difficult, although with the milder maritime climate of Ireland, there may be more opportunities to treat fallen leaves, compared to colder areas where the leaves and ground are frozen for long periods during the winter. However, persistent winter and spring rains often make orchards impassable for chemical or mechanical treatment of the fallen leaves. Urea application is further complicated by legislation which outlaws nitrogen application during the winter period.

There have been a number of reports that reductions in ascospore numbers achieved by mechanical or chemical methods have an effect on subsequent scab development. Holb (2007) reported that using a range of techniques to treat fallen leaves, such as removal, disc cultivation, shredding or covering the orchard floor with plastic foils, reduced leaf litter density which in turn resulted in reductions in spur-leaf scab incidence the following spring compared to non-sanitised areas. The greatest reductions were in the order of 16 to 27% achieved with the plastic cover. Such a reduction in a maritime climate would not be sufficient to allow for a reduction in spray usage.

In organic apple orchards in France, Gomez *et al.* (2007) demonstrated the benefits of complete removal of leaf litter, by a combination of leaf sweeping and tillage within rows, in reducing apple scab inoculum. This resulted in low levels of leaf and fruit scab, enabling growers to omit summer fungicide treatments for apple scab control. Again however, the traditional dry French summer conditions do not apply to Ireland.

In 2- and 3-year studies in Dutch and Hungarian orchards, chemical, (both urea and fungicide) treatment of fallen leaves on the orchard floor and non-chemical (leaf shredding) resulted in significantly lower scab incidence on spur-leaf clusters compared to the treatment without any sanitation (Holb, 2006). However, the sanitation effects on scab levels on older leaves and on fruit were both low and variable from year to year (Holb, 2006). This is consistent with the results achieved in Ireland, where the beneficial effects of leaf sanitation on leaf and fruit scab were minimal in each of the 4 years of the trial. There could be a number of reasons for this: (a) it is virtually impossible to achieve total destruction or removal of infected leaves and even though inoculum was reduced there were still enough viable pseudothecia to produce ascospores and initiate infection, (b) once new leaves started to form, spread of the pathogen by asexual conidia and resultant disease development could be rapid in suitable weather conditions, (c) inoculum reduction may have been achieved within the trial orchards but, in areas of intensive apple production, the pathogen could be introduced from neighbouring orchards (although Gomez *et al.* (2007) measured the scab lesion gradient which indicated that ascospore spread was not important beyond a 20 m distance from the source and similar short distance spread of ascospores was also reported by Holb *et al.* (2004a), conidia have been reported to disseminate over very long distances (Hirst and Steadman, 1961)), (d) the apple cultivar Bramley's Seeding readily forms small wood scab lesions in which the pathogen can overwinter asexually and act as an inoculum source the following spring (while many of these lesions may be removed during winter pruning, those remaining could still contribute to the disease cycle), (e) conidia can also overwinter on shoots and buds and can contribute to early season scab infections (Holb, Heijne and Jeger, 2004b). Such overwintering conidia may require control by early fungicide applications as suggested by Holb, Heijne and Jeger (2005); these authors also proposed that additional winter pruning of the upper third of the last year's growth might be beneficial combined with a fungicide spray at the green-tip stage. This strategy would not be suitable for Bramley trees in Ireland as wood scab has never been a major issue and the value of the crop does not warrant this style of pruning.

In many situations, both mechanical and chemical treatments of leaf litter can dramatically reduce both ascospore release in the spring and the subsequent development of leaf and fruit scab. This can allow growers to delay the first scab fungicide application by several weeks without reducing effective disease control (MacHardy, Gadoury and Rosenberger, 1993). However, in areas of intense apple production in temperate maritime climates, such as occur in Ireland, it is impossible to achieve sufficiently low levels of inoculum, both ascospore and conidial, to permit any delay in the first application of fungicides in a scab control programme for Bramley's Seedling apple.

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