

Integrated pest and disease management

What is Integrated Pest and Disease Management (IPDM)?

It is the integration of all the best management methods and practices for control of pests and diseases:

- within economic constraints
- meeting all legal requirements
- to achieve a sustainable, high standard of pest and disease control
- so that fruit quality and yield are not impaired
- minimising risks to human or animal health or to the environment from the use of plant protection products

Basic requirements

- A knowledge of the main pests and diseases of apple
- How to recognise them and assess them
- Their life cycles and the driving forces behind infestation or infection
- Varietal susceptibility
- Alternative hosts
- Natural enemies
- Cultural, biotechnological, biological and chemical control methods
- The occurrence of pesticide resistance and how to avoid it.

This information is set out in detail in this Best Practice Guide. It is also important that you:

- Have knowledgeable, trained, qualified (pesticide use) and well-motivated staff including those who do manual work (pruning, spraying, harvesting etc.) in the orchard.

- Grow varieties that are resistant or of low susceptibility to the main pests and diseases, especially, in order of priority, to scab, mildew, canker, rosy apple aphid and sawfly if possible.
- Maintain a high standard of tree management to ensure that trees have the correct balance between growth and regular cropping and have an open canopy structure to ensure good air circulation, and easy penetration of light and spray.
- Undertake regular, thorough assessment and recording of the levels of pests and diseases in each orchard on the farm.
- Keep accurate and comprehensive records of all actions in the orchard including spray applications meeting all statutory and Code of Practice requirements.

Approach

Follow the action calendar below through the season:

- Assess the levels and risks of pest and disease by regular orchard inspection.
- Use traps and forecasting models based on weather and orchard data as set out in the action calendar.
- If control of a pest or disease is necessary, use a cultural, biological or biotechnological control method if possible.
- Only use a plant protection product when necessary.
- If control with a plant protection product is necessary, use the safest product to humans and the environment but which is effective against the pest.
- Do not use products that are harmful to key natural enemies (e.g. do not use synthetic pyrethroids on apple as they are harmful to the orchard predatory mite, *Typhlodromus pyri*, and many other natural enemies).

Pest and disease action calendar

Time/growth stage	Check list of Integrated Pest and Disease Management tasks
Dormant period	
	Assess overwintering populations of rust mite behind growing shoot buds, fruit tree red spider mite winter eggs round spurs, aphid and sucker eggs on shoots and scale insects on bark. Earmark orchards with damaging populations of any of these pests for treatment at the appropriate time.
	Remove badly cankered branches, wood scab and mildew infected (silvered) shoots, root stock sucker growths (which may harbour capsid eggs) during winter pruning. Protect pruning wounds with suitable canker paint
	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.
	Service and calibrate weather station. Start temperature records from 1 January.
	Stock check pesticide store.
Just pre bud-swell	
	Consider a pre-bud-burst spray of a copper fungicide (check current approval status), especially where canker and scab were bad the previous season. This may give some control of overwintering scab and protect against <i>Neonectria</i> canker.
Bud-swell	
	Start weather station records of leaf wetness, humidity and rainfall. Run disease forecasting (e.g. RIMpro) and pest life cycle 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	

	Monitor populations of apple blossom weevil adults at edges of orchards using beating method if pest was present previous season. Apply a spray of chlorpyrifos (Dursban etc.) in good conditions if threshold exceeded
	Continue sprays for scab to maintain good protection at this sensitive stage
Mouse ear	
	Monitor numbers of rust mites on outer rosette leaves. If threshold (5 mites per outer leaf) is exceeded, apply acaricide, or include 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 cluster	
	Conduct pre-blossom pest assessment for aphids, winter moth, tortrix moth, caterpillars, apple sucker, capsids, rust mite and other minor pests. Apply pre-blossom insecticide spray if necessary.
	Start mildew spray programme. Choice of product, dose, volume and interval will depend on varietal susceptibility and mildew levels last year
	Continue sprays for scab to maintain good protection at this sensitive stage
Pink bud	
	Check truss leaves for scab until early June. Early detection of a potential problem is essential.
	Assess primary mildewed flower trusses. >2% indicates a problem, >10% a severe problem. Use eradicant mildew fungicide.
	Put out white sticky traps for sawfly adults.
First flower	
	Continue spray programme for scab and mildew as necessary
	Apply first spray for blossom wilt . Repeat 7 days later. Cox, James Grieve, Lord Derby and several cider varieties are very susceptible.
Full bloom	

	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 rosy apple aphid, sawfly, winter moth, clouded drab moth, fruit tree red spider mite, rust mite and capsid, and capped blossoms due to apple blossom weevil.
End of blossom	
	Continue spray programme for scab and mildew as necessary.
	Assess primary mildewed vegetative terminal buds. >2% indicates a problem, >10% a severe problem. Use good eradicant mildew fungicide, decrease spray interval and increase spray volume if a problem.
	Check for signs of wilting, dying blossoms due to blossom wilt . Cut out affected trusses now while they can be seen and before cankers form. Earmark problem orchards for treatment the following year.
	Check for early signs of collar rot in older orchards on susceptible rootstocks. Early detection means the tree can be saved.
	Apply post blossom insecticide spray if required for capsid , sawfly , winter moth , clouded drab moth, rosy apple aphid or other pests.
	Apply acaricide spray for rust mite or fruit tree red spider mite if necessary
	In orchards where leaf midge has been a severe problem and where establishment of the parasitic wasp <i>Platygaster demades</i> is to be encouraged, start monitoring numbers of leaf midge eggs in growing points twice weekly in a representative orchard until harvest. Avoid spraying broad-spectrum insecticides when midge eggs are numerous to avoid harming the adult parasite, which is active when leaf midge eggs are numerous.
	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	
	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

	<p>Monitor secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round.</p> <p>Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.</p>
	<p>In orchards where canker is a problem, apply a spray, e.g. captan, to protect leaf scars from canker during summer leaf fall. Sprays at this time may reduce <i>Neonectria</i> rots in store.</p>
	<p>Conduct early June pest assessment for rosy apple aphid, woolly aphid, rosy leaf curling aphid (look out next year), sawfly damage (earmark for treatment next year), clouded drab moth, fruit tree red spider mite, rust mite.</p>
	<p>Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming <i>Platygaster demades</i>.</p>
	<p>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.</p>
	<p>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 suitable insecticide when sum reaches 90-100%. Repeat sprays to maintain protection through egg hatch period. This action should not be necessary if fenoxycarb (Insegar) was used just before and, if necessary, just after blossom.</p>
	<p>Continue weekly monitoring of pheromone traps for codling and tortrix moths. If methoxyfenozide (Runner) or indoxacarb (Steward) is to be used, which is advisable if Blastobasis is a problem the first spray should be delayed until the start of egg hatch.</p>
Late June	
	<p>Continue monitoring secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round. Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.</p>
	<p>Continue sprays for scab only if necessary.</p>
	<p>Look for signs of die back on extension growth caused by canker. Cut out and burn.</p>
	<p>Conduct late June pest assessment for woolly aphid, green apple aphid, fruitlet mining tortrix, fruit tree red spider mite, rust mite. Apply control treatments as necessary.</p>

	Continue weekly monitoring of pheromone traps for codling and tortrix moths. If methoxyfenozide (Runner) or indoxacarb (Steward) is to be used, which is advisable if Blastobasis is a problem, the first spray should be delayed until the start of egg hatch.
	Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming <i>Platygaster demades</i> .
	Continue regular beat sampling for Blastobasis if necessary. Apply methoxyfenozide (Runner) or indoxacarb (Steward) sprays if pest is detected.
July-August	
	Continue monitoring secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round. Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.
	Continue sprays for scab only if necessary
	In orchards where a risk of Neofabraea rot or Phytophthora rot has been determined, apply sprays of a recommended fungicide at 2-3 week intervals to protect fruit against infection.
	Conduct late July-mid August pest assessment for woolly aphid , green apple aphid , fruit tree red spider mite , rust mite . Apply control treatments as necessary.
	Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming <i>Platygaster demades</i> .
	Continue regular beat sampling for Blastobasis adults throughout July if necessary. Apply methoxyfenozide (Runner) or indoxacarb (Steward) sprays if pest is detected, or if it was a problem in the previous year.
Pre-harvest	
	Conduct rot risk assessment in each orchard. Determine best way of minimising losses due to rots.
Harvest	

	Train pickers to be vigilant for pest and disease blemishes to fruit and record the causes of significant losses in each orchard. Be vigilant for sawfly and Blastobasis damage.
Post harvest	
	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 pseudothecia and prevent the overwintering stage of scab developing.
Leaf fall	
	To protect leaf scars from canker infection, apply an approved fungicide spray the start of leaf fall and again at 50% leaf fall.
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	
	Go to top of table and start again. Practice makes perfect!

Pest and disease assessment

Best practice requires levels of pests and diseases in each orchard to be assessed and recorded on a regular basis and that treatment with pesticides only to be applied when necessary. These are also requirements of industry quality assurance schemes such as the Assured Produce scheme and of the Pesticide regulations. Furthermore, unnecessary use of pesticides is wasteful and undesirable environmentally.

Detailed methods are set out for the assessment of the most important pests and diseases of apples in the UK. Sampling methods, treatment thresholds and actions and their timings if thresholds are exceeded for apple pests and diseases in Integrated Pest and Disease Management are given.

When to assess

- Assessment should be done at least fortnightly from bud-burst to mid-August.
- Assessment of [scab](#) and [mildew](#) should be done on each occasion.
- Ideally, assessment should be done before a spray round is due to be applied so that decisions about the need for treatment, the interval between spraying, the best choice of product, the dose and volume rate can be taken on an informed and rational basis.
- Pest assessments should be done at the same time. However, there are a number of key times when pest assessment is particularly critical as follows:

Key times for pest assessments

Bud-burst	Where apple rust mite or apple blossom weevil occurred the previous year
Green cluster-pink bud	All orchards (as near to blossom as possible for late hatching
	pests but so that a pre-blossom spray can be applied if required)
Late blossom	All orchards to determine need for petal fall sprays
Early June	All orchards
Late June	All orchards
Late July-mid August	All orchards

Pheromone traps should be set out in orchards and monitored weekly until the end of August.

Sample size

- Ideally, 50 trees should be sampled in each orchard. However, examining such large numbers of trees is time consuming and is unlikely to be economically viable. A minimum of 10 trees, preferably 20, should be assessed per orchard.
- If trees are small, sample more trees per stopping place to give a volume of canopy roughly equivalent to 3 x 3 x 2 metres.
- If a particular pest or disease is clearly over the threshold, assessment for that pest or disease in the particular orchard can be curtailed. However, it is important to check that this is not just an isolated patch.
- Bias should be avoided by taking samples systematically. For example, fix your eye on a particular branch and sample the nearest truss/branch/leaf on the right or left of the one you selected. This avoids picking out or avoiding obvious damage.
- Take successive samples from the north, south, east and west segments of the tree, inside and outside the canopy.

It is very important to maintain general vigilance for signs of pests or diseases as you walk through the orchard.

Where to sample

Remember that although a reliable, representative sample is wanted, the object of sampling is to find trouble if it is there.

- Infestations are often patchy so the ground should be covered as well as possible.
- Particular attention should be paid to areas of the orchard with higher disease risk, e.g. for apple scab, dips or sheltered areas in the orchard where the trees are likely to remain wetter for longer.

- Ideally, the 10-20 or more trees will be spread over the whole block of fruit but in practice the sampling route will usually be a compromise between the ideal and the shortest route for covering the ground.
- The most awkward situation is where it is not possible to pass easily through the rows e.g. on hedgerow trees.
- In this situation it is necessary to walk up and down three or four rows.

Suggested routes in example orchards and sampling points are given in the [attached diagram](#). Arrows indicate the route and places for pausing to inspect and sample trees carefully

Normally, the main variety is sampled but where another (pollinator) variety is present and known to be susceptible to a particular pest, sample that variety instead for that pest (e.g. Worcester Pearmain or Discovery for [fruit tree red spider mite](#), Egremont russet for [rosy apple aphid](#), Gala for [scab](#) etc.)

How to sample

Visual assessment: Examine the blossom trusses, leaves etc. closely or a take a quick look at shoot tips for aphids, aphid damage, caterpillar damage, scab and mildew.

- Normal eyesight (with spectacles if necessary) is needed and a hand lens (x10 is usually adequate) is necessary for small pests such as spider mites, small caterpillars, early signs of scab lesions etc.
- Rust mites are generally easier to spot with a 20x hand lens.

Beating: A branch is tapped sharply (to jar the branch to dislodge insects) with the hand or a beater (e.g. 0.25 m long stiff rubber pressure hose) over a 0.25 m² area beating tray or net.

- This method gives good estimates of [apple blossom weevil](#), [capsids](#), [caterpillars](#) and beneficial insects, but it is important to avoid damage to the branch.





Pheromone trap, delta design, showing rubber dispenser lure

Pheromone traps:

- The trap for each species should be separated by several, preferably at least 10, metres.
- The traps should be set out at petal fall and monitored weekly.
- Lures should be changed as per the manufacturer's instructions, but at least monthly where instructions are not given.

Home made beating tray

Materials:

1 piece of thin plywood or hardboard, 400 x 625 mm for the tray

1 piece of hard or soft wood 30 x 15 x 400 mm to act as a handle

2 m of approximately 6-8 mm square beading to form an edge around the tray

- Fix the handle to tray, in the same plane as the tray with one end in the centre of the tray and the other protruding 200 mm half way along a long edge.
- Fix the beading around the edge of tray.
- Paint the tray a light colour so that insects are easily visible and so that the tray surface can be wiped clean and to protect the wood from water.

Organising the assessments

Organisation of assessment will depend on the size and circumstances of the farm. Assessment should be done by a trained person with normal eyesight who recognises the range of important pests and diseases and natural enemies of apple and their damage symptoms and who understands the principles of Integrated Pest and Disease Management. If they are not a direct employee and are to give advice on treatment with pesticides they must be BASIS trained.

- Records should be made on record sheets attached to a clipboard, in a notebook or in an electronic notebook.
- It is wise to use pencil as this does not run if the paper gets wet.
- Records should be made for each sampling point, at least initially.
- A record should be made of potential trouble spots (headlands, patches of thin soil, near woods or gardens etc.).
- Once experience is gained, recording can be abbreviated.

A simple scoring system widely used in the UK is as follows:

- 0=absent
- 1=trace
- 2=slight infestation (below threshold)
- 3=moderate infestation (above threshold)
- 4=heavy infestation well above threshold
- 5=severe infestation

Thresholds

- If the threshold for a pest or disease is reached appropriate action should be taken.

- The thresholds given here are simple (i.e. they do not take into account variety or crop or other factors).
- They are generally conservative to ensure a margin of safety.
- If a pest or disease is just below the threshold, repeat sampling after a short period may be appropriate.

Sampling methods, treatment thresholds and actions and their timings if thresholds are exceeded for apple pests and diseases in Integrated Pest and Disease Management			
Time/growth stage Sampling unit per tree (visual inspection unless beating specified)	Pest/disease	Threshold	Action and time for treatment
Dormant period			
2 vegetative buds on one-year shoots	Apple rust mite	Average 10 mites per bud	Treat with a suitable selective acaricide at mouse-ear
4 branch nodes on 2-3 year old wood	Fruit tree red spider mite winter eggs	30% branch nodes with >5 eggs	Treat with clofentezine (Apollo) before flowering, preferably before mouse-ear
Whole tree	Wood scab Apple mildew (silvered shoots) Apple canker and wood-rotting fungi Mummified brown rot fruit]]] Presence]]]] Remove during winter pruning

]	Remove or push into alleyway to be macerated by mower
Whole orchard	Over-wintering leaf litter	Easily found	Macerate to encourage breakdown prior to bud-burst
Bud-burst to mouse ear			
Beat 2 branches (if pest present previous year)	Apple blossom weevil adults	5 weevils per 50 beats	Treat with chlorpyrifos (Dursban etc.) as soon as possible
2 outer rosette leaves	Apple rust mite	Average of 5 mites per outer leaf	Treat as soon as possible pre-blossom
Green cluster to pink bud			
Whole orchard	Rosy leaf curling aphid	Presence on rosette leaves	Spot treat with aphicide
Time/growth stage Sampling unit per tree (visual inspection unless beating specified)	Pest/disease	Threshold	Action and time for treatment
Whole tree	Apple scab	% trees infected:	Intensify programme of eradicant and protectant

Time/growth stage Sampling unit per tree (visual inspection unless beating specified)	Pest/disease	Threshold	Action and time for treatment
Late blossom to 80% petal fall			
Whole orchard	Apple sawfly	1 or more adults caught in white sticky trap or pest present at threatening levels previous year	Treat with suitable insecticide within 7 days of petal fall
Whole tree	Apple scab Primary vegetative mildew European apple canker, Neonectria fruit rot	Presence of visible symptoms 2% mildewed shoots >25% with canker	Intensify programme of eradicant and protectant fungicide sprays at full dose, reduce spray interval Intensify programme of eradicant and protectant fungicide sprays at full dose and medium volume (500 l/ha) reduce spray interval. Indicates high risk of fruit infection and need to apply sprays at petal fall and 14

			days later to protect fruit
Whole tree	Rosy apple aphid Capped blossoms caused by apple blossom weevil	1 infested per 25 trees Presence	Treat with suitable insecticide at petal fall Earmark for treatment with thiacloprid (Calypso) at bud burst the following year
4 trusses	Apple sawfly Winter moth or clouded drab moth caterpillars Capsid	10 egg insertions per 100 trusses 3 caterpillars per 100 trusses 2 trusses per 100 trusses infested or damaged	Treat with suitable insecticide within 7 days of petal fall Treat with suitable insecticide at petal fall Treat with suitable insecticide promptly at petal fall
Receptacles of 2 flowers per tree	Apple rust mite on receptacle or calyx	An average of 1 or more mites per flower or fruitlet	Treat with suitable acaricide promptly at petal fall
Mid-May			
10 trusses on each of 4 branches	Scab on leaves, flowers or fruitlets	% trusses infected: <2.5% = low 2.5-9.0% = moderate >9% = high	Intensify programme of eradicant and protectant fungicide sprays at full dose, reduce spray interval according to severity and risk of infection
2 leaves per tree	Fruit tree red spider mite Apple rust mite	Average of 2 mites per leaf] Treat with suitable acaricide promptly

		<p>Average of 5 mites per leaf</p> <p>(greater numbers of mites may be tolerated if the orchard predatory mite <i>Typhlodromus pyri</i> is abundant. See sections on fruit tree red spider mite and apple rust mite)</p>] Treat with suitable acaricide promptly
Fortnightly after petal fall (June, July, August and, where necessary, September)			
Whole tree	<p>Rosy apple aphid</p> <p>Woolly aphid</p> <p>Rosy leaf curling aphid</p> <p>Sawfly</p> <p>Blossom wilt</p> <p>Canker in 1-2 year old shoots</p> <p>Neonectria eye rot</p>	<p>1-2 colonies</p> <p>4% of trees with aphids on extension growth</p> <p>Presence</p> <p>Presence</p> <p>Presence</p> <p>Presence</p> <p>Presence</p> <p>Presence</p>	<p>Treat with suitable aphicide as soon as possible</p> <p>Treat with suitable aphicide as soon as possible</p> <p>Spot treat with suitable aphicide</p> <p>Earmark for treatment following year</p> <p>Prune out. Treat with fungicide following year</p> <p>Prune out. Treat with fungicide at leaf fall</p> <p>A moderate to high incidence indicating risk of rotting in store</p>

4 shoots per tree	Scab on leaves	% shoots infected: <2.5% = low 2.5-9.0% = moderate >9% = high	Intensify programme of eradicant and protectant fungicide sprays at full dose, reduce spray interval according to severity and risk of infection
Time/growth stage Sampling unit per tree (visual inspection unless beating specified)	Pest/disease	Threshold	Action and time for treatment
Top (apical) 5 leaves in 2 growing shoots per tree	Secondary apple powdery mildew	8% of leaves mildewed = 30% shoots infected	Intensify programme of fungicide sprays at full dose and medium volume (500l/ha), reduce spray interval
2 leaves per tree	Fruit tree red spider mite Apple rust mite	Average of 2 mites per leaf Average of 10-50 mites per leaf, higher value later in season (greater numbers of mites may be tolerated if the orchard predatory mite Typhlodromus pyri is abundant. See sections on fruit tree red spider mite and apple rust mite)	Treat with suitable acaricide as soon as possible
Fruit on whole tree	Sooty blotch and fly speck	Presence	Earmark for treatment next year. Implement cultural control measures
Pheromone traps	Codling moth	>5 moths per trap per week for 2 weeks, not necessarily successive.	Treat 7-10 days after threshold catch (exact interval calculated from

		Applications of granulovirus may need to be made slightly before this threshold is reached.	max and min daily temperature)
	Fruit tree tortrix moth	>30 moths per trap per week	Treat about 2 weeks after threshold catch
	Summer fruit tortrix moth	30 moths per trap per week or significant damage previous year	Treat 7-10 days after threshold catch (exact interval calculated from max and min daily temperature).
Shortly before harvest (14-7 days before harvest)			
Whole orchard	Storage rots Brown rot Phytophthora rot	Conduct rot risk assessment Assess incidence on fruit: > 1% indicates high risk of rot in store Assess incidence of bare ground in tree row (20% or more = risk) and % of crop less than 0.5 m from ground (15% or more = risk)	Selective picking at harvest 20 mm or more rain in 15 days before harvest in orchards at risk = risk of rot in store. Options: avoid harvesting low fruit for store or market early.
Post harvest in orchard			
Whole orchard	Canker	Damaging levels present (25% of trees or more)	Apply copper sprays at leaf fall - check status of current authorisation
10-20 leaves per tree	Late scab infection on undersides of leaves	Present < 3% scabbed = low >3% scabbed = high	Spray urea shortly before leaf fall and macerate fallen leaves in winter

Place at least one trap for each species ([codling](#), [fruit tree tortrix](#) and where it occurs, [summer fruit tortrix moth](#)) in each major block of fruit.