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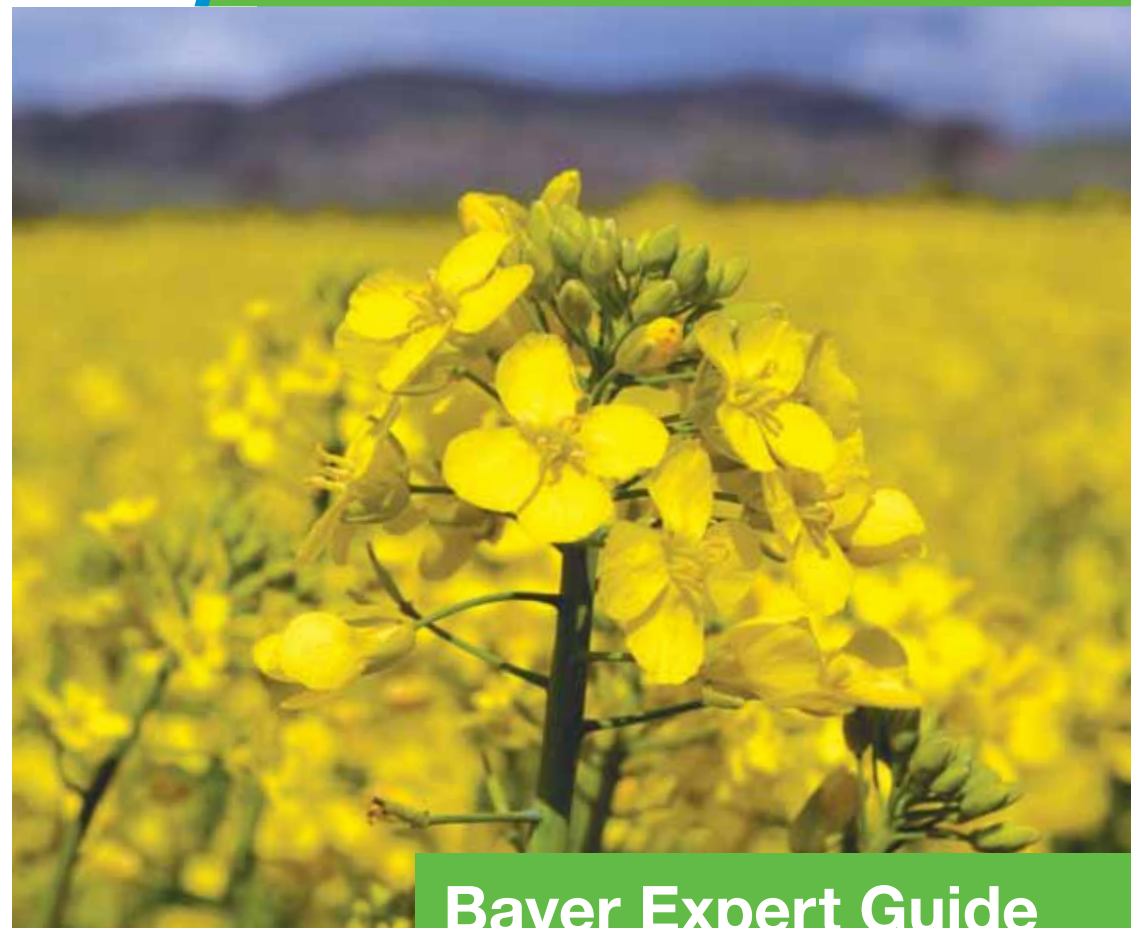
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Bayer Expert Guide Winter Oilseed Rape

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Introduction

The potential yield of UK winter oilseed rape crops is 6.5 t/ha but until 2011 average farm yields had remained static since the mid 1980s at around 3.0 t/ha. The average of 3.9 t/ha achieved in 2011 was a big leap forward and many crops reached the high performance band of 5.0 to 6.0 t/ha for the first time.

Building on this success, growers now have the potential of 6.5 t/ha within their sights. Oilseed rape is no longer a break crop for winter wheat. It is very much a profit generator in its own right and one that will reward investment of time and expertise in crop management.

This publication brings together the best practices of oilseed rape crop management that contribute to yield maximisation and provides a practical guide to the agronomy of oilseed rape needed to minimise yield loss to weeds, pests and diseases.

It has been authored by a team of independent experts in conjunction with the technical development managers at Bayer CropScience, a leader in oilseed rape crop protection. Together we hope you will find it a valuable guide in realising the full potential of your oilseed rape crops; in yield, quality and profit.

Authors



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1

Yield maximisation

Dr Pete Berry and Susie Roques, ADAS UK

Seed number and seed weight determine oilseed rape yield. Understanding how these two components can be influenced is vital to the maximisation of yield.

To maximise seed number the canopy must be managed to reach the right size at flowering so it will go on to produce the optimum pod number. Seed rate, establishment and nutrition are the key factors that can be managed to achieve this.

Although the duration of seed filling and thus seed weight is weather dependent, it can also be managed by effective disease control and avoiding lodging, so the plant optimises use of available sunlight through the seed filling period.

This chapter explains how these yield factors can be managed to target the full yield potential of UK crops.

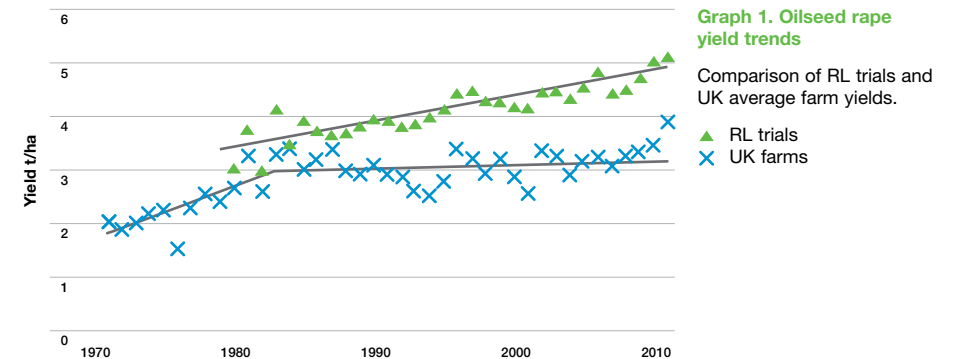


Photo © Blackthorn Arable Ltd

1.1 Yield potential

The potential average yield of winter oilseed rape in the UK has been estimated at 6.5 t/ha. Combining the best traits of current varieties into one variety and employing optimal crop management methods could achieve this yield. Longer term it is estimated that even greater yields are possible, mainly through breeding better varieties.

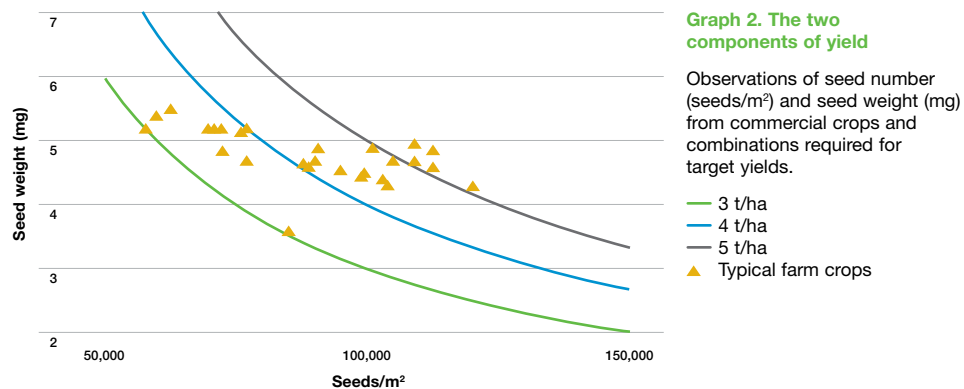
Average oilseed rape yields on UK farms are about half of the 6.5 t/ha potential yield and have been static since the early 1980s. However, yields in the HGCA Recommended List (RL) trials have continued to increase over the same period at a rate of about 0.05 t/ha per year, leaving a widening gap between RL trial yields and farm yields (Graph 1). This suggests that, although further breeding effort has a role to play in raising yields, the potential of existing varieties is not yet being realised. Therefore, there is considerable potential to increase farm yields through good crop management.



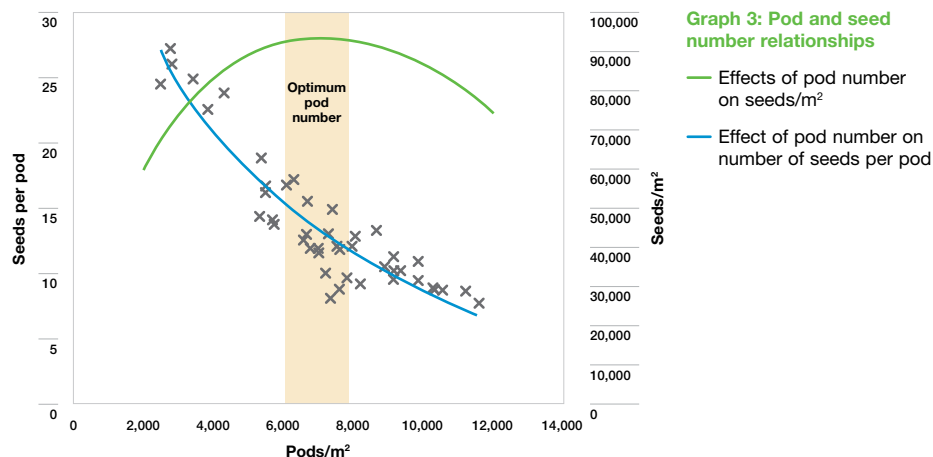
Opinions differ about what are the main factors holding back farm yields. Suggestions have included tighter rotations, soil compaction, reduced cultivations, sub-optimal establishment, sub-optimal crop nutrition, poor canopy management and inadequate crop protection. It is likely that yield stagnation has resulted from a combination of these and other factors.

1.2 How yield is determined

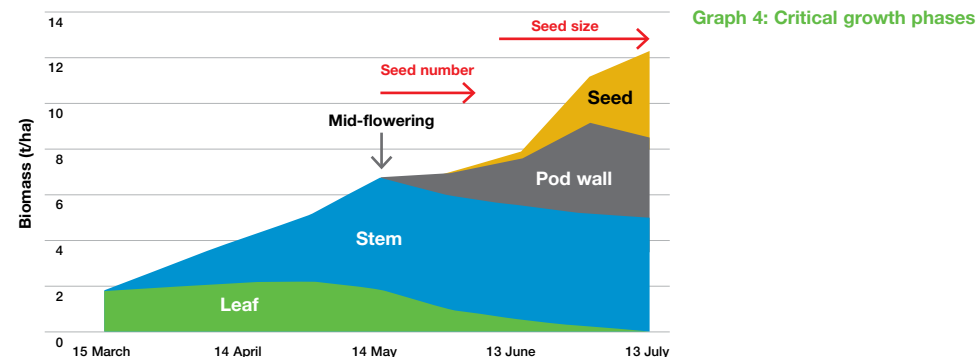
Oilseed rape yield can be broken down into two components: seed number and seed weight. It is possible to achieve the same yield either by high seed number and low seed weight or vice versa. Analysis of typical farm crops has shown that achieving a high seed number is critical for achieving high yields of 5 t/ha and more (Graph 2). Therefore efforts to improve yield should focus first on increasing seed number.



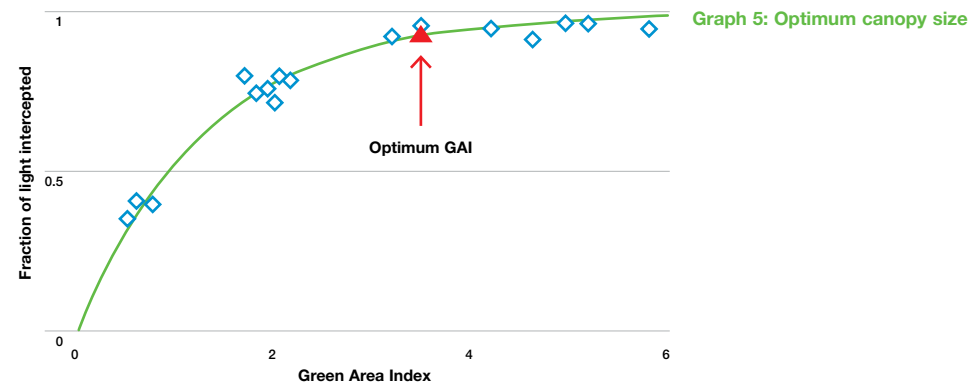
A high pod number (pods/m²) does not always lead to a high seed number (seeds/m²) because there is a negative relationship between pod number and the number of seeds per pod (Graph 3). In order to maximise seed number it is necessary to achieve an optimum pod number in the range of 6,000 to 8,000 per square metre. Crops are unlikely to reach their potential yield if pod number is significantly higher or lower than this.



Seed number is determined by the amount of photosynthesis carried out by the crop during a critical two to three week period from around mid-flowering onwards (Graph 4). Crop photosynthesis at this time can be maximised by achieving an optimum sized canopy at flowering.



Canopy size is measured in units of Green Area index (GAI) defined as square metres of green tissue area (leaf, stem and pod) per square metre of ground. As canopy size increases, so does the proportion of sunlight captured by the crop, which is beneficial for growth. However, there is a diminishing return, as once the crop is capturing most of the available sunlight, further increases in canopy size only increase light interception by a small amount (Graph 5).

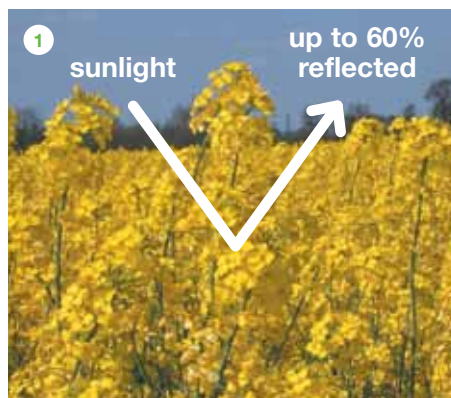


Crops with very large canopies – GAI greater than 4.0 – may result from drilling before the end of August, using high seed rates, volunteer plants, high levels of soil residual nitrogen, or mild autumn and winter temperatures. They waste resources by producing excess leaf and stem. Furthermore, very dense crops reduce the light available for photosynthesis at flowering, as the thick flower layer reflects up to 60% of sunlight before it reaches the leaves ①.

Larger crops will also set more than the ideal 6,000 to 8,000 pods/m² and are at greater risk of lodging. Trials have shown that the optimum sized canopy to maximise seeds/m² and yield potential has a GAI of 3 to 4 at flowering (Graph 5). This can be achieved through judicious choice of seed rate, correct spring nitrogen application rates and timings, and by appropriate use of PGRs.

Once seed number has been set it is then critical to realise full yield potential by prolonging the seed filling period and maximising photosynthesis. Seed filling is lengthened by low temperatures; for example, a drop of 2°C in average temperature prolongs seed filling by about five days by delaying ripening.

Whilst growers cannot control temperature, they can maximise the seed filling period by controlling diseases which reduce green area and cause premature plant death. Photosynthesis during seed filling can be maximised by avoiding lodging ② and prolonging leaf life since leaves use light more efficiently to produce biomass than pods and stems. Lodging can cause yield losses of up to 50%.



Sunlight reflection by densely flowering crops

Photo © ADAS UK Ltd



A lodged crop

Photo © ADAS UK Ltd

1.3 Husbandry

Sowing date

The optimum window for sowing oilseed rape is generally from 20th August to 10th September. High yielding crops can be achieved from sowing at the end of September but sowing in early August often leads to oversized canopies which are difficult to manage.

Seed rate and target plant population

To maximise yield it is important to establish enough plants to create the optimum sized canopy at flowering. Excessive plant populations have been shown to reduce yield even in the absence of lodging. Sparsely sown plants compensate by producing more branches, pods per branch and seeds per pod. At lower plant populations pods also remain green for longer thereby prolonging seed-filling.

In most conditions the ideal plant population is 25 to 40 plants/m² for both open-pollinated and hybrid varieties. However, higher plant populations may be required in certain situations such as where high pressure from pigeon grazing or weed competition is expected or in areas where spring growth is likely to be restricted by very dry weather.

Plant population is determined by seed rate and percentage establishment. Plant establishment depends primarily on soil conditions with good seed to soil contact being critical for good establishment. With good seedbed conditions, a seed rate of 40 seeds/m² should be sufficient to establish the target plant population of 25 to 40 plants/m². But establishment can decline significantly in sub-optimal seedbed conditions and a judgement must be made about the likely percentage plant establishment based on the conditions at drilling. Use table 1 below to calculate the required seed rate in seeds/m² by working back from target plant population and assuming likely plant establishment percentage.

Target plants/m ²	Plant establishment %					
	100	90	80	70	60	50
20	20	22	25	29	33	40
30	30	33	38	43	50	60
40	40	44	50	57	67	80
50	50	56	63	71	83	100
60	60	67	75	86	100	120
70	70	78	88	100	117	140
80	80	89	100	114	133	160

Table 1. Seed rate calculation table

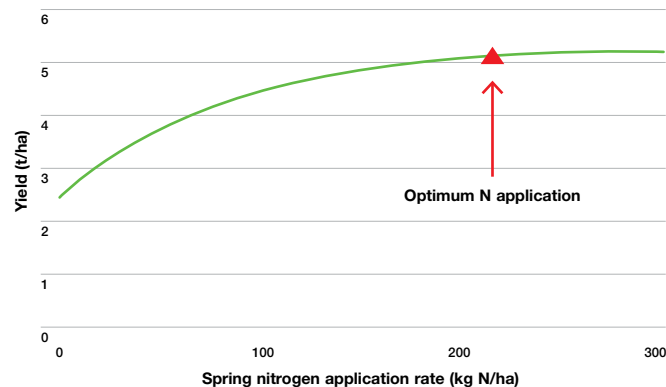
Sowing seed by weight alone (kg/ha) is not advisable, as individual seed weights vary considerably, giving a wide range of seed numbers per kilogram of seed. Use the equation below to calculate required seed rate in kg/ha from your thousand seed weight and target seed rate in seeds/m².

$$\text{Seed rate (kg/ha)} = \frac{\text{Thousand seed weight (g)} \times \text{target seeds/m}^2}{100}$$

When drilling rows wider than 30 cm it is important to use a seed rate that will not result in over-crowding of plants within rows as this can reduce yield.

Nutrition

To achieve high oilseed rape yields it is necessary to supply an adequate amount of all major nutrients including nitrogen, phosphorus, potassium, sulphur and magnesium. Minor nutrients such as boron may also be deficient in certain situations. Spring applied nitrogen usually has the greatest effect on oilseed rape yield with responses of up to 3 t/ha (Graph 6). Manipulation of nitrogen rate and timing helps growers to achieve the target GAI of 3.5 at flowering.



Graph 6: Response to spring nitrogen

The benefit of autumn applications of nitrogen is uncertain, but they are more likely to be beneficial if the supply of plant available nitrogen in autumn is very low, for example where large amounts of straw have been incorporated from the previous crop with minimal soil cultivations.

Sulphur applications are increasingly important for oilseed rape due to 90% reductions in atmospheric deposition over the past 30 years, as air pollution has been reduced. Sulphur applications are recommended on all mineral soils, with most oilseed rape crops requiring about 50 to 75 kg SO₃/ha for optimal yield. This can be supplied by applying fertiliser containing readily available sulphur as ammonium sulphate or magnesium sulphate in early spring. Sulphur deficiency can be diagnosed by analysing young fully expanded leaves at early flowering using a malate:sulphate test. This test is too late to apply remedial sulphur to the current crop but should be used to guide fertiliser requirements of subsequent crops.

Other essential major nutrients phosphorus (P), potassium (K) and magnesium (Mg) move slowly in the soil and some soils may contain large reserves sufficient for crop uptake over several years. The reserves are usually measured as indices and growers should aim to maintain P index 2, K index 2- and Mg index 1. Changing these nutrient indices is a long-term process taking several years. There is value in having soils sampled and analysed every three to five years to ensure target indices are maintained. Applications of P, K and Mg are aimed at replacing nutrients removed in the harvested crop and, where necessary, building up soil supplies to the target index. Refer to the RB209 Fertiliser Manual for guidance on amounts and timings.

Crop protection

Effective crop protection is vital throughout the growing season to enable an oilseed rape crop to achieve the plant population, GAI and pod number targets to maximise yield. In autumn, slug, flea beetle and pigeon control is required to allow a sufficient plant population to establish, whilst effective weed control prevents competition for resources.

In order to achieve the optimum GAI at flowering it is necessary to control the key early diseases *Phoma* and light leaf spot. Pollen beetle levels should be kept below threshold to enable the optimum number of pods to be set.

Prolonged and effective seed filling also requires the control of *Sclerotinia*, *Phoma* and light leaf spot, which cause premature ripening and plant death. *Verticillium* wilt has the same effects and where *Verticillium* is present in the soil, its severity can be limited through variety choice, farm hygiene and reducing the frequency of oilseed rape in the rotation.

1.4 Characteristics of an optimised crop

Crop characteristics required to achieve the full yield potential of 6.5 t/ha are summarised in Table 2 below. These include;

- ▶ reducing the amount of light reflected by flowers to help increase the number of seeds set to 130,000/m²
- ▶ extending the duration of seed filling by several days
- ▶ increasing the efficiency of conversion of light to dry matter (radiation use efficiency) by avoiding lodging and prolonging leaf life

Increasing the amount of stem carbohydrate (stem reserves) accumulated before flowering that is later relocated to the seed through breeding will also contribute to greater yields.

	Typical farm crop	Maximum yielding crop
Date of mid-flowering	1st May	23rd April
Percentage flower cover	60%	38%
Number of seeds/m ²	80,000	130,000
Seed-filling traits		
Start date	23 May	18 May
Duration	40 days	46 days
Light intercepted by green tissue	86%	86%
Radiation use efficiency	0.47 g/MJ radiation	0.75 g/MJ radiation
Contribution of stem reserves	5%	10%
Individual seed weight (91% DM)	3.8 mg	5.5 mg
Yield (91% DM)	3 t/ha	6.5 t/ha

Table 2. Key crop characteristics

2

Sowing

Ron Stobart and Dr Nathan Morris, NIAB TAG

Seedbed condition and sowing method are major factors in determining establishment which in turn sets the foundation of the crop's potential. Oilseed rape is particularly sensitive to seedbed conditions and good seed to soil contact is essential to optimise establishment.

Growers generally choose the sowing method that best suits their soil type and farming system. However, flexibility should be retained to work in a timely fashion and cope with the variety of weather conditions from one season to the next.

This chapter outlines the main sowing methods, their suitability to soil conditions and provides guidance on selection of the method best suiting the season to achieve good, even emergence.

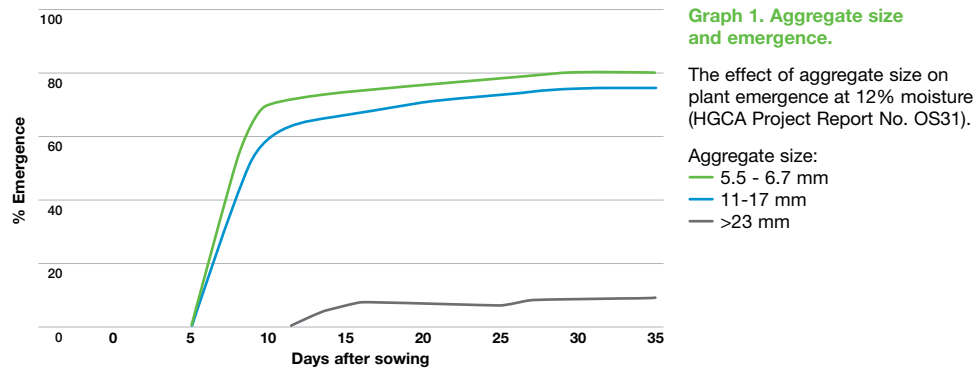


Photo © Evington Morris

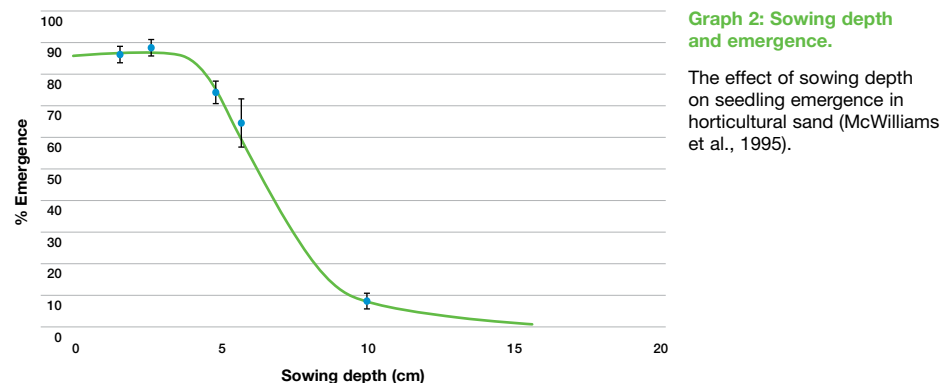
2.1 Seedbed requirements

Due to the small size of oilseed rape seeds crop establishment is particularly sensitive to seedbed conditions. It is therefore important to understand a few fundamental principles on the influence of soil conditions and seedbed requirements for good crop establishment.

To ensure a high percentage of emergence it is important to achieve good seed to soil contact. In dry conditions, and particularly on heavy soils, soil aggregate size influences the potential for this. Large aggregates are less conducive to establishment and transfer of moisture to the seed. Percentage emergence falls dramatically as aggregate size increases (Graph 1).



The sensitivity of oilseed rape emergence to sowing depth (Graph 2) indicates that sowing seed deeper than 5 cm can have a dramatic effect on emergence. Where seed is not actually drilled, establishment percentages can be very variable. When using sub-casting, and to a lesser extent autocasting, it is important to consider both the field conditions, trash distribution and placement of seed to ensure it is not left on the surface or sown too deep.



While techniques that do not disturb the soil can deliver benefits in reducing the broadleaf weed burden and keeping grassweed roots close to the surface, which can aid control, such methods can also restrict seed treatment and herbicide options. Specifically, any methods that leave seed on the surface, such as autocast, restrict options for pre-emergence residual herbicide use and where insecticide seed treatments are used all seed must be buried.

2.2 Sowing methods

A synopsis of some of the commonly used techniques for establishing oilseed rape is presented below.

Autocast

Autocast can be very cost-effective but is high risk so attention to detail and increased monitoring post spreading are essential. As it requires a certain degree of naturally occurring surface tilth, to achieve good seed to soil contact, autocast is only suitable on certain soil types such as self-structuring clays. This method relies on good soil structure and, as such, any compaction should be corrected earlier in the rotation.

Often straw spreaders are not able to distribute chopped straw evenly and leave dense straw mats. Seedlings growing through these tend to be spindly and prone to disease leading to patchy establishment. Seed rates are generally higher than with other methods and this reflects the variability in establishment achieved from it. Slugs can be a particular problem; it is therefore advisable to roll as soon as possible after autocasting to improve seedbed tilth. While this method still has its followers it has generally declined in popularity over recent seasons.

Direct drilling

Where surface tilth is not present, particularly on lighter soils, this method can be used successfully and, due to lower soil disturbance, can significantly reduce soil moisture loss. However, the precautions advised for autocast apply equally to direct drilling. Trash and crop residue, if distributed unevenly, can be a problem and a straw rake may help as will leaving longer stubbles.

Sub-casting

Sub-casting methods have grown in popularity over recent seasons largely due to their speed and ease. These distribute the seed into disturbed soil often behind widely spaced tines such as those of a subsoiler ①. It is important to set up the implement so that the seed is placed in the disturbed soil and not directly behind the leg to ensure seed is sown no deeper than 5 cm.



Sub-casting oilseed rape into cereal stubble

Photo © NIAB TAG and Agrovista

Sub-cast systems can work well in dry soil conditions suitable for creating a fine tilth. But when soils are wet this technique often creates undesirable ‘slotting’ whereby the soil smears leaving an open slot that can cause compaction and leave seeds with poor soil contact.

Non inversion tillage

Disc or tined cultivators can offer the greatest flexibility, particularly if a seeder unit can be attached and detached easily, and are now some of the most common methods. They can have a high horsepower requirement per meter of working width, depending on cultivation depth. A seeder unit can be attached if seedbed conditions are suitable for a single pass operation or seed can be drilled with a cultivator drill in a separate pass. Whichever approach is used consolidation with a roll is imperative for good seed to soil contact.

Ploughing systems

Ploughing can produce an excellent seedbed, if secondary cultivations achieve good consolidation and retain soil moisture. However, this method can be expensive and slow so is often used as a last resort on poorly structured soils or where grass-weed pressure is high within the rotation.

2.3 Selection of sowing method

Understanding the right soil conditions needed to optimise establishment is crucial and any potential compaction problems should be identified early. Hence, it is always worth noting where possible soil damage may have occurred to help ensure it is remediated when conditions allow. Soil conditions should be the prime consideration in choice of sowing method and ideally the option best suiting the season should be chosen (Table 1). It is important to remember that crop establishment sets the foundation for the crop’s potential and influences its subsequent management.

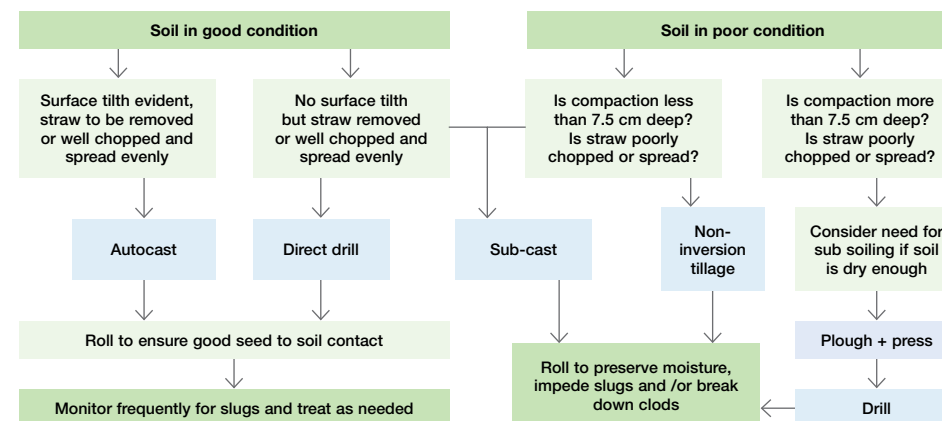
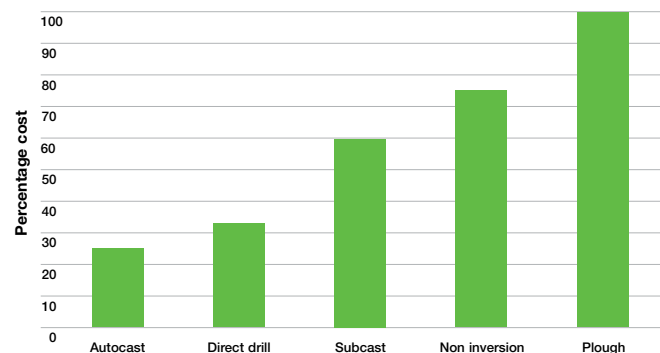


Table 1: Guide to sowing method choice.

Adapted from HGCA Information sheet 10: Soil conditions and oilseed rape establishment.

Note: insecticide treated seed must not be broadcast and must always be covered by soil.

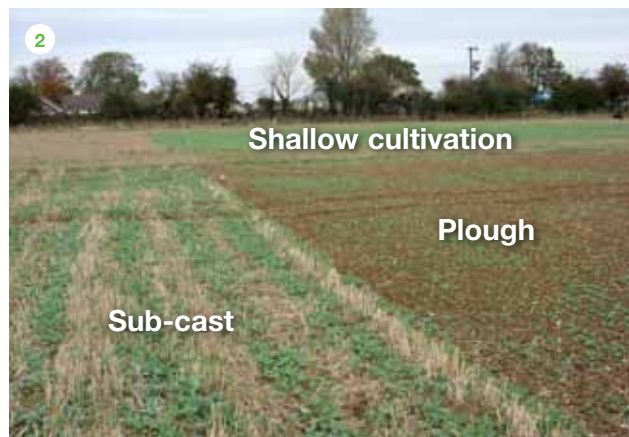
As well as selecting a method that suits soil conditions and availability of equipment, costs may also influence choice (Graph 3). However, any potential savings can easily be swallowed up by poor crop performance due to patchy establishment.



Graph 3: Relative costs of sowing methods

Scale of costs relative to ploughing as 100% (HGCA information sheet 10).

Moisture conservation is critical to ensure that seed germinates and emerges evenly with strong vigour. The picture below 2 demonstrates the effect sowing method can have on crop emergence when seedbed conditions are relatively dry. It can be seen that sub-cast or shallow non-inversion cultivation aids moisture retention and significantly improves uniformity of crop establishment compared to the plough.



2

Shallow cultivation

Plough

Sub-cast

STAR Project: The degree of crop establishment from different sowing methods. Picture taken on 9th October 2009, crops drilled on 29th August.

The STAR project (Sustainability Trial in Arable Rotations) is delivered through NIAB TAG with the continued support of The Felix Cobbold Trust.

Sowing methods and crop establishment Photo © The Felix Cobbold Trust

3

Autumn agronomy

The prime objective of autumn agronomy is to take the crop from emergence into winter with the target plant population established at eight to nine true leaves and in good health. This requires effective control of weeds, pests and diseases.

Slugs and cabbage stem flea beetle are the main pests that can threaten establishment. Rape winter stem weevil and peach-potato aphids also come into crops during autumn although symptoms of their damage may not be visible until spring.

Damping off and downy mildew are the main disease threats to establishment. Light leaf spot and *Phoma* are the main foliar diseases that enter crops in autumn and can have a significant impact on ultimate yield.

This chapter summarises the main approaches to autumn weed control and provides profiles of the autumn pests and diseases of oilseed rape with a guide to identification, outline of their biology and control measures.



Photo © Agriphoto / Tim Scrivener

3.1 Weed control

Ron Stobart and Jim Orson, NIAB TAG

The need for weed control

Winter oilseed rape requires weed control measures for the same reasons as any other annual crop; to minimise yield loss to weeds, ease harvesting, minimise carry over of pests or diseases, reduce weed numbers in following crops and prevent contamination of the final product.

In the autumn crop vigour varies from year to year, field to field and often from part-field to part-field. Vigorous crops can withstand more weed competition and the crop typically tolerates surprisingly high numbers of low growing weeds with little or no loss in yield. These include annual meadow-grass, speedwells and shepherd's purse. Weeds that can shade the crop during early summer are much more competitive. These include cleavers ①, sowthistles and poppies ②.



Cleavers Photo © Nigel Cattlin / FLPA



Sowthistles and poppies Photo © Nigel Cattlin / FLPA

Weeds that can contaminate a harvested sample include charlock ③ and runch ④. Being near-relations to oilseed rape means that they can be a challenge to control selectively, although new options are available or in the pipeline.



Charlock Photo © Nigel Cattlin / FLPA



Runch Photo © Nigel Cattlin / FLPA

However, weed thresholds and time of competition are mainly theoretical concepts. The most effective herbicides have specific timing requirements and the crop has to be kept relatively weed free to ensure that weed populations do not build up over the rotation.

The role of winter oilseed rape in the rotation

Oilseed rape has maintained its role as an opportunity to provide effective grass-weed control in rotations comprising autumn sown crops, but the context has changed over the years. The 'fops' and 'dims' provided high levels of black-grass ⑤ control in the 1970s and early 1980s in particular. Since then the rise of herbicide resistance in black-grass has meant that the 'fops' and 'dims' now provide little or no control of this weed.



Black-grass Photo © Evington Morris

However, there are two key herbicides for oilseed rape – carbetamide and propyzamide – whose efficacy is not affected by herbicide resistance in this very important weed. In contrast, there are no herbicides available at present in cereals whose efficacy is not affected by herbicide resistance in black-grass. Hence, the onus for supporting grass-weed control in the rotation has typically passed from the 'fops' and 'dims' to propyzamide and/or carbetamide.

Impact of pesticide regulations

Pesticide regulations have influenced the choice, dose and timings of key selective herbicides in recent years. There can now only be a total of two applications of products based on the 'fops' or 'dims'. Each application has to target a different grass-weed and the same active ingredient cannot be used twice in the crop.

In addition, the maximum dose of metazachlor has been reduced and can only be used over a three year rotational period. Some restrictions on the application of clopyralid in the autumn and winter are also being introduced.

Impact of the Water Framework Directive

Carbetamide and propyzamide have been commonly recorded in sources of drinking water at levels exceeding the 0.1 parts per billion specified in the EU Drinking Water Directive. Whilst levels that just exceed this concentration can be removed at water treatment works, preventing contamination of drinking water remains a real challenge.

For a short time, significant spikes in concentrations can occur that the water treatment works cannot reduce to the level required by the directives. Hence, particular care needs to be taken in the filling and emptying of sprayers and time of application in areas that are a source of drinking water. Surface run-off of water, particularly from the tramlines of recently sprayed fields, is a significant contributor to the levels of these pesticides in surface waters. Hence, effective grass buffers ⁶ have a major role to play.

Keeping active substances out of water is of vital importance to the industry or there is a serious risk of restriction of use in the future.

For further information visit www.voluntaryinitiative.org.uk



6 m grass buffer strip Photo © Evington Morris

Herbicide programmes

Autumn sown oilseed rape typically receives a pre-emergence (or early post-emergence where label recommended sowing depths are not achieved) herbicide product or product mix to control broad-leaved weeds. Typically these contain metazachlor that also controls annual meadow-grass and contributes to the control of other grass-weeds.

This is often followed by a post-emergence application of a 'fop' or 'dim' to control volunteer cereals ⁷. Effective control is required to ensure that the crop is an effective break from take-all in wheat and barley. Where crop vigour is low but volunteer numbers are high then this application should be made as soon as the oilseed rape plants reach the minimum size on the product label.

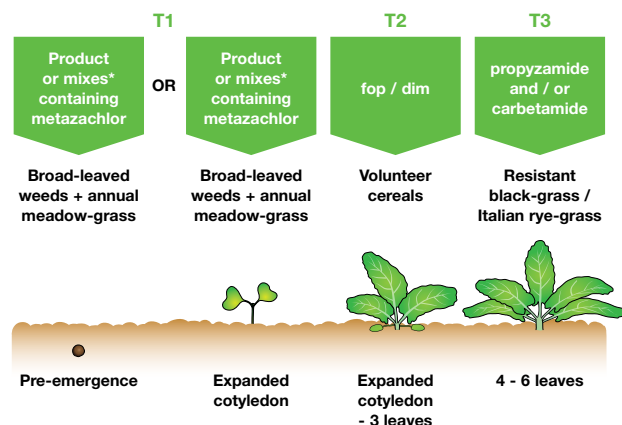
Where resistant black-grass and/or resistant Italian rye-grass is an issue then typically propyzamide and/or carbetamide are applied in early to mid-November or over the winter period (refer to product labels for timing guidance).



Volunteer cereals Photo © Evington Morris

They both work through weeds' roots so to ensure these are as close to the soil surface as possible the soil should be well consolidated. Despite the presence of chopped straw, the un-disturbed soil between the rows of crops established with the sub-casting technique is ideal for effective control. The soil should be moist at the time of application and following rain will aid efficacy. The soil should also be cool at the time of application, particularly for propyzamide, because these herbicides can breakdown too rapidly in the soil for effective control.

Diagram 1 below illustrates how these herbicides are typically used in a three-spray programme for effective weed control in autumn sown oilseed rape crops.



Some crops may require further herbicide treatment for particular problem weeds. An autumn treatment of bifenox may be needed to control charlock and/or runch or an early spring application of clopyralid with picloram may be needed to control sowthistles, prickly lettuce and cleavers.

Innovation offers new possibilities for weed control. Varieties of autumn sown oilseed rape that are tolerant to the imidazilones (e.g. imazamox) are available that open up alternative strategies for broad-leaved weed control. It is also likely that a new herbicide for the control of charlock and some other key broad-leaved weeds can be anticipated in the near future.

3.2 Autumn Pests

Dr Richard Meredith, Bayer CropScience and Dr Steve Ellis, ADAS UK

Cabbage stem flea beetle *Psylliodes chrysocephala*



The cabbage stem flea beetle is a widespread pest of UK oilseed rape crops. Adult feeding produces 'shot-holing' symptoms on cotyledons and early leaves, resulting in stunting and poor plant vigour. Severe infestation can kill small seedlings at emergence.

Identification

Adult beetles are blue-black and 3 mm to 4.5 mm long. When disturbed they jump using specialised hind legs ③.

The creamy white larvae have numerous dark spots on the back and are up to 7 mm long. They have a dark brown head, three pairs of legs and a dark plate at the tail end ③.

The initial symptom of adult feeding on cotyledons and young leaves is distinctive 'shot-holing' ③.

This can slow crop establishment and with severe infestations plants can be killed; occasionally there can be total crop failure.

The damage caused by larvae can also be economically significant. They can enter plants from October until early April. An infested plant may contain 30 or more larvae, which tunnel first in the leaf stalks of lower leaves and then cause extensive damage to the stems, tunneling in the pith and destroying the growing points of primary and secondary racemes. These wounds also provide an ideal entry point for *Phoma*, light leaf spot, *Botrytis* and other fungal diseases.



Cabbage stem flea beetle adult



Cabbage stem flea beetle larva



'Shot-holing' damage

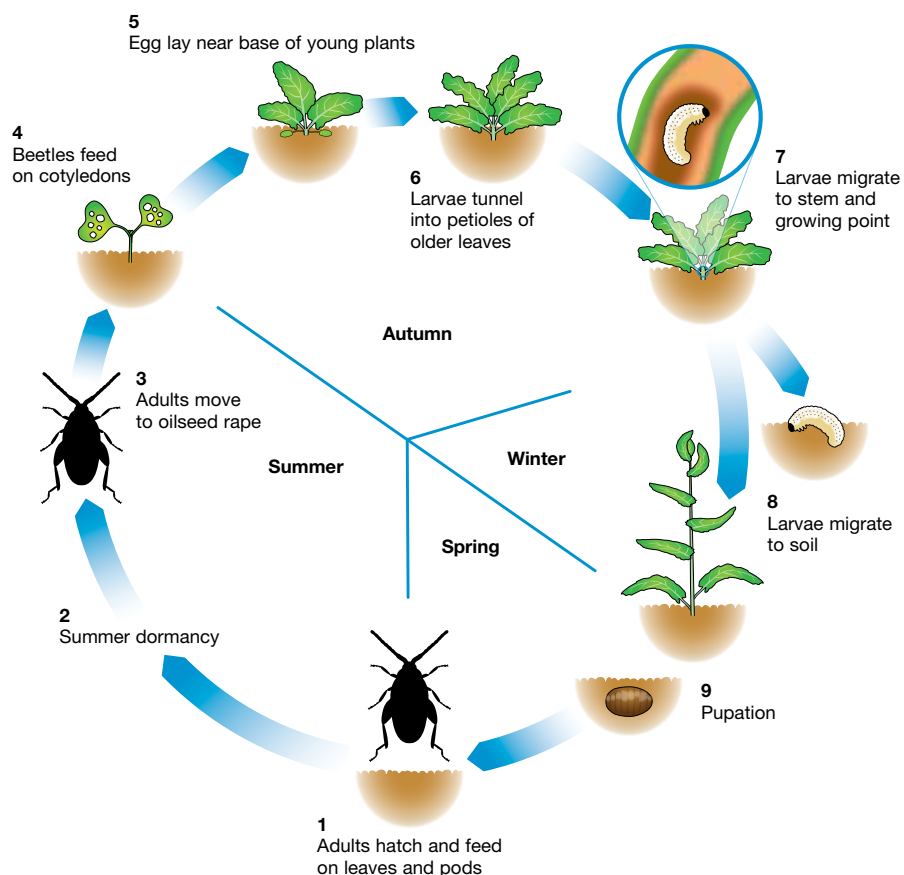
Biology

Adult beetles emerge in late June to early July (1) and feed on mature stems and pods before moving to shaded areas for a period of summer dormancy (2).

In September they move to new crops (3) and feed on the cotyledons and leaves of young plants (4). After around two weeks of feeding the females lay their eggs near the base of young plants (5). Their egg laying period depends on temperature and can extend for several weeks.

The larvae can hatch from late autumn until spring and penetrate the host plant by invading the petiole (6) and then migrating into the stem (7). In late spring the larvae exit the host plant to pupate in the soil (8,9).

Life cycle of the cabbage stem flea beetle



Control

Cultural

Finding beetles feeding on crops during the spring and summer is an indication of a potential threat to new sowings if they are to be located nearby. Adult beetles can also often be found in large numbers among harvested seed where they do no harm.

If possible, avoid sowing the new crop adjacent to previous oilseed rape stubble as pest transfer and damage can be much more pronounced. Delaying sowing can help minimise the window of adult feeding and thus reduce the number of eggs laid.

Chemical

Sowing seed protected with a modern insecticidal seed treatment reduces damage caused by adults and reduces the number of eggs laid, thus indirectly reducing the numbers of larvae in plants.

Consider applying an early pyrethroid spray if adults have eaten:

- ▶ over 25 % of the leaf area at the 1 to 2 true leaf stage
- ▶ over 50 % of the leaf area at the 3 to 4 true leaf stage
- ▶ the crop is growing more slowly than it is being destroyed

Crops should also be monitored for larval damage. Water trapping or plant dissection can determine the need for treatment.

Fill two yellow water traps – 25 cm in diameter and resembling plant pot saucers – with water and a drop of detergent to ensure any trapped beetles sink and drown. Place them on the headland 24 m apart and 6 m from the edge of the crop. Empty weekly and leave in place until adult activity declines at the end of October. If more than 35 beetles are caught per trap a pyrethroid spray should be applied.

Alternatively, 25 plants should be randomly sampled and the leaf stalks dissected to determine the number of larvae present. Pyrethroid treatment is required if on average two or more larvae per plant are found.

For further information refer to HGA Topic Sheet 98: Revised thresholds for economic cabbage stem flea beetle control.

Flea beetles

Phyllotreta spp

Flea beetles can severely check growth, stunt young plants and ultimately kill them where pest pressure is high. Late sown spring crops are most at risk from attack by adult flea beetles.

Identification

There are many species of flea beetles which feed on brassicas and these range in colour from shiny metallic black (Turnip flea beetles; *P. cruciferae*, *P. nigripes*) ① to black with yellow stripes along each wing case (Large striped flea beetle; *P. nemorum*) ②.

The adults are 2 mm to 3 mm long making them smaller than cabbage stem flea beetles. They have well developed hind legs, which allow them to jump many times their own height when disturbed, and are most active in warm dry conditions. The larvae are 2.5 mm long, white with a brown head and three pairs of legs.

Most damage is caused by adults feeding on the cotyledons, stems and young leaves leaving characteristic pits and small holes; symptoms referred to as 'shot-holing' ③. These small holes expand as the leaves develop.

The larvae feed in 'mines' within the plant tissue and those of some species also feed on the plant roots. In hot, dry conditions large numbers of invading adults can put the establishment of spring sown oilseed rape crops at risk unless control measures are taken.



Turnip flea beetle Photo © Blackthorn Arable Ltd



Large striped flea beetle
Photo © Blackthorn Arable Ltd



Flea beetle damage Photo © Blackthorn Arable Ltd

Biology

Depending on spring temperatures, adults emerge from their overwintering sites in March or April and migrate to oilseed rape crops to feed on leaves. In favourable conditions flea beetles fly distances of up to one kilometre in search of suitable host plants.

Eggs are laid alongside host plants and after two to three weeks the larvae emerge and burrow into the plant feeding on the leaves, and sometimes roots. When fully fed the larvae pupate in the soil and emerge in July to feed on early sown crops. The adults overwinter in tussocky grass, hedges or other sheltered locations. There is only one generation per year.

Control

Cultural

Delaying sowing can help minimise the window of flea beetle activity after emergence. Sowing into a well consolidated seed bed is also beneficial, improving germination and early crop vigour. With spring crops sow as early as possible to avoid attacks.

Chemical

Modern insecticidal seed treatments can give early protection to autumn sown crops. There are no established thresholds so subsequent foliar spraying decisions have to be based on similar criteria to the cabbage stem flea beetle.

Peach-potato aphid (*Myzus persicae*) and turnip yellows virus

MODESTO

Peach-potato aphids rarely reach numbers required to cause direct feeding damage but are the main vector of turnip yellows virus (TuYV) in oilseed rape crops. In recent research this virus has been seen to cause yield losses of up to 25%.

Identification

Winged aphids can enter crops in September to October. They are 2 mm to 3 mm long, oval in shape and vary in colour from green to pale yellow and pink. All these colour variants can occur in the same aphid colony ①.

This aphid does not form dense colonies ② and when crowded tends to move to infest other parts of the same or neighbouring plants. As a result it rarely reaches levels causing direct feeding damage. However, its tendency to move short distances in response to crowding greatly enhances its effectiveness as a virus vector.

Peach-potato aphids are the main vector of TuYV which can cause yield losses of up to 25% and reduce oil content. Early infection causes the greatest yield loss.

Symptoms of reddening around leaf edges ③ are often confused with physiological or nutritional deficiencies and usually not expressed until six months after initial infection from aphids migrating in to crops the previous autumn.



Peach-potato aphid adult and nymphs



Peach-potato aphid colony

Photo © Blackthorn Arable Ltd



Turnip yellows virus

Photo © Evington Morris

Biology

Peach-potato aphids migrate from their summer hosts to winter hosts – mainly winter oilseed rape, brassicas and herbaceous weeds – in late September to early October. They rarely overwinter as eggs on peach trees which are only located in small numbers in the southernmost parts of Britain.

They can remain active over winter, potentially continuing to spread TuYV through crops into the spring. Winged forms start to migrate to fresh summer hosts from late April to early June. Numbers reach a peak in July.

Control

Cultural

If there is a risk of aphid activity in the late summer it can be worth delaying drilling, to avoid spread of virus into very young plants and to maximise the period of protection from insecticidal seed treatments.

Chemical

Drilling seed protected with a modern insecticidal seed treatment is now the only effective line of defence against peach-potato aphids spreading TuYV. This is mainly due to the high levels of MACE and kdr / super kdr resistance within aphid populations which render autumn foliar sprays of pirimicarb and pyrethroids largely ineffective. Depending on seed treatment choice eight to 10 weeks activity from the date of drilling can be expected.

Pigeons

Identification

Pigeons can appear all year round in large flocks. They pose a particular problem in the winter and early spring. Adult wood pigeons measure between 38 cm and 48 cm from the tip of the bill to the tip of the tail. They have slate grey plumage which grows darker on the wings and tail, both of which have black tips ¹.

The juveniles lack the white patches on the neck which are distinctive on adults.

Pigeons graze on developing oilseed rape crops and will often strip leaves right down to the main veins ². During feeding meristems are often damaged and as a result the plant compensates by producing many additional lateral shoots from the stem base.

Damage is often uneven across a crop, so can cause patchy spring development and inconsistent plant height and pod maturity at harvest.

Control

A well-established, uniform and vigorous crop is the best way to repel pigeons as it limits their ability to land and feed. If crop establishment is patchy then a combination of shooting and deployment of bird-scarers or bangers can be used to reduce their feeding.



Pigeons Photo © David Hosking / FLPA



Pigeon damage Photo © Marcus Webb / FLPA

Rape winter stem weevil

Ceutorhynchus picipitarsis



Until 1982 rape winter stem weevil was relatively uncommon in the UK but has since increased locally in parts of Lincolnshire, as far north as Scotland, and may be becoming more common in East Anglia.

Identification

Adults are 2.5 mm to 4 mm long, metallic black with reddish brown tips to the legs ¹ and can be found in crops from early autumn onwards. The larvae are 4 mm to 5 mm long, white with distinct brown capsule heads, legless and 'C' shaped ².

Adult feeding has little impact on plants and it is the tunnelling and feeding of the larvae through the winter and into the spring which causes crop damage.

Larval feeding during winter may not cause any externally visible symptoms but can sometimes destroy a whole plant. Plants attacked in early autumn may be killed. Cutting open the stem base of an infested plant will usually reveal tunnels and feeding grubs ³.

Symptoms in spring are obvious; plants are stunted, produce many lateral branches and may sometimes die.



Rape winter stem weevil adult

Photo © Nigel Cattlin / FLPA



Rape winter stem weevil larva



Rape winter stem weevil damage

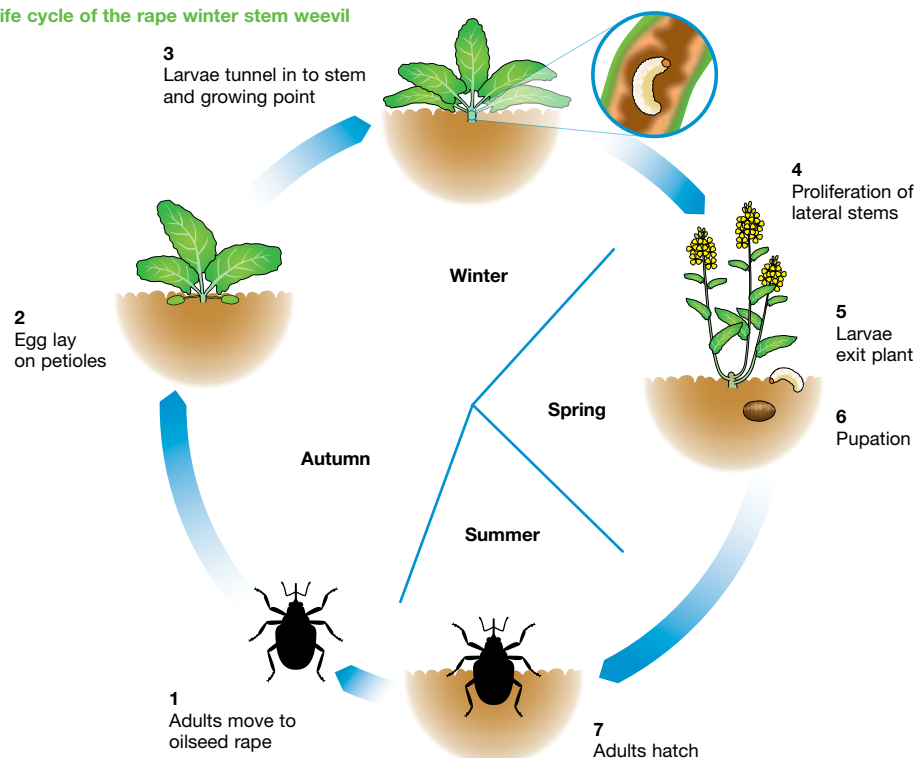
Photo © AgroConcept

Biology

Adults migrate into newly sown crops in late September to early October (1). After around a month's feeding, the females begin to lay eggs on petioles close to the stem (2) and given mild conditions can continue to do so throughout the winter.

During winter the larvae hatch, tunnel into the stem and growing point and feed there until spring (3). This can kill the main shoot leading to proliferation of lateral stems in spring (4). Mature larvae exit plants in April (5), pupate in the soil (6), then hatch in May to June and enter a period of summer dormancy. (7).

Life cycle of the rape winter stem weevil



Control

Crops should be inspected for presence of rape winter stem weevil from September onwards. There is no established threshold but repeated sightings warrant treatment. Pyrethroid sprays targeting cabbage stem flea beetle and/or aphids are also effective against rape winter stem weevil. However, treatment must be timed accurately to control adults during their three to four week feeding period prior to egg laying.

Slugs

Deroceras and *Arion* spp

Slugs can cause serious damage to winter and spring-sown oilseed rape by eating the cotyledons and first true leaves. If plants are killed the resulting gaps provide landing sites for pigeons. In extreme cases high slug pressure at emergence can cause crop failure.

Identification

The grey field slug (*Deroceras reticulatum*) ① is the most common and significant slug pest in oilseed rape and is ubiquitous in the UK.

Important round backed species are the garden slug (*Arion hortensis*) ② and the dusky slug (*Arion subfuscus*) which can both be abundant in oilseed rape.

Slugs cause damage by feeding on leaves ③. The critical period for seedlings is from germination to the four true leaf stage. Slug attack during this period can kill plants but beyond it they can grow away from damage.

Where plants are lost to slug damage the gaps left are attractive to pigeons which can cause further damage.



Grey field slug



Garden slug



Slug damage

Biology

The grey field slug and other *Deroceras* species usually go through one complete generation plus one partial generation a year. Breeding activity normally peaks in spring and in autumn but they can breed at any time of year when conditions are suitably mild and moist.

Arion species have annual life cycles and breed at a time of year that is characteristic of each species. For example the garden slug breeds in spring to early summer and the dusky slug breeds in late summer to early autumn.

Slugs lay eggs in batches of 10 to 50 in soil cavities and under stones or similar cover when the soil is moist but not waterlogged. Up to 500 eggs per slug may be laid in a season by some species. Eggs hatch after a period of a few weeks in summer or months in winter and grow steadily to maturity.

Slugs thrive in wet, mild conditions so are a particular problem to establishing oilseed rape crops in wet autumns. Under hot, dry conditions they move down the soil profile to avoid dehydration. Slug activity on the soil surface declines dramatically below 5°C.

Control

Cultural

Seedbed preparation and quality are at least and potentially more important than chemical control as they can reduce slug numbers and restrict their movement.

Oilseed rape sowing methods involving minimal cultivations are now very popular. The seedbeds produced often have the advantage of being firmer and restrict slug movement but may also leave more debris from the previous crop near the surface providing food and refuge for slugs. Reducing cultivation also limits the physical destruction of slugs in the upper layers of the soil.

Chemical

Trapping is the most effective way to assess the size of the slug population present and thus the risk of crop damage. Traps must be set when the soil surface is visibly moist to ensure slugs are sufficiently active to be recorded in them. Spread traps out across the field in a 'W' formation, with nine traps per field up to 20 ha and 13 traps per field over 20 ha, and bait with layers mash.

In the brief period between harvesting the previous cereal crop, especially if it is wheat, and drilling oilseed rape, the weather may not be suitable for trapping so it is advisable to start in the standing cereal crop before harvest. A catch of four or more slugs per trap in standing cereals, or one or more slugs per trap in cereal stubbles, indicates a possible risk. Where slug numbers are at or above these thresholds a pellet application is required if one or more of the following criteria – which indicate significant risk to seeds and seedlings – are also met;

- ▶ The field is drilled during a period of generally wet weather
- ▶ Wet weather delays sowing in a prepared seedbed
- ▶ The seedbed is coarse and cloddy and further consolidation is not possible after sowing
- ▶ The crop is slow to emerge or to grow through the early vulnerable stages and symptoms of slug damage are seen

Turnip sawfly

Athalia rosae

MODESTO

Although rare in the UK for many years there have been reports of significant outbreaks of turnip sawfly on oilseed rape in recent seasons, especially in southern and eastern England.

Identification

Adult turnip sawflies are around 7 mm to 8 mm long, yellow and black in colour ❶ and lay eggs on the leaves of young oilseed rape plants. The emerging larvae are greenish black with a lighter coloured stripe along their side and are up to 18 mm long when fully grown ❷. Sawfly larvae can be easily distinguished from caterpillar larvae as the former have a pair of legs on each segment.

Larvae are easily seen on or near damaged plants. They feed quickly and extensively on leaves leaving them skeletonised ❸. Young plants can be severely checked but more developed and vigorous crops are able to withstand moderate feeding activity.



Turnip sawfly adult



Turnip sawfly larva



Turnip sawfly damage

Biology

The adults hatch from pupae in early summer and, in favourable warm conditions, lay eggs into the leaves of brassica plants. Within 10 days larvae emerge and start feeding on the host plant. When fully fed the larvae move down into cracks in the soil to pupate. There can be up to three generations per year.

The source of infestation to winter oilseed rape crops can either be the third UK generation coming from nearby hosts or migrants carried from the continent by wind currents.

Control

Later sown crops may escape the peak of egg laying, and gain an advantage from prolonged seed treatment protection.

Work in Germany, where the pest is more of an issue, has given a threshold of one to two larvae per plant. However there has been little work done in the UK to validate this and it is only a guideline.

Modern insecticidal seed treatments provide useful control of early infestations. A foliar pyrethroid spray, as used for cabbage stem flea beetle, will also be effective in mild autumns when migration into oilseed rape may be extended.

3.3 Autumn Diseases

Andrew Flind, Bayer CropScience and Dr Peter Gladders, ADAS UK

Clubroot

Plasmodiophora brassicae

The clubroot pathogen is soil-borne. Its effects can be devastating so once a field is heavily infested it may no longer be viable to continue growing oilseed rape in it. The challenge for growers is therefore to maintain high soil pH as a preventative measure and adopt hygiene measures to minimise movement of soil on machinery and footwear from infested fields to clean ones.

Identification

Initial clubroot symptoms are detectable in the autumn. During the early stages of an infection there may be no foliar symptoms but the main taproot and large lateral roots will begin developing galls. These are usually solid, white and irregular in shape ¹ and begin to discolour and rot as the season progresses ².

Crop damage becomes apparent once the galls start to decay and plants wilt or turn purple. Severely infected plants die during winter as the root system rots away and this can result in bare patches within the crop. In spring, as stem elongation begins, infected plants are stunted and older leaves die prematurely due to restriction of nutrient supply ³.



Early gall development

Photo © AgroConcept



Advanced gall development

Photo © AgroConcept



Plants stunted by clubroot

Photo © AgroConcept

Biology

Clubroot spores in the soil become active and germinate in the presence of brassica roots when temperatures are above 15°C and soils are moist; early sowing of winter crops aggravates the disease.

The spores then penetrate root hairs and cells where they release secondary spores. These can either penetrate further into the root tissue or move back into the soil to re-infect other root hairs.

The pathogen releases hormones which stimulate cell division in the root causing gall formation. As galls decay clubroot resting spores are released back into the soil.

All brassica crops – swede, turnip, broccoli, Brussels sprouts, cauliflower and cabbage – are affected by clubroot, as are cruciferous weeds such as shepherd's purse and charlock. The pathogen has also been found in grasses. Although grasses do not develop gall symptoms, their presence in the rotation will aid its persistence.

Clubroot is favoured by acidic, poorly draining soils and is prevalent in regions where brassicas are widely grown.

Control

Maintaining good drainage and a pH of 7.0 to 7.3 by regular liming can reduce the risk of clubroot.

Varieties with resistance to clubroot are available; these may show limited galling that generally has no significant effect on yield. Currently clubroot resistance relies on a single major gene and this can be broken if varieties with the same resistance are used repeatedly. Therefore it is important to protect varieties' resistance by spacing them widely in rotations; no tighter than one year in five is advisable.

Resistant varieties contribute to management of clubroot but it will remain a threat to future cropping as resting spores can remain viable in the soil for more than 20 years.

Strict hygiene precautions are vital to prevent infection of clean fields. The pathogen can be transported from field to field by machinery, people and flooding. Having completed work in a field known to be infected, knock the soil from all tools and footwear and power wash any machinery before departure.

Damping off and *Rhizoctonia* stem rot

Pythium spp and *Rhizoctonia solani*



Damping off is caused by a variety of soil borne pathogens of which *Pythium* and *Rhizoctonia* species are the most important. Where crops are sown without a fungicide seed treatment it can result in significant loss of seedlings and sub-optimal establishment.

Identification

Damping off occurs soon after sowing. Symptoms include seed rotting, failure to emerge, root rotting and collapse of seedlings following emergence. It can be difficult to recognise as affected seedlings soon shrivel and disappear.

Young plants are more resistant to attack and when the hypocotyl is affected may show symptoms known as 'wirestem' ①. Affected plants are weakened and may snap off at soil level or die.

Later in the season, *Rhizoctonia* can cause angular and well-defined grey lesions, with a brown periphery. These often appear at the plant base but do not girdle the stem ②.

Rhizoctonia has also been associated with premature ripening late in the season when it can be found readily on the roots. Another symptom of *Rhizoctonia* is known as 'white collar' when fungal growth spreads over the stem base later in the season. It occurs when there are humid conditions or there is standing water around the roots of the crop. The strains of *Rhizoctonia* involved may not always be pathogenic to oilseed rape.



'Wirestem' symptoms



Rhizoctonia lesions

Photo © AgroConcept

Biology

A number of fungi are implicated in damping off including; *Rhizoctonia*, *Pythium*, *Phytophthora* and seed-borne pathogens such as *Alternaria* spp. and *Phoma lingam*.

Rhizoctonia solani, for example, has a widely varied morphology and will attack a wide variety of plants. There are specialised strains of *R. solani* that are likely to cause more damage to oilseed rape and other brassicas. *R. solani* is adapted for survival in soil and spreads by means of fungal threads (hyphae). Some *Pythium* species have resting spores that germinate in the soil in response to nutrient stimuli from seeds and seedlings. Infection then takes place in just a few days. Cold, wet conditions favour damping off, as seedlings are slower to emerge, giving more opportunity for the pathogen to attack the young plant.

Control

Good seedbed preparation and drainage aid seedling establishment. An effective fungicide seed treatment helps prevent infection until the plant is beyond the vulnerable stage.

Downy mildew

Hyaloperonospora parasitica

Although early sown, vigorous crops can grow through downy mildew infection it can have more serious effects on later sown or backward crops, particularly in wet conditions. Severe attacks can result in seedling loss and sub-optimal establishment.

Identification

Downy mildew is a threat to oilseed rape from emergence up to the three to four true leaf stage. The upper surfaces of affected leaves have ill defined, irregular, yellowed areas **1** while the lower surfaces will have lesions which are covered in white to grey sporulating fungal growth **2**.

Both cotyledons and the first true leaves can be killed by downy mildew if the lesions coalesce to affect most of their surface.

Downy mildew can occur on leaves throughout the year and often spreads through the canopy during stem extension and flowering.

It can also infect pods which will be covered in yellow or fawn brown lesions. In humid conditions these are covered in white to grey sporulating growth **3**. If the infection is severe enough the whole pod will bronze and ripen prematurely.



Downy mildew on upper leaf surface

Photo © Nigel Cattlin / FLPA



Downy mildew on underside of cotyledon

Photo © Nigel Cattlin / FLPA



Downy mildew on pod

Photo © AgroConcept

Biology

Infection can be introduced by either airborne spores from volunteers and nearby brassicas or oospores produced by previous crops which are able to survive in the soil without a host. Infection is favoured by temperatures between 10 to 15°C and humidity from rain or dew. The spores germinate by producing germ-tubes that penetrate the cell walls, often on the lower sides of leaves, and then the leaf tissue becomes colonised.

Control

Early sown crops are able to grow through the vulnerable stages quickly and so are at less risk. For later drilled crops, some fungicidal seed treatments can improve downy mildew control. Foliar sprays (e.g. chlorothalonil) are useful only as protectants, and are usually not required.

Light leaf spot *Pyrenopeziza brassicae* (asexual stage *Cylindrosporium concentricum*)



Light leaf spot is the most damaging disease to crops in Scotland and is increasingly being identified as a serious problem in England. Fungicides work best as protectants so early action in the autumn is essential. If crops are inadequately protected light leaf spot can spread through the plants affecting leaves, stems, flowers and pods. Untreated crops can suffer yield losses of 50% or more.

Identification

First symptoms of light leaf spot are generally seen from January onwards although in favourable conditions they may appear as early as November; this is more likely in the north of England and in Scotland.

Large numbers of very small white spots (spore masses) are visible on green leaf tissue **1**. These quickly develop into discrete lesions with pinkish centres and many more of the spore-forming white spots surrounding them **2**.

In the most severe cases whole leaves can be killed; these often do not abscise and instead remain attached to the plant **3**. When disease pressure is intense, light leaf spot affects the developing leaves and buds causing plant stunting and leaf distortion **4**.



Light leaf spot spore masses

Photo © Nigel Cattlin / FLPA



Light leaf spot lesion

Photo © Nigel Cattlin / FLPA



Leaf death

Photo © AgroConcept

Infection will also progress from leaves onto stems and lateral branches. Elongated, fawn lesions, surrounded by black speckling will be seen **5**. When conditions are humid white spore masses will also form on and around these stem lesions.

If the weather allows the disease to progress, pods are also affected. The whole raceme can become infected resulting in distorted pods that turn brown and may shatter prematurely or produce little yield **6**.



Leaf distortion

Photo © AgroConcept



Stem lesion

Photo © Nigel Cattlin / FLPA



Pod infection

Photo © AgroConcept

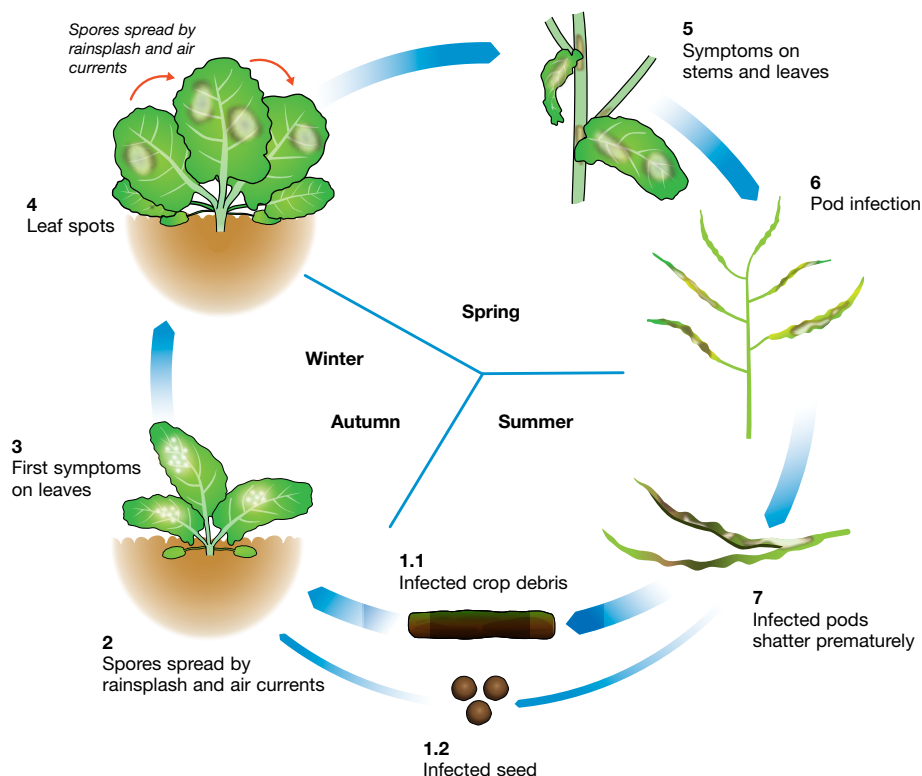
Biology

Light leaf spot can infect a wide range of cultivated brassica species and some related weeds. It survives in crop debris (1.1) which is the main source of infection producing air-borne ascospores in autumn that introduce the disease into new crops (2). First symptoms (3) may appear in early winter but are generally seen from January onwards.

Secondary spread occurs via splash-dispersed spores generated by fungus on leaf lesions (4). In spring, ascospores may be produced on dead leaves enabling the disease to continue spreading throughout the crop canopy (5). Pods may become infected (6) causing them to distort and shatter prematurely (7).

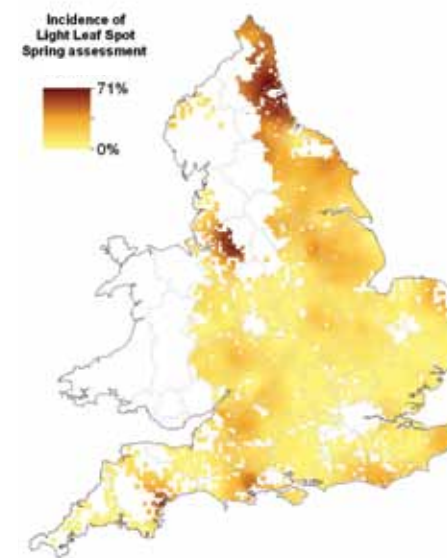
Cool, wet conditions favour light leaf spot. The optimum temperature for its development is around 15°C but it is still able to develop in frosty conditions. Spores can germinate and produce lesions in 14 days but more typically it takes three to four weeks to complete a disease cycle.

Life cycle of light leaf spot



The map below gives an indication of the light leaf spot distribution across England and Wales. It is usually most severe in the north and west but can now be found very widely throughout England.

The oilseed rape section of CropMonitor (www.cropmonitor.co.uk) has a diagnostic tool to assess light leaf spot risk based on field conditions.



Light leaf spot incidence 2002 - 2011
Image from CropMonitor, Food and Environment Research Agency © Crown Copyright 2012

Control

Cultural

Varietal resistance to light leaf spot is the first line of defence. If there is history of the disease in your area, consider growing a variety with a good resistance profile.

Cultivation techniques are also very helpful in controlling the disease. Burying stubble from previous crops reduces the risk of spores being blown onto current cropping areas.

Chemical

Triazole fungicides are currently the only means of chemical control; prothioconazole is the strongest of the group. Timely application is essential for effective control as all fungicides need to be used preventatively, which can be difficult given the weather conditions often prevailing at the right time for treatment.

Without any useful alternatives it is vital to protect the action of triazoles. Two applications are recommended; one in autumn and another in winter or early spring at around 50 to 100% of full label rate. Within this range, higher rates should be used when disease pressure is severe or in high disease risk areas. If only one application is to be made it is essential to use a robust fungicide at full rate. Resistant varieties should be treated to guard against the potential for their resistance to break down.

Phoma leaf spot and stem canker

Leptosphaeria maculans
(asexual stage *Phoma lingam*)

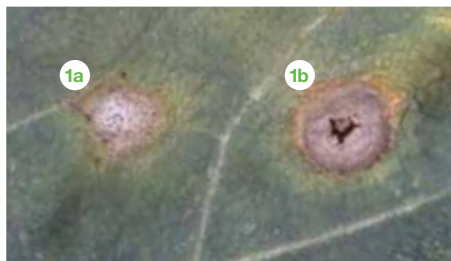
In England *Phoma* is the main autumn disease problem for oilseed rape and later sown crops are at greatest risk. The pathogen's impact is however most noticeable in the following summer when stem canker develops and plants ripen prematurely or lodge where stems are weakened. Typical yield losses in unprotected crops of susceptible varieties are in the range of 0.5 to 0.7 t/ha.

Identification

Phoma leaf spot infection can begin from September onwards as crops emerge. Initial symptoms are white to fawn circular lesions which become dotted with small black fruiting bodies **1a**. These leaf lesions are green underneath. Occasionally they cause partial leaf death **2** before winter, but generally have a minimal effect on growth until spring.

These large leaf lesions are caused by *Leptosphaeria maculans* (*Phoma A*). A second species, *Leptosphaeria biglobosa* (*Phoma B*) produces small dark lesions with few fruiting bodies **1b**. *L. biglobosa* can spread to stems but has less impact than *L. maculans* on yield.

Subsequently the fungus grows from the leaf spot to the stem via the petiole. Sunken brown stem canker **3** symptoms appear around six months after initial infection. They gradually enlarge, girdle the stem and weaken it leading to early ripening, lodging **4** and plant death.



Phoma leaf spot initial infection

Photo © Jonathan West



Partial leaf death

Photo © Blackthorn Arable Ltd



Early stem canker

Photo © Blackthorn Arable Ltd



Advanced stem canker

Photo © AgroConcept

Biology

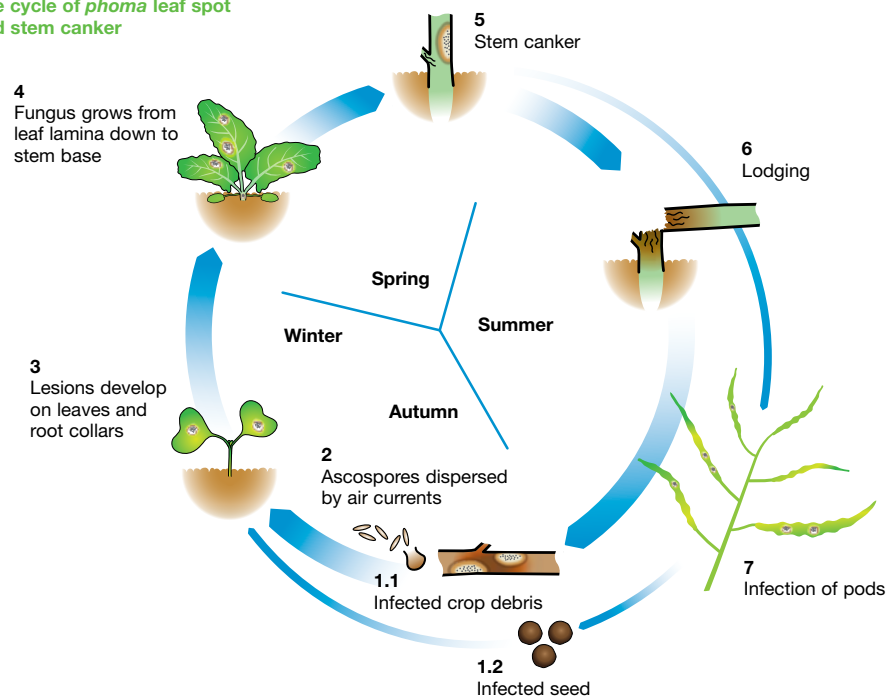
In the UK the principle source of initial infection is air-borne ascospores released from the stubble or debris (1.1) of a previous oilseed rape crop during warm, humid weather. They are dispersed by air currents (2) and land on and infect the leaves, and sometimes root collars, of young plants where lesions develop (3). Early epidemics are associated with above average rainfall in August and September. If the cotyledons are infected, seedlings may die in the autumn.

The fungus then grows from the leaf lamina into the petioles and down to the stem base (4) leading to visible stem canker symptoms in spring (5). The rate of this growth varies widely; from 5 mm per day at 20°C down to 1 mm per day at 5°C. In summer these stem cankers cause lodging and premature ripening (6).

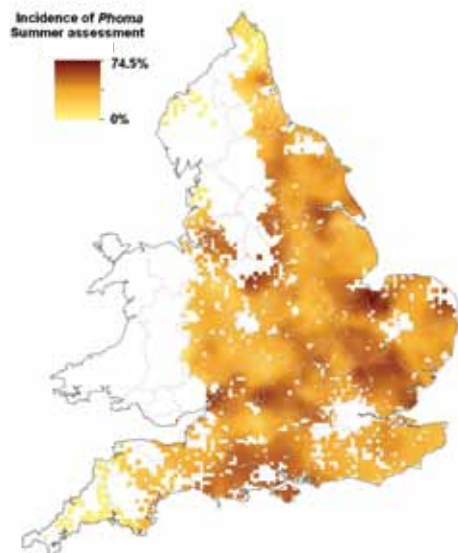
There may be some spread to pods (7) which develop brown lesions with a black margin, potentially leading to premature ripening and seed infection (1.2) which can be a secondary source of infection spreading to new crops.

Although a second type of spore (pycnidiospore) is produced on leaf lesions, these are considered to be of minor importance under UK conditions.

Life cycle of phoma leaf spot and stem canker



An insight into the Phoma risk in your local area is shown on the map below. The highest risk areas are usually in the south and east.



Phoma incidence 2002 - 2011

Image from CropMonitor, Food and Environment Research Agency © Crown Copyright 2012

Control

Cultural

Varietal resistance to Phoma canker is provided in the HGCA recommended lists. It should be noted that varietal resistance alone cannot be relied upon for stem canker control. A combination of varietal resistance and chemical treatment is needed for robust and sustainable control.

In addition to varietal selection, thorough cultivation that buries the stubble of previous oilseed rape crops and any resting spores in the soil can greatly reduce its impact. Early drilling can also be helpful, as the fungus will take longer to reach the stem of advanced plants with larger leaves.

Chemical

The threshold for fungicide application is when 10 to 20% of plants are showing leaf spot symptoms. For smaller plants – before the six true leaf stage – when temperatures are above 15°C, it is advisable to err towards the 10% end of this scale. As the crop develops and temperatures cool, thresholds can be relaxed to the 20% end of the scale.

The three key considerations in fungicide choice are; plant size, temperature and rainfall. In a high-risk season, with high rainfall and temperatures, a robust application of triazole fungicides is generally needed to protect yield. Furthermore the effectiveness of any treatment is dependent upon timing and dose. It is now well established that a split treatment of two foliar sprays – one at half dose in the autumn and another four to six weeks later – provides best protection.

4

Spring Agronomy

The prime objective of spring agronomy is to produce a healthy crop canopy with a green area index of around 3.5 at flowering. This requires management of spring nitrogen and plant growth regulation along with effective pest and disease control.

The main spring pest of oilseed rape is cabbage seed weevil which feed in pods and reduce seed number. Pollen beetle entering crops during the green to yellow bud phase can also reduce the number of flowers that develop into pods.

Sclerotinia can develop strongly in crops in spring leading to premature ripening and lodging. Light leaf spot infection from the previous autumn can also continue to spread resulting in significant yield loss. Maintaining a healthy canopy through the seed filling period is key to maximising yield.

This chapter explains the principles of canopy management and provides profiles of the spring pests and diseases of oilseed rape with a guide to identification, outline of their biology and control measures.



Photo © Evington Morris

4.1 Canopy Management

Dr Pete Berry and Susie Roques, ADAS UK

Nitrogen Management

Canopy size is chiefly determined by nitrogen uptake. Oilseed rape crops must take up 50 kg N/ha to build each unit of GAI. To build the optimum canopy by flowering with a GAI of 3.5 a crop must therefore take up 175 kg N/ha.

The amount of nitrogen taken up by late winter or early spring generally remains in the crop until flowering. The mineral nitrogen present in the soil in late winter or early spring is usually entirely taken up by the crop by flowering. Nitrogen fertiliser applied in the spring is typically taken up with 60% efficiency. By measuring or estimating the nitrogen present in the soil and crop at the start of spring, and applying these principles, it is therefore possible to calculate the nitrogen rate which should be applied to achieve the ideal canopy at flowering (Table 1).

Table 1. Example calculation of crop nitrogen requirement using the canopy management method.

	Crop A	Crop B
Soil Mineral Nitrogen (kg N/ha) measured in February (a)	25	15
Crop Green Area Index (GAI) in February	1.5	0.5
Crop nitrogen content in February (b) = GAI x 50	75	25
Soil Nitrogen Supply (c) = SMN (a) + crop N (b)	100	40
Target Green Area Index at flowering	3.5	3.5
Target crop nitrogen content at flowering (d)	175	175
Shortfall in available nitrogen (d - c)	75	135
Nitrogen fertiliser (kg N/ha) to be applied by flowering, assuming 60% uptake efficiency	125	225

Soil mineral nitrogen content can be measured by soil sampling and analysis or using the field assessment method given in the RB209 Fertiliser Manual.

The amount of nitrogen taken up by the crop following winter can vary considerably from less than 20 kg N/ha to over 150 kg N/ha. This has a very strong impact on spring fertiliser requirement and it is therefore vital that crop nitrogen content is estimated by the end of winter. Crop nitrogen content can be calculated from canopy size, given that each unit of GAI contains about 50 kg N/ha.

To estimate GAI use the four benchmark crop photographs below 1 to 4. It is more difficult to estimate the GAI and nitrogen content of large crops with GAI of 3.0 or more. For these, collect the leaves and stems from a square metre of crop, cutting the stems at ground level, record the fresh weight in kilograms and multiply by 0.8 to estimate GAI.

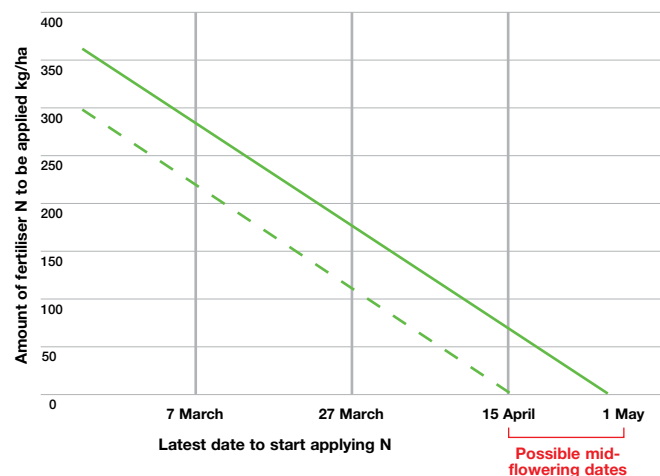


Fertilising to achieve a GAI of 3.5 at flowering is generally sufficient to achieve a yield of 3.5 t/ha. High-yielding crops need more nitrogen with each additional tonne over 3.5 t/ha necessitating a further 60 kg of fertiliser N/ha on top of that required to build a GAI of 3.5. While eventual crop yield can never be known with complete accuracy, yield potential can be estimated from prior yields on the same farm in order to determine nitrogen requirement.

After accounting for fertiliser nitrogen uptake efficiency of 60%, oilseed rape effectively takes up about 5 kg of fertiliser N/ha/day up to flowering. After flowering the rate of uptake is often much slower or zero. This means that spring nitrogen must be applied early enough to allow the majority to be taken up by around the middle of flowering.

Nitrogen fertiliser should be delayed for crops with large canopies exceeding a GAI of 2.0 to reduce the chance of creating an over-large canopy and reduce lodging risk. Graph 1 provides a rough guide to the latest date for the first nitrogen application. The majority of nitrogen must be taken up by the middle of flowering so the latest date for starting applications depends on when mid-flowering is likely to fall. The graph shows two examples of when mid-flowering could fall; 15 April or 1st May. In general, the nitrogen required to reach a GAI of 3.5 should be applied between early green bud and yellow bud with any single application being no greater than 100 kg N/ha.

For crops with a yield potential of 3.5 t/ha or more, it is recommended that the additional nitrogen for high yield is applied late at yellow bud/early flowering, to minimise the risk of causing an over-large canopy at flowering. If there is thought to be a risk of an unusually dry spring, a greater proportion of the nitrogen should be applied at the first split timing, to enable uptake before the soil becomes too dry.



Graph 1. Latest date for starting nitrogen applications.

Graph assumes mid-flowering dates of 15th April or 1st May.

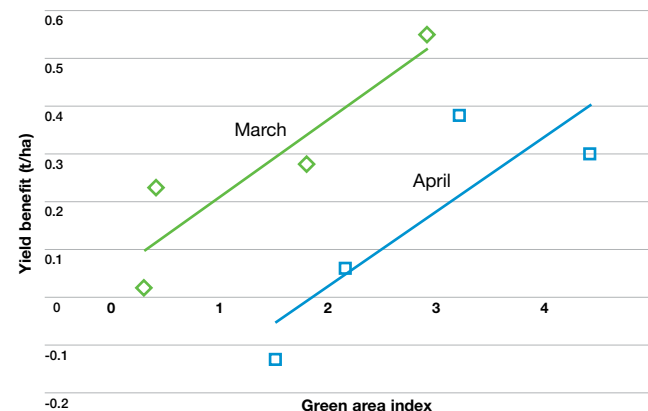
When the middle of flowering is expected to occur on a different date, the latest date to start applying nitrogen must be adjusted accordingly.

There is usually a yield benefit from applying foliar nitrogen between the middle of flowering and the start of pod development. HGCA research has shown that this yield benefit occurs even when optimum amounts of soil applied nitrogen fertiliser have been used. A rate of 40 kg of foliar N/ha is generally optimal. Applications should be made when the air temperature is no higher than 18°C to avoid excessive leaf scorch.

Plant Growth Regulation

The primary role of Plant Growth Regulators (PGRs) is to reduce lodging risk by restricting plant height. PGRs can increase yield in the absence of lodging by reducing light reflection and interception by the flowering layer and limiting canopy size. Metconazole has also been shown to increase rooting depth.

The yield response to PGRs is closely related to canopy size in early spring (Graph 2). PGRs should be applied to crops with a GAI greater than 1.0 at early green bud (usually in March), or greater than 2.0 at yellow bud (usually in April). The photographs on page 57 can be used as a guide to which crops should receive a PGR. For lodging-prone varieties PGRs are also recommended even at slightly smaller canopy sizes.



Graph 2. Effects of crop canopy size on yield response to PGR.

Graph shows yield responses to Folicur (tebuconazole) applied in March or April.

Open squares and diamonds show experimental data; solid lines show best-fit.

Yield increases are generally maximised by applying PGRs between late green bud and mid-flowering. Where applications are aimed particularly at reducing lodging it is best to apply earlier in this range for greatest effect.

The fungicides tebuconazole and metconazole have PGR activity and are recognised as the most effective PGRs for oilseed rape. Their dual PGR and fungicidal activity mean that optimal timings must often take account both of the need to control disease and regulate the canopy. In crops with small canopies which do not require growth regulation at the early stem extension stage, light leaf spot should be controlled with fungicides which do not have growth regulatory action.

4.2 Spring pests

Dr Richard Meredith, Bayer CropScience and Dr Steve Ellis, ADAS UK

Brassica pod midge

Dasineura brassicae



Brassica pod midge are found throughout the UK and their effect on yield is linked to the activity and presence of cabbage seed weevil. Damage often appears most severe on crop headlands.

Identification

The adult brassica pod midge is small, around 2 mm long, and difficult to distinguish from other midges. The midge is dependent for successful egg laying on previous damage to the pod, usually the feeding or egg laying punctures made by cabbage seed weevil.

Newly hatched larvae are tiny, translucent and difficult to see. Later they become white and are easily visible. Fully grown larvae are about 2 mm long and have no head capsule or legs ¹.

While the brassica pod midge itself is very difficult to spot, the damage caused by its larvae is certainly noticeable. Single pods on the main raceme and then later on lateral branches become yellow or swollen ².

Infested pods will split prematurely releasing larvae to the ground and resulting in complete loss of seed from the pod.



Brassica pod midge larvae

Photo courtesy of Food and Environment Research Agency © Crown Copyright 2012



Brassica pod midge damage

Photo © Blackthorn Arable Ltd

Biology

Adults typically emerge in late spring from cocoons in fields where brassica crops were grown in the previous year. After mating, the females live for around four days and in that time use holes made by other insects, particularly cabbage seed weevil, to lay up to 60 eggs per seed pod.

The larvae feed on the inner walls of pods and release toxins which cause the pods to swell and distort, eventually splitting early. Larvae fall to the soil and pupate, producing a second generation of adults that move on to later flowering brassicas and produce further larvae that overwinter in cocoons in the soil.

Control

Cultural

The brassica pod midge is mainly a pest in oilseed rape, but they can also live on cruciferous weeds and infest mustard and seed crops of other crucifers such as swede, turnip rape and radish. As the brassica pod midge is a weak flier, growing oilseed rape in a wide rotation and controlling cruciferous weeds such as charlock and runch can help keep populations down.

There are many predatory insects which feed on brassica pod midge larvae. Parasitic wasps can kill up to 70% of the larvae in developing pods. Many larvae are also consumed by ground beetles when they fall to the soil.

Chemical

Specific insecticidal control of brassica pod midge is not generally necessary. Providing cabbage seed weevil has been controlled pod midges are unable to cause significant damage.

Cabbage seed weevil *Ceutorhynchus assimilis*



Cabbage seed weevil are widespread throughout the UK. Larvae feeding in pods can cause severe losses and their exit holes provide access for brassica pod midge.

Identification

From late April onwards as temperatures rise above 13°C adults emerge from hibernation and enter crops to lay eggs in developing seed pods. Adult seed weevils are 2.5 mm to 3 mm long, black and covered with grey hairs giving them a slate grey appearance, with black feet **1**. The head has the standard downward curved proboscis of weevils.

Larvae are creamy yellow and 4 mm to 5 mm long with a distinct head **2**. The only externally visible symptoms of attack are larval exit holes in seed pods.

Biology

Around three weeks after emerging from their overwintering sites (1) females begin to lay eggs in developing seed pods and continue to do so until seeds are fully set (3). The larvae which hatch from the eggs then feed for four to five weeks on the seeds (4). When they are fully grown the larvae make small exit holes in the pods, around 1 mm diameter, from which they reach the soil where they pupate (5).

The next generation hatches in August and then moves to non-crop areas to overwinter (7).



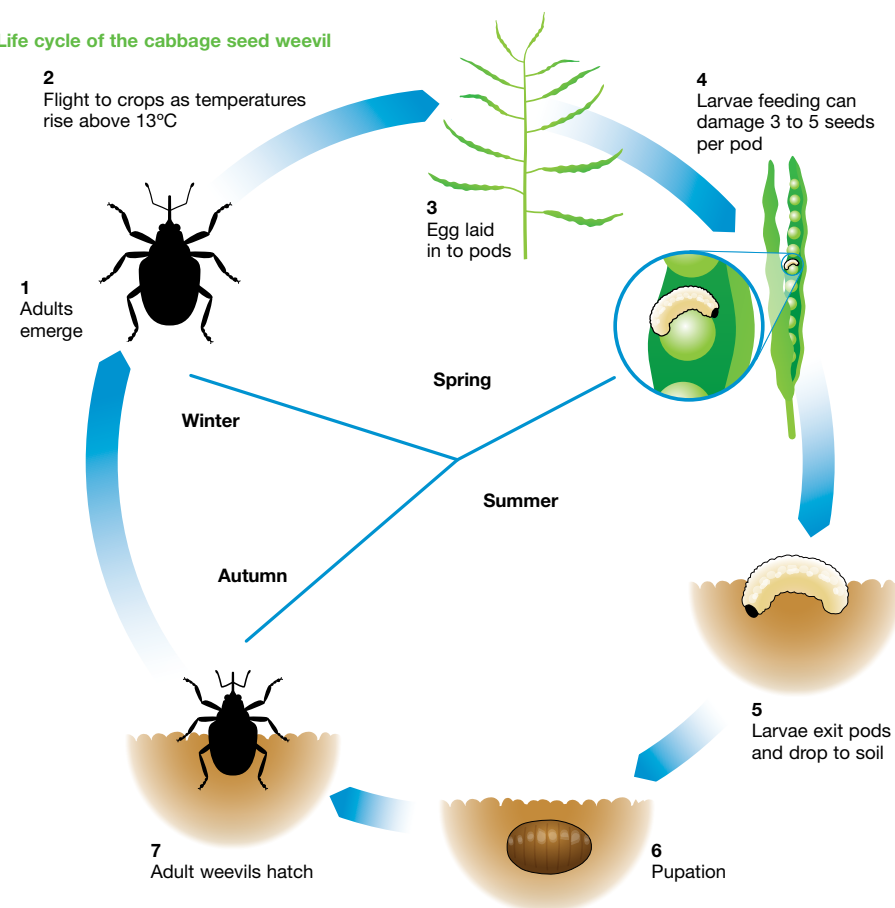
Cabbage seed weevil adult

Photo © Nigel Cattlin / FLPA



Cabbage seed weevil larva

Life cycle of the cabbage seed weevil



Control

Pyrethroid insecticides are widely used to control cabbage seed weevil. Spray thresholds vary geographically, from one weevil per two plants in northern Britain, to one weevil per plant elsewhere. Lower thresholds should be used if there has been a history of brassica pod midge damage, especially the previous year.

Good control of cabbage seed weevil is also the only way to reduce the risk of infestation by brassica pod midge, which relies on cabbage seed weevil exit holes for entry into pods to lay eggs.

A foliar spray can be applied at any time during the flowering period, if cabbage seed weevil are present at threshold levels, but the most effective treatments will be those applied at the end of flowering on the main raceme.

Mealy cabbage aphid

Brevicoryne brassicae

Damage by mealy cabbage aphids is often restricted to individual plants rather than whole crops. Although this aphid species carries turnip mosaic virus and cauliflower mosaic virus, incidence in oilseed rape is generally low and it is their feeding which can cause damage to crops.

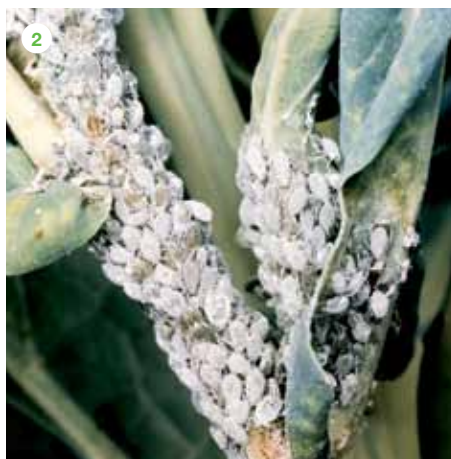
Identification

Crops are usually at risk of damage by mealy cabbage aphids from February when egg hatch starts and overwintered adults become active. The adult aphids are 2.0 mm to 2.5 mm long, greyish green, with a body covering of greyish white mealy wax ①.

Mealy cabbage aphids form large colonies on stems and flowering shoots of individual plants ②. These can cause serious feeding damage leaving plants stunted and weakened. Colonies are easily identifiable and significant populations cause yield loss.



Mealy cabbage aphid adult



Mealy cabbage aphid colony

Biology

This aphid is restricted to herbaceous *Brassicaceae* (*Cruciferae*) throughout its life cycle. It lays shiny black eggs in October on the stems and leaves of cruciferous crops that will continue to grow through the winter, such as oilseed rape.

Eggs hatch between February and April, producing young that feed on leaves and shoots. Winged forms produced in May to July migrate to newly planted brassica crops where numbers can increase rapidly.

In recent years, more of the population has spent the winter as adult stages rather than eggs. These individuals, if they survive, have a head start in warm springs over the young hatching from eggs. There is considerable variation in the annual pattern of infestation.

In practice this pest rarely reaches damaging levels as, although there may be heavy infestation on individual plants, the proportion of such plants in the crop is often small.

Control

Treatment thresholds are 13% of winter oilseed rape plants infested or 4% of spring oilseed rape plants infested before petal fall.

Pyrethroid insecticides are widely used for control of the mealy cabbage aphid. Systemic aphicides or products with vapour action are the most successful as this helps the active ingredient get through the waxy layer surrounding the aphid. The addition of adjuvant oil to the spray mix can also help to break down this waxy layer and improve control.

Pollen beetles are widely distributed throughout the UK. Infestation of winter oilseed rape is often too late to cause serious damage and yield loss. However, damage at green to yellow bud can be serious, particularly on backward crops.

Identification

Adult beetles are up to 2.5 mm long and metallic green to blue black in colour ①.

The larvae are creamy white, 3 mm to 4 mm long, with a brown/black head and three pairs of short brown legs. The upper sides of their bodies are lightly coloured with dark brown spots and short bristles.

Initial signs of attack are bite holes in developing buds ② which result in blind stalks. Following successful egg laying and hatching, larvae may also feed on flower buds leaving entry points for fungal infection, particularly *Botrytis*.



Pollen beetle adult



Pollen beetle damage

Biology

Adult pollen beetles emerge from mid-March to May, as temperatures reach 15°C, and pose a threat when large numbers enter crops before flowers open. They are only a pest while buds are still closed. It is the loss of pod sites which can have an impact upon yield if the attack is severe. Once flowers are open the beetles do not need to bite into buds to access pollen and can actually aid pollination.

Females lay two to three eggs in closed flower buds which hatch after seven to ten days. The emerging larvae feed on the pollen inside and potentially the bud itself.

When fully developed, the larvae pupate in the soil and adults emerge in mid-summer and move on to other hosts such as autumn flowering brassicas.

Control

Cultural

If pollen beetles are active in your area it is certainly worth considering an early flowering variety - rated 6 or above on the recommended list - to narrow the window of crop susceptibility. The longer the period of beetle activity before buds open, the more likely it is that adults and larvae will destroy buds.

Chemical

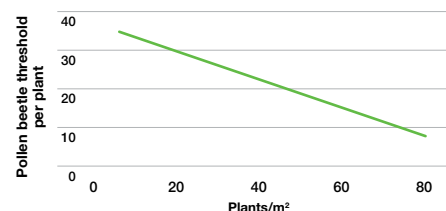
The proPlant decision support system, available at the Bayer CropScience website, predicts the start, peaks and progress of pollen beetle migration.

It indicates when in-field monitoring of pollen beetle numbers is required and helps to time treatment accurately.

Recent work by ADAS has demonstrated that crops with low plant populations have a higher pollen beetle threshold than more dense plantings. This is due to greater compensatory branching and production of excess flowers per plant.

A new threshold scheme has been proposed based on knowledge of the maximum number of buds each beetle can destroy and the minimum number of excess flowers produced. Although this requires further validation across a greater range of varieties it can be used as a threshold guide to take account of the crop's tolerance to potential beetle damage.

Graph 3 below was produced from work on three winter and two spring oilseed rape varieties and requires further validation. A single line is shown as thresholds for winter and spring crops may not be significantly different.

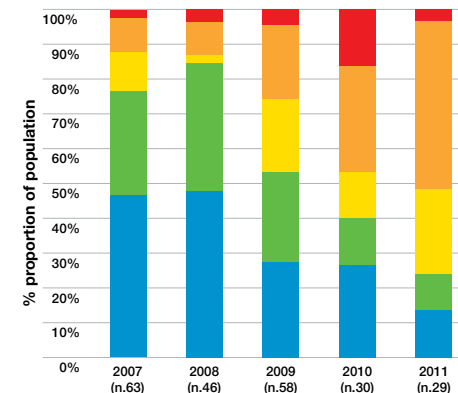


Graph 3: Pollen beetle control thresholds

Source: HGCA information sheet 13: Controlling pollen beetle and combating insecticide resistance in oilseed rape.

Pyrethroid insecticides have been widely used to control pollen beetle. However, there is growing concern about populations which are resistant to pyrethroids in the UK.

In mainland Europe there is well-established resistance and it first appeared in the UK in Kent in 2006. Since then it has spread across southern



Graph 4: Pyrethroid resistance in UK pollen beetle 2007-11

Legend:
■ Highly resistant
■ Resistant
■ Moderately resistant
■ Susceptible
■ Highly susceptible

Source: IRAC

and eastern counties and, in population monitoring over the last two years, resistant individuals have been found in the midlands, northern England and southern Scotland.

Population monitoring by IRAC has found susceptibility declining year on year and in 2011 only 24% were susceptible (Graph 4). It is now clear that the UK has followed the trend of other mainland European countries where resistant populations have become dominant.

If you suspect there may be pyrethroid resistant populations in your area, a neonicotinoid insecticide such as thiacloprid should be used instead. Also, if you have applied a pyrethroid and an above-threshold beetle population survives, a neonicotinoid spray should be applied as soon as possible to gain control and counter the spread of resistance.

4.3 Spring diseases

Andrew Flind, Bayer CropScience and Dr Peter Gladders, ADAS UK

Dark leaf and pod spot

Alternaria brassicae and *A. brassicicola*

Folicur

Damaging attacks of *Alternaria* have become less common in recent years. The widespread use of triazole fungicides in autumn and winter gives incidental control and has made it a relatively minor disease. However, if warm wet weather coincides with the flowering period, it can still be economically damaging.

Identification

Leaf symptoms of *Alternaria* can be found from the seedling stage onwards. Initial symptoms are small black spots about 1 mm in diameter ①. These lesions develop into characteristic 'target-spots', 5 mm to 15 mm in diameter, with light and dark concentric rings ②. Secondary spotting occurs around the target spots and if left unchecked can cause leaves to turn brown and fall off.

The greatest impact on yield is when *Alternaria* spreads to pods ③ causing premature ripening, pod splitting and loss of seed. The pathogen can penetrate the pods and infect the seed within. Problems are often associated with early lodging.

Biology

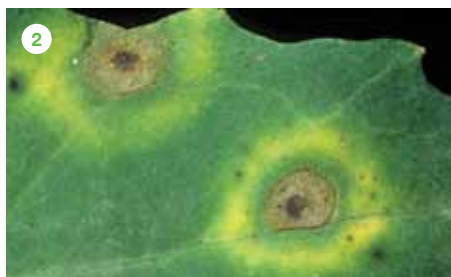
Alternaria is introduced into a crop either by infected seed or spores from previous crop debris in neighbouring fields.

If infected seed is sown, seedlings may suffer from damping off or emerge with diseased cotyledons.



Alternaria initial symptoms

Photo © Nigel Cattlin / FLPA



Alternaria target spot lesions

Photo © Nigel Cattlin / FLPA



Alternaria on pods

Photo © Nigel Cattlin / FLPA

When infection starts from airborne spores initial symptoms may be difficult to find. The disease usually develops slowly at the rosette stage by splash dispersal of spores within the crop.

In the spring and summer disease development becomes more active. There will often be reinfection and transfer to uninfected plants via airborne spores released from 'target spots'. Optimum conditions for infection are 17°C to 25°C and spores can infect within four hours of landing on a wet leaf at 22°C.

Infected pods may be smaller, ripen earlier and shatter before harvest. This often occurs in patches scattered throughout the crop. Very rapid spread can occur in thundery weather.

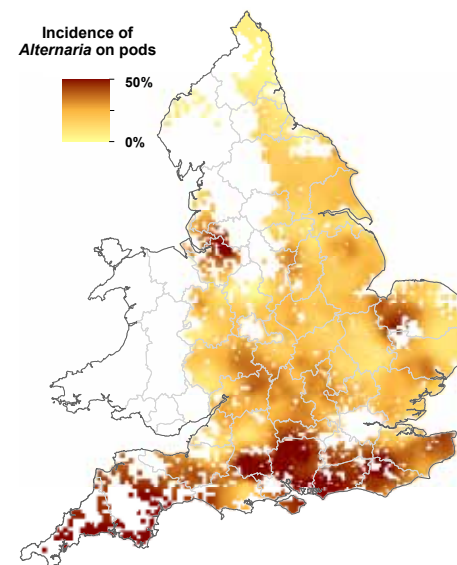
The incidence of *Alternaria* pod spot has been variable over the last ten years as it is so weather dependent. Risks are highest in the south.

Control

Cultural

There are no varieties with resistance to *Alternaria*, but there are cultural measures that can be taken to limit the effects of the disease. Crop residues of oilseed rape, or other brassicas in nearby fields, should be buried by ploughing or cultivations prior to the emergence of new oilseed rape crops.

Crop canopies should be well managed in spring, avoiding excessive levels of nitrogen so that the risks of lodging are minimised.



Alternaria incidence on pods 2002 - 2011

Image from CropMonitor, Food and Environment Research Agency © Crown Copyright 2012

Chemical

As seed can be a source of infection, it should be tested for *Alternaria* (and *Phoma*) and treated for the pathogens if found to be infected. Control of foliar disease is not usually required until the flowering period. Economic benefits from treatments are most likely to be achieved from sprays applied to protect the crop from mid-flowering up to early pod fill. If a specific *Alternaria* spray is not justified, a useful reduction in inoculum can be achieved by many of the fungicides used for *Sclerotinia* control at mid-flowering.

Grey Mould

Botrytis cinerea



Botrytis generally enters oilseed rape plants via damaged or senescent tissue and is more of a problem in the north where foliage is damaged by winter frosts. *Sclerotinia* sprays achieve largely incidental control during flowering, but it can still be damaging given warm, wet conditions during petal fall.

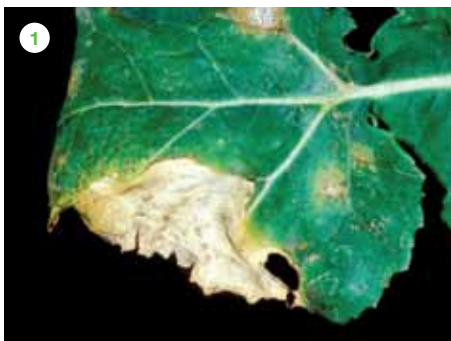
Identification

Botrytis spores are ubiquitous in the environment so there is potential for infection throughout the year. Under normal conditions there needs to be stress or damage to the plant to enable the pathogen to enter. Leaf areas scorched by frost, chemicals or nitrogen fertilisers are prone to infection ①. The pathogen can also invade senescent tissues and even infect healthy plants if weather conditions are particularly warm and humid.

The first symptoms are usually greyish or white lesions on damaged or senescent leaves ②. Greyish fungal growth develops on the lesions and this is often sparse and difficult to identify unless there have been humid conditions. Nitrogen scorch will be evident a few days after application and *Botrytis* colonises scorched leaf and stem tissues very quickly.

At flowering, grey lesions with concentric zones develop around fallen petals that have stuck to the leaves. Small lesions may coalesce leading to collapse of the whole leaf and spread to the stem ③.

The stem lesions are white or pale brown to grey and are very similar to those produced by *Sclerotinia*. The presence of greyish sporulating mould on the lesion is the main differentiating feature ④, but *Botrytis* does not usually form sclerotia within the stem cavity. As stem symptoms become more severe, they may girdle the stem causing premature ripening or complete collapse of plants ⑤.



Leaf scorch

Photo © Blackthorn Arable Ltd



Botrytis initial symptoms

Photo © AgroConcept GmbH

Botrytis is also common on pods that have been damaged by seed weevil or brassica pod midge. The whole pod is usually affected and prone to shatter.

Biology

The disease is present all year round. Appearance of symptoms depends on the presence of senescent or damaged tissues, particularly leaves. The development of *Botrytis* is favoured by temperatures above 10°C and long periods of high humidity or frequent rainfall.

Control

Cultural

There is no varietal resistance to *Botrytis* but good crop management and balanced nutrition, to ensure that crop canopies are optimised and lodging risk is minimised, will reduce the risks of economic damage.

Chemical

Fungicides applied for *Sclerotinia* control have useful activity against *Botrytis* and treatment timing is similar. The risks of fungicide resistance are high for *Botrytis* so alternate fungicide products or use mixtures. Follow manufacturers' guidelines on chemical and fertiliser use to avoid scorching.



Botrytis stem lesion

Photo © AgroConcept GmbH



Grey mould girdling stem

Photo © Nigel Cattlin / FLPA



Advanced infection

Photo © Nigel Cattlin / FLPA

Powdery mildew

Erysiphe cruciferarum



The occurrence of powdery mildew is very variable from year to year. It is most apparent on winter oilseed rape in the south and east. Symptoms can be found in the autumn, particularly on earlier sowings, and from flowering onwards. Spring oilseed rape is often very severely affected. This disease is of increasing concern, as prolonging green leaf retention is part of the strategy to improve yields.

Identification

After infection by airborne spores, scattered white colonies develop on the leaves, stems and pods. It can occur on both sides of the leaves ❶ but will generally be more apparent on the underside where it is sheltered from rain.

When there are numerous colonies, white powdery growth covers large parts of the plant surface including stems, flowers and pods ❷.

Where the disease is well established it can cause yellowing of the leaves and, in severe cases, leaves die prematurely ❸.

In some years when the disease is less active, the fungal growth is sparse and symptoms may be restricted to fine black speckling on the foliage and stems.



Powdery mildew leaf symptoms

Photo © Blackthorn Arable Ltd



Powdery mildew pod symptoms

Photo © AgroConcept GmbH



Late season symptoms

Photo © AgroConcept GmbH

Biology

Powdery mildew is dispersed by airborne spores that originate from infected volunteers and nearby crops. Warm temperatures and periods of high humidity favour development, dispersal and germination of spores. It declines during the winter as older, infected leaves are shed.

Control

Whilst control of powdery mildew with fungicides has been demonstrated, its impact on yield remains uncertain. Fungicides applied for *Sclerotinia* control may have some effect on the disease but lack the persistence to fully protect pods.

Triazole fungicides such as prothioconazole and tebuconazole have useful activity against powdery mildew and have approval for use on other types of brassicas. Sulphur may provide some control if used at an early stage of disease development.

Sowing from late August onwards can reduce the risks of autumn infection. Oilseed rape volunteers in neighbouring fields should be destroyed by cultivation or ploughing prior to the emergence of new crops.

Sclerotinia stem rot

Sclerotinia sclerotiorum



Sclerotinia is an important disease of oilseed rape causing yield losses of 30% to 50% in severely affected crops. Attacks are very variable from year to year and between fields on the same farm in the same year. Identifying crops at risk is a priority in the spring agronomy of both autumn and spring sown crops.

Identification

Leaf infection occasionally occurs during the winter and this can lead to early stem infection but crops are most at risk of *Sclerotinia* infection from the onset of flowering. During flowering, initial infection comes from mainly airborne ascospores landing on petals. The disease develops when petals fall and stick to leaves or stems with moisture from light rain (1).

Rotting petals provide sufficient nutrition for the fungus to penetrate the leaf cuticle resulting in pale brown or white leaf lesions. Stem lesions develop where the pathogen spreads by mycelial growth from leaf lesions and where initial infection is in the leaf axil (2).

White stem lesions develop, spread up and down the stem and may become covered in white fungal growth in humid weather (3). When infection occurs towards the end of flowering, more lesions tend to develop on the smaller branches than on the main stem. When lesions have girdled the stem, the stems and pods beyond the lesions ripen prematurely. In lodged crops, *Sclerotinia* can spread rapidly by plant to plant contact.



Petal stick Photo © ADAS UK Ltd



Sclerotinia leaf infection Photo © AgroConcept GmbH



Sclerotinia stem lesions Photo © Nigel Cattlin / FLPA

The fungus completes its life cycle by forming irregular black resting bodies known as sclerotia in the stem cavity (4) and in the roots when lesions are at stem bases. Sclerotia also form on the outside of the lesion following suitably humid weather.

With severe infection plant stems are weakened by lesions. This can cause lodging and stem splitting releasing sclerotia back into the soil to become the source of inoculum for future crops (5).

Biology

Sclerotia occur within the soil profile and those in surface layers germinate in spring when soil temperatures are above 10°C to form apothecia (6). Soils must be moist for germination to occur. These mushroom-like structures (1) are 5 mm to 15 mm in diameter and produce ascospores which are discharged into the air (2).

Crops are most at risk where ascospores are produced within an oilseed rape crop but some spores are dispersed more widely to surrounding crops. Ascospores land on petals (3) and infect the plant when temperatures are above 7°C and there are long periods of high humidity.



Sclerotia inside stem Photo © Nigel Cattlin / FLPA



Stem splitting



Apothecia developing from sclerotia

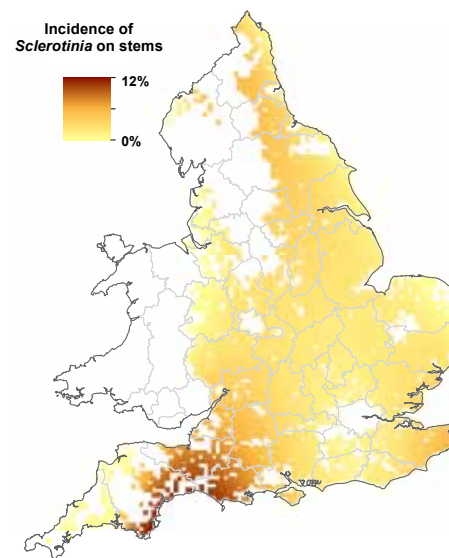
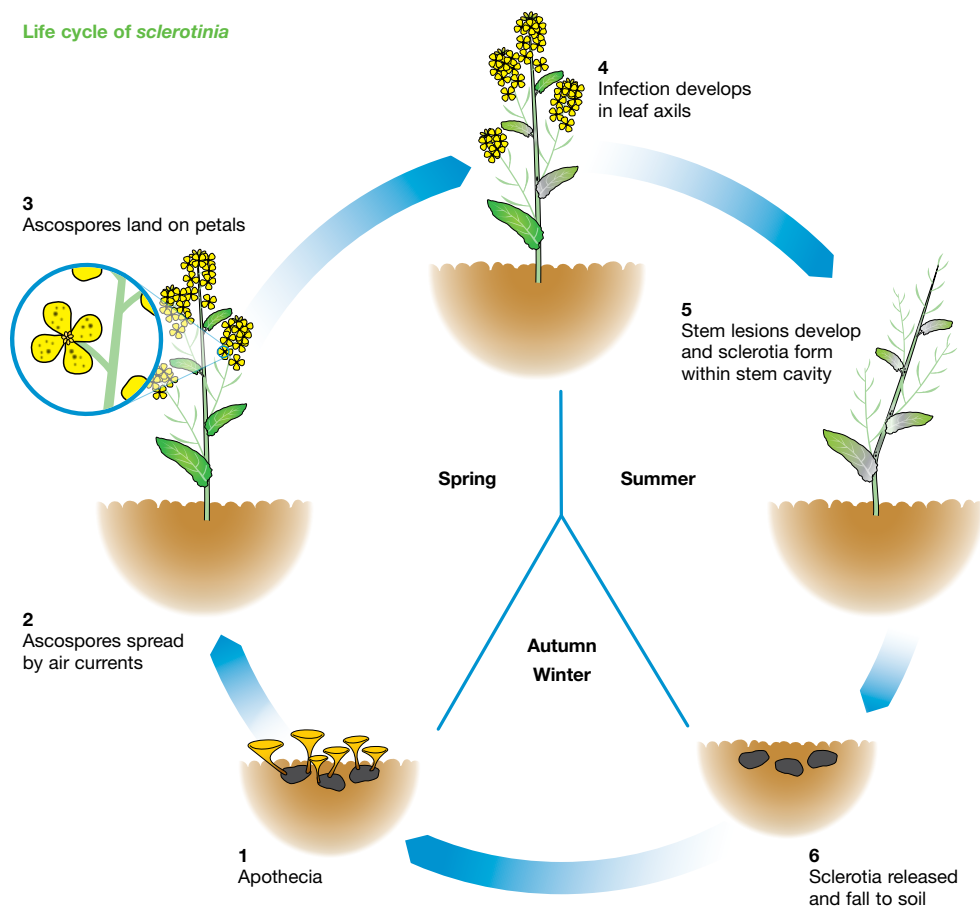
Photo © AgroConcept GmbH

Disease develops when petals fall and collect in the axils of upper leaves (4). Whilst most infection is associated with petals, plants can also be attacked through senescent or damaged tissues.

Stem lesions develop (5) and girdle the stem causing premature ripening. Sclerotia form within the stem cavity and are released (6) when stems split as the crop lodges.

Most crops generally show only low levels of *Sclerotinia*. The last major epidemics occurred in England in 2007 and 2008. Conditions are usually more conducive for the disease in the south west, Herefordshire and coastal areas but severe attacks have occurred in all regions.

Life cycle of sclerotinia



Sclerotinia incidence on stems 2002 - 2011
Image from CropMonitor, Food and Environment Research Agency © Crown Copyright 2012

carrots and other vegetable crops are all very susceptible to *Sclerotinia* and increase risks if grown in rotation with oilseed rape. *Sclerotinia* also affects many common weed species including mayweed, deadnettle, cleavers, chickweed, fat-hen and field pansy, which underlines the importance of rotation-round weed control.

Chemical

A number of factors need to be considered in the planning of fungicide programmes to protect oilseed rape from *Sclerotinia*. Field history is key as sclerotia can persist in soil for seven to 10 years. The presence of any apothecia from March onwards in the crop or in nearby fields indicates that protection will be needed.

Fungicides are used as protectants and will not eradicate developing lesions. Effective control relies on good spray penetration into the crop canopy. In flowering crops, fungicides will coat the petals and this will contribute to disease control should they stick to the leaves or stems below. The optimum application timing is usually prior to mid-flowering, ahead of the main period of petal fall.

Because of the difficulty in identifying infection periods, a more robust approach for high risk situations is a two-spray programme, with the first spray at yellow bud to early flowering and the second about three weeks later at mid-flowering. It is important to consider plant growth regulation requirements and other diseases when selecting fungicides to use.

Control

Cultural

Although there is no known varietal resistance to *Sclerotinia*, there are other cultural options to limit its potential to damage crops. Ploughing a field after oilseed rape buries sclerotia and impairs their ability to germinate if they can be kept deeply buried. Avoid excessive nitrogen applications so that crop canopies are not too dense or likely to lodge.

Rotation is an important tool to combat *Sclerotinia*; four years is the recommended interval between susceptible crops. Tighter rotations of oilseed rape have contributed to *Sclerotinia* problems. Peas, potatoes,

Verticillium wilt

Verticillium longisporum

Verticillium wilt was first diagnosed in the UK in 2007 and is currently the focus of research to better understand the disease and potential control measures both cultural and chemical. Recent surveys have confirmed cases as far north as Yorkshire but the most seriously affected areas are in the east and south east.

Identification

Although infection occurs mainly in autumn, from soil-borne resting spores called microsclerotia, most symptoms are usually only seen in crops close to harvest.

Initially there is yellowing ¹ and later bronzing up the side of the stem ² extending from the stem base to the upper branches. Typically only part of the stem shows symptoms, but during severe infections the whole stem can be affected.

Both *Phoma* and *Verticillium* symptoms can be present in the same plant. The extension of symptoms into the branches distinguishes *Verticillium* from *Phoma* lesions. *Verticillium* may produce yellowing symptoms on one half of the leaf, but this does not appear to be a very reliable diagnostic feature ³.

Grey or black discolouration can be found underlying the vertical stripes and this becomes more pronounced as plants senesce or ripen ⁴. The grey colour is due to the formation of new microsclerotia as the pathogen develops outside the vascular tissues.



Stem yellowing

Photo © AgroConcept GmbH



Bronze stem striping

Photo © AgroConcept GmbH



Half leaf yellowing

Photo © AgroConcept GmbH



Senescent stems

Photo © ADAS UK Ltd

Biology

The *Verticillium* wilt pathogen is a specialised species that affects brassicas and is distinct from *Verticillium dahliae* that affects a wide range of broad-leaved crops and weeds. Microsclerotia are capable of long term survival in soil and clean fields can become infested by the introduction of infected seed, soil or plant debris from fields where crops have suffered previously.

Microsclerotia germinate in autumn and the hyphae colonise the plant's root system, but at this stage there are no obvious symptoms. In spring during stem extension, the pathogen spreads through the vascular system and colonises the aerial parts resulting in the development of stem symptoms. Warm spring conditions are favourable for the spread of *Verticillium* through the plant

Control

There is some evidence of differences in varietal susceptibility to *Verticillium* wilt and plant breeders should be consulted for information about their varieties. Further work is required to define the benefits of using resistant varieties.

Cultural

Rotation of brassica crops is likely to remain an important method for control of *Verticillium*. At low risk sites, a gap between brassicas of four years is advised, but where *Verticillium* risks are high, a much longer rotation may be required. Very early sowing should be avoided. Strict hygiene measures are needed to prevent movement of soil and microsclerotia on machinery and other farm equipment to clean fields. Seed from infected crops should not be used as it may be contaminated with *Verticillium*.

Chemical

Work is underway to study the potential role of fungicides in combating this disease but currently there are no products with approval for its control.

White leaf spot

Mycosphaerella capsellae



White leaf spot is a minor disease of oilseed rape and specific treatment is rarely required as triazole fungicides used for control of *Phoma* and light leaf spot provide good incidental control.

Identification

Leaf symptoms are seen from autumn onwards as small lesions 1 mm to 3 mm in diameter which are fawn in colour, often with a darker centre **1**. They appear very similar to downy mildew and often both diseases occur together. Larger white lesions develop subsequently and these usually have irregular dark markings within the lesions and a brown margin.

Symptoms known as 'grey stem' can occur on susceptible varieties after flowering when the disease is severe. Pods can also become affected and show dark brown blotches that look similar to net blotch lesions in barley.

Biology

The disease cycle starts in autumn with the spread of airborne ascospores from nearby infected crop residues. There is splash dispersal of spores within the crop from the leaf lesions. The crop can grow away from the disease in spring unless there is sufficient rain to facilitate movement of spores to upper leaves.



White leaf spot initial symptoms

Photo © Nigel Cattlin / FLPA

Control

Triazole fungicides such as prothioconazole have activity against white leaf spot and so generally provide satisfactory control when used against *Phoma* or light leaf spot in autumn or during flowering against *Sclerotinia*.

5

Harvest

Dr Pete Berry and Susie Roques, ADAS UK

There are three main harvesting techniques to choose from; desiccation, swathing and direct-combining. The best method depends on a range of factors including location, stage of ripening, lodging, weed levels, weather and disease levels.

This chapter outlines the three techniques and provides guidance on the key issue of timing, to maximise yield and quality.



Photo © www.agripix.co.uk / Tim Scrivener

Methods of harvest

Oilseed rape plants can produce more than 10 branches which means there can be a range of ripening dates between the first formed pods on the terminal raceme and the later pods on the last formed branch. Harvest or desiccation date must therefore be chosen carefully to maximise yield and quality.

Desiccation

Desiccation is the most common method of preparing the crop for harvest and is growing in popularity. It is particularly useful where crops are lodged or where weed infestation is high. A potential disadvantage is that it can dry the crop rapidly leading to pod shatter if combining is delayed and there are high winds and/or heavy rain before the crop can be harvested. There are however products which claim to reduce pod shatter in this situation.

Glyphosate is the most common desiccant used; it generally costs less than other products, but it is fairly slow acting. It should be applied when two thirds of seeds in pods picked from the middle of the main raceme are brown. The crop is generally ready for harvest 14 to 21 days later. Glyphosate is less effective in severely lodged crops.

Diquat is applied later, when 90% of seeds at the centre of the main raceme are brown to black. It works faster, making the crop ready for harvest five to 10 days after application, and helps to even out maturity so is particularly useful on a crop with varying stages of ripeness.

Glyphosate is translocated within the plant and kills the roots of perennial weeds like docks and thistles whereas Diquat is only effective against annual weeds, and the rapid desiccation may cause pods to become brittle and more likely to shatter.

Glufosinate ammonium (Harvest) is applied when most pods in the centre of the main raceme are yellow and seeds are reddish brown. It tends to be quite slow acting with harvest up to 21 days after application, but the risk of pod shatter is less. Glufosinate ammonium is widely used on oilseed rape crops grown for seed.

Swathing

Swathing is becoming less common and should only be chosen for upright crops, or only slightly leaning crops, as 20 to 30 cm of stubble is needed to support the crop and allow it to dry. Crops containing high weed levels are also unsuitable for swathing, as their moisture hinders the drying process. Swathing is usually undertaken by a contractor and timed when the middle pods have seeds that are just turning brown, with harvesting two to three weeks later. This technique is useful for exposed sites with a high risk of pod shatter.

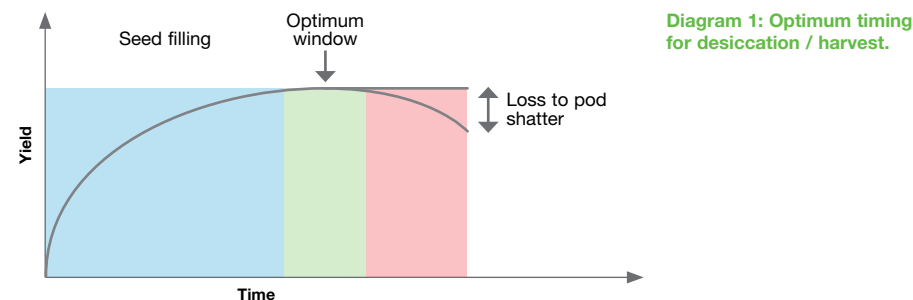
Direct combining

Direct combining without desiccation is increasing but still relatively rare. It is the lowest cost method, and generally causes less damage as only one pass is involved. However, it should only be considered for crops grown on sheltered sites where weed populations are low. Seed moisture content of direct combined crops can be higher than with desiccation or swathing so harvest is often slightly later.

Maximising yield and quality

Seed filling continues for approximately 40 days so it is important not to desiccate or swath too early as each lost day of seed filling reduces yield by 1 to 2%. Furthermore, seeds accumulate most oil during the second half of seed filling so premature desiccation or swathing will also reduce oil content.

Acting too early therefore sacrifices both yield and quality. However harvesting too late runs the risk of losing yield to pod shatter. Diagram 1 below illustrates the trade-off between these two factors and the optimum window to aim for.



Losses due to travelling through the crop to apply a desiccant using a high clearance sprayer have been estimated at 0.6%.

If the insides of seeds are green, rather than yellow, this indicates the presence of chlorophyll which may lead to rejection by the crusher. Excessive nitrogen rates may increase seed chlorophyll content.

Managing diseases

Crops should be checked shortly before harvest for disease to inform future decisions on rotations. Key ones to look for are *Verticillium* and *Sclerotinia*.

If high levels of either are present, the oilseed rape rotation should be lengthened. To avoid severe *Sclerotinia* epidemics in future years, infected stubble should be buried by ploughing.

6

Pest and disease control products



Damping off and seed-borne *Phoma*



Turnip sawfly



Cabbage stem flea beetle



Peach-potato aphid



Slugs



Cabbage stem flea beetle



Rape winter stem weevil



Phoma leaf spot



Light leaf spot



Autumn

A summary of the Bayer CropScience range of seed treatments, insecticides and fungicides designed to protect oilseed rape from sowing to harvest.



Sclerotinia



Light leaf spot



Phoma stem canker



Light leaf spot



Phoma stem canker



Alternaria



Cabbage seed weevil



Brassica pod midge



Pollen beetle



Spring

