The essence of integrated farming is to manage interactions for profit and the environment.

Planning and attention-to-detail are essential elements in a sustainable production system.
INTRODUCTION

Farming systems

Farming systems range widely, from conventional to organic. Each system has advantages and disadvantages; neither is necessarily right or wrong, or better or worse. A third ‘integrated’ system is also worthy of serious consideration.

Integrated cropping

The integrated system aims to produce profitable crops and also to be environmentally sensitive. Methods used encompass a range of agronomic measures, including rotation, cultivation type and cultural technique and cover both cropped and non-cropped areas. Pesticides and fertilisers, recognised to have an important role in producing high yields of quality crops, can be used judiciously where required.

There are several definitions of integrated farming, for example:

“A system of agriculture which is more sustainable for the environment and profitable over the long term, encourages biodiversity and which produces safe, affordable food.”

The principle of integrated farming is to consider all inputs and practices, both within a crop and a farm, and their interactions. By so doing, farming practices can be adapted to reduce adverse effects, such as pollution caused by leaching and run-off, soil erosion, effects on non-target species and loss of habitats and biodiversity.

Most consumers demand high quality produce at the lowest possible price and supermarkets supply this. A small, albeit increasing, proportion of people consider that it is worth paying a premium for organic produce.

This booklet summarises research results showing sound agronomic and environmental reasons why farmers should adopt integrated practices; many indeed already do so. In general the crops produced cost no more, and may cost less than conventionally produced food. However, the term or concept ‘integrated’ is poorly understood by the general public and currently carries no marketing advantage, which limits its competitive position in the market.

Does integrated farming deliver?

Experimental studies consistently show it is possible to reduce inputs, deliver environmental benefits and still maintain, or even increase, profitability. Output may drop, but so do costs.

As costs are more tightly controlled, profitability is less vulnerable if prices fall unexpectedly. The agronomic risk is reduced considerably since the integrated approach is designed to minimise weed, disease and pest damage through greater awareness and knowledge.

Results have been collated from the nine sites (shown opposite) where integrated and conventional farming systems and their financial performance were compared. The integrated system was the most profitable overall at five sites.

Where the integrated system was not more profitable (4 of the 6 LINK: IFS sites), some less profitable spring break crops were included in the rotations at the beginning of the experiment. Where more suitable break crops were selected in the FOFP, RPMS and LIFE sites, gross margins were higher.

Assessment of the relative profitability of integrated farming is highly dependent on grain price as shown below.

Research on integrated cropping

Findings from nine experimental sites in the main arable areas of England and Scotland have contributed to the information and suggested techniques in this guide. The locations included a wide range of crops, soil types and climates. The sites included commercial farms and research centres.

From 1990 to 1997 an extensive data set was compiled from more than 300 integrated and conventional field comparisons across sites, crops and years. This research was designed to develop practical integrated arable farming systems on a field scale.

Integrated farming can be seen in practice at many LEAF demonstration farms throughout the UK.

Is there an integrated blueprint?

There are no blueprints or prescriptions to be universally applied. However, a strategy can be developed based on crop-by-crop and field-by-field ‘decisions’. At each site, attention to detail, regular crop monitoring and the need for precision are all important. This guide addresses the step-by-step approach.

Farmers must determine priorities, e.g. nitrate leaching or soil erosion, pesticide leaching or farmland birds, and then plan a whole farm approach for sustainable production and profit, in an improved environment.

IACPA

The Integrated Arable Crop Production Alliance was formed in December 1994 to bring together leading UK organisations involved in integrated farming: LIFE (Less Intensive Farming and the Environment), FOFP (Focus on Farming Practice), LINK: IFS (Integrated Farming Systems) RPMS (Rhône-Poulenc Farm Management Study) BEAM (Balancing Environment and Agriculture in the Marches) – joined IACPA 1999 LEAF (Linking Environment And Farming)

TIBRE (Targeted Inputs for a Better Rural Environment)

FWAG (Farming and Wildlife Advisory Group)

(See page 35 for further details about IACPA projects)

IACPA members work together to ensure that:

• a representative range of common cropping problems is addressed in their research;
• literature and R&D findings are exchanged on a regular basis to avoid unnecessary duplication;
• important results are disseminated quickly and effectively to the industry.

EXTENSIVE RESEARCH HAS DEMONSTRATED THE BENEFITS OF ‘INTEGRATED’ FARMING OR CROPPING. THE NEED NOW IS BOTH FOR GREATER ON-FARM ADOPTION OF THE PRACTICES AND PUBLIC UNDERSTANDING OF WHAT IT MEANS.
Reduced crop protection and fertiliser needs.

Consider grass leys within the arable rotation if

Maximise the benefits of break crops, eg

Spread workload.

Include spring crops, where profitable and practical.

Requires early identification of market opportunities.

Enhanced biodiversity and farmland birds.

Avoid erosion-prone crops on erosion-prone sites.

Workload shifted from autumn.

Avoid large blocks of the same crops or

Plan a diverse rotation, which profitably meets

outputs, a well-planned rotation allows more high-

yielding first wheat crops following break crops and

affords opportunities to enhance quality.

The ‘ideal’ rotation

An ideal rotation would include a balance of crops from different crop groups - cereals, legumes, root crops and broad-leaved arable crops - with no group occupying more than half the land area at any time.

A diverse crop rotation aims to break cycles of pests and diseases, improve weed control options, provide sufficient crop cover to prevent erosion and improve nutrient cycling and soil condition. The consequences of different rotations on soils and nutrients can be assessed (see pages 8 and 9), forming the basis for choosing ones which have less environmental impact.

Potential problems

Options can be limited. Root crops demand heavy investment in machinery and production. Quotas and contracts limit other crops, eg sugar beet, vining peas and certain field vegetables. Some crops are less profitable than others although they may give benefits elsewhere in the rotation.

Soil type can also be limiting. For instance, spring crops are difficult to establish on heavy land.

Economics have a major influence on crop choice.

Some practical suggestions

Avoid long runs of winter cereals.

Maximise the benefits of break crops, eg through improved grass weed control, even if only occasional.

Calculate gross margins over running 5-year periods, not just on the basis of single years.

Choose break crops with care, making sure that you have a market before the crop is sown.

Interactions

Soils

The level and intensity of cultivations depends on rooting structure and tillth required for chosen crop. Potatoes require very deep cultivations to create beds and ridges, while cereals and oilseed rape can be direct drilled into stubble.

Previous crop residues and soil structure also influence cultivation needs. In particular, large quantities of cereal chaff and straw hamper establishment of following crops. Harvesting can cause soil compaction, especially if heavy machinery is used to lift roots on wet soils late in the year. After harvest, crop volunteers can be controlled, eg volunteer potato tubers rot if left exposed to frost on the soil surface; oilseed rape volunteer seed should be left on the surface to reduce dormancy and encourage germination and then be cultivated or sprayed off.

Carefully-managed cover crops have minimum impact on subsequent establishment. However, they may reduce soil moisture for spring-sown crops, lock up N during crop establishment and harbour slugs.

Establishment

Market choice is the key influence on crop and variety selection. Rotation affects crop quality (eg milling wheats with high N needs usually follow a break crop) and disease incidence. Varietal diversification reduces disease pressure. Sowing date, seed rate and variety choice are all affected by local climatic conditions. The busy autumn and harvest workloads can be eased by crop and variety selection.

Nutrition

Phosphate, potash, magnesium and other nutrient needs depend on soil reserves and crop off-takes. Fertility can be maintained at acceptable levels by applications to receptive crops.

Nitrogen is applied crop-by-crop, according to crop needs, previous crop residues, soil organic matter reserves and atmospheric deposition. Crops with low N demand, eg spring rape, can reduce fertiliser inputs over the whole rotation. Legumes fix nitrogen and can leave high crop residues. Good rotational management utilises the fertility in crop residues.

Farmyard manure can replace inorganic fertiliser and benefit soil fertility. Solid manures can be applied over-winter to stubbles provided leaching is avoided. When spread in liquid form, care must be taken to avoid run-off. Cover crops can reduce N leaching over-winter, but N release may be unpredictable later in the season.

Weeds

Crop rotation is an essential part of weed management. It allows herbicide rotation and weed control by cultivation. Weed flushes between crops can be killed by cultivation, but this can lead to nitrogen mineralisation and leaching. Mechanical weed control can be very suited to row crops. Chemical control of grass weeds is best achieved in broad-leaved crops.

In cereals, adjusting sowing date, cultivations and herbicides all help to reduce problems with grass weed control.

Crop volunteers are a constant challenge. They can harbour pests and diseases as well as contaminating seed crops.

Rotation can prevent carry-over and build-up of pests between susceptible crops. Rotation is essential to reduce soil-borne pests like nematodes. Adherence to recommended cropping intervals minimises pest build-up.

Preceding crops can create specific pest issues, eg slug populations can build up in oilseed rape to threaten following cereals.

Large blocks of crops can exacerbate problems as pests can move easily between adjoining fields.

Planting vulnerable crops next to fields where similar crops grew the previous year poses a particular risk.

Diseases

Crop rotation is the first line of defence against disease carry-over and development.

A wide range of crops and sowing dates enhances habitats and produces a varied landscape. Large areas of mono-crop farming limit opportunities for wildlife to find food, breeding sites or shelter. Over-winter stubbles benefit farmland birds. Spring-sown crops may be less favourable to some invertebrates. Some spring crops encourage rare arable weeds. Spring germinating weeds are particularly valuable to birds.

Benefit

- Reduced crop protection and fertiliser needs.
- Spread workload.
- Improved soils.
- Requires early identification of market opportunities.
- Workload shifted from autumn.
- Increased weed control opportunities.
- Enhanced biodiversity and farmland birds.
- Reduced N fertiliser inputs.
- Reduced risk of pest and disease build-up, or spread to successive crops.
- Benefits to wildlife.
- Improved soil structure, fertility, organic matter content and biodiversity.
- Improved weed control.
- Prevent soil loss, erosion and flooding.
1 ROTATION

1 ROTATION

Crop characteristic scores to assess consequences of any rotation

A scoring system, developed as part of the European Concerted Action on Integrated Farming, can be applied over a range of financial, physical and chemical properties to assess the effects of different rotations.

<table>
<thead>
<tr>
<th>Crop choice</th>
<th>Financial</th>
<th>Physical properties</th>
<th>Chemical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield t/ha</td>
<td>Crop cover</td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>GM £/ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter wheat (first)</td>
<td>8.50</td>
<td>580</td>
<td>0</td>
</tr>
<tr>
<td>Winter wheat (second)</td>
<td>7.65</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>5.75</td>
<td>490</td>
<td>-2</td>
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<tr>
<td>Winter barley</td>
<td>6.35</td>
<td>450</td>
<td>1</td>
</tr>
<tr>
<td>Spring barley</td>
<td>5.50</td>
<td>440</td>
<td>-2</td>
</tr>
<tr>
<td>Winter oats</td>
<td>6.75</td>
<td>500</td>
<td>1</td>
</tr>
<tr>
<td>Spring oats</td>
<td>5.5</td>
<td>430</td>
<td>-4</td>
</tr>
<tr>
<td>Rye</td>
<td>5.75</td>
<td>435</td>
<td>1</td>
</tr>
<tr>
<td>Triticale</td>
<td>6.00</td>
<td>460</td>
<td>1</td>
</tr>
<tr>
<td>Legumes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter peas</td>
<td>3.60</td>
<td>445</td>
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<tr>
<td>Spring peas</td>
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<td>-4</td>
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<tr>
<td>Set-aside with cover</td>
<td>-</td>
<td>192,220</td>
<td>2</td>
</tr>
</tbody>
</table>

Based on F.P. Vereijken, EU Concerted Action, AIR3CT920755.

1. Crop choice - A rotation should be diverse to minimise potential pest and disease problems, provide weed control options, and improve soil fertility and structure. Ideally, no crop should occupy over 25% and no crop group, eg cereals, over 50% of the rotation. Short rotations with two winter wheats (especially as first wheats) will not meet ideal crop targets but are currently favoured for profitability.

2. Rotation target - crop < 25%; crop group < 50% & 3. Financial - Estimated average yields and gross margins (GM) - for feed crops - based on Nix (2002), are given. Also consider effect of area payments on profitability of a rotation.

4. Crop cover - Crop cover protects soil in wind or water erosion-prone areas and reduces nutrient or pesticide leaching or run-off. Bare soil over winter increases potential risks. A rotation, using cover crops where appropriate, minimises these problems.

5. Soil structure - The different rooting characteristics of crop groups can affect soil condition and workability. The time of harvest may affect soil condition, the need for subsequent cultivations and the following crop. Earlier harvesting causes less compaction than later harvesting. Combining and vining are less damaging than lifting root crops.

6. Nitrogen offtake - The estimated quantity of nitrogen taken from soil reserves by the harvested crop.

7. Nitrogen transfer - The quantity of N left by the harvested crop which is available to the subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification.

8. Nitrogen need - In the rotation examples below, this is calculated from N offtake from the planned crop minus N transfer from the previous crop, to give net N input needed from manure or fertiliser. Ideally, high transfer crops are followed by high offtake crops.

Rotation target < 2

Example A: Combinable crops and potatoes

<table>
<thead>
<tr>
<th>Crop</th>
<th>GM £/ha</th>
<th>Group</th>
<th>Cover</th>
<th>Structure</th>
<th>N offtake</th>
<th>N transfer</th>
<th>N need</th>
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</thead>
<tbody>
<tr>
<td>Winter wheat</td>
<td>580</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Winter barley</td>
<td>450</td>
<td>Cereals</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Winter oilseed rape</td>
<td>390</td>
<td>Brassicas</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>580</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Potatoes</td>
<td>1600</td>
<td>Potatoes</td>
<td>-4</td>
<td>-3</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Average</td>
<td>730</td>
<td>60%</td>
<td>0.2</td>
<td>0.4</td>
<td>2.6</td>
<td>1.4</td>
<td>2.6</td>
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<tr>
<td>Target</td>
<td>&lt;50%</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>-</td>
<td>&lt;2</td>
<td>-</td>
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Example B: Combinable crops with rotational set-aside

<table>
<thead>
<tr>
<th>Crop</th>
<th>GM £/ha</th>
<th>Group</th>
<th>Cover</th>
<th>Structure</th>
<th>N offtake</th>
<th>N transfer</th>
<th>N need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter wheat</td>
<td>580</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Set-aside</td>
<td>220</td>
<td>Other</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Winter oilseed rape</td>
<td>390</td>
<td>Brassicas</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>580</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Winter beans</td>
<td>445</td>
<td>Legumes</td>
<td>-2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Average</td>
<td>443</td>
<td>40%</td>
<td>0.4</td>
<td>1.4</td>
<td>2.6</td>
<td>1.4</td>
<td>1.2</td>
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<tr>
<td>Target</td>
<td>&lt;50%</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>-</td>
<td>&lt;2</td>
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Example C: Combinable crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>GM £/ha</th>
<th>Group</th>
<th>Cover</th>
<th>Structure</th>
<th>N offtake</th>
<th>N transfer</th>
<th>N need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter wheat</td>
<td>580</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>500</td>
<td>Cereals</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Winter oilseed rape</td>
<td>390</td>
<td>Legumes</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Average</td>
<td>490</td>
<td>67%</td>
<td>0.7</td>
<td>1.7</td>
<td>4</td>
<td>0.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Target</td>
<td>&lt;50%</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>-</td>
<td>&lt;2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Good soil management improves soil structure and reduces environmental problems.

**Interactions**

**Rotation**
Rotation partly dictates cultivation method. A balance is needed between crop establishment and soil management to conserve nutrients and minimise erosion.

Crop choice determines level of cultivations needed for root structure and tilth.

Some crop situations influence cultivation requirements for the next crop by affecting soil structure. Crop residues improve soil workability and leave nutrients, thereby helping to improve establishment of the following crop.

**Advantages of reducing cultivation intensity**

- Machinery costs
- Energy costs
- Soil damage [traffic]
- Erosion
- N leaching
- Agrochemical losses

**Non-ploughing**

- Plough
- Minimal cultivation
- Direct-drilling

- Decreasing intensity of cultivations
- Work rate
- Residue decomposition
- Biological activity
- Soil structure
- Function & stability of soil pores
- Profits

**Sowing date**

Local soil conditions and establishment method determine sowing date. A seedbed can be established more quickly using minimal cultivation, compared with ploughing, on most soils.

At peak work periods, it may be necessary to reduce cultivation passes and increase operating speed. This applies especially when combination cultivator drills are used to establish crops at optimum timing. Reducing cultivation intensity can also speed up operations.

**Seed-rate**

To achieve optimum plant populations, seed-rates need to be matched to establishment technique. Seed-rate may be increased to compensate for reduced crop establishment in poorer soil conditions.

**Nutrition**

Soil N mineralisation increases with increasing intensity of cultivation. Mineralised nitrogen can leach into surface or ground water. Leaching risk is greater if land is ploughed in the autumn, especially if spring drilling is delayed.

Over-winter leaching, in high risk areas, can be reduced by sowing cover crops, incorporating crop residues after harvest, allowing natural regeneration or sowing the next crop early. However, cover crops may release N unpredictably later the following season.

Leaching risk varies with soil type, organic matter content and climate. Nutrient loss increases if warm, moist soil is cultivated and drains flow. Practices that reduce mineralisation help in high-risk areas, especially in Nitrate Vulnerable Zones and on underdrained land in water catchment areas.

P & K

Ploughing, especially on sloping fields, increases soil erosion or run-off of soil sediment and phosphate. Minimal tillage reduces these risks.

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**Principles**

Soil is easily damaged and harm can be long term. Management aims to use mechanisation to create good seedbeds, while maintaining soil structure, avoiding compaction and preserving the habitat for beneficial fauna especially earthworms. Good management protects soil against slumping through water-logging as well as erosion threats from flood or wind-blow. A guide to managing crop establishment, SNI (2001) is a good reference.

**‘Ideal’ soil management**

This depends largely on soil type, aspect, weather, crop needs and existing weed problems. Ploughing is not always necessary on all soils, every year. It consumes considerable energy and can be damaging to earthworms, predatory beetles and spiders. Heavy equipment may cause compaction and soil pans. Ploughed soil is more prone to soil erosion in wet seasons.

In many circumstances, minimal cultivation or direct drilling is preferable. It is cheaper, quicker and less damaging to soil structure. Minimal cultivations typically incorporate 70% of crop residues, leaving 30% on the soil surface. This helps limit soil erosion and run-off, and enhance habitats for several bird species.

**Potential problems**

Minimal cultivations may not suit all soil types every year, eg on sands, on compacted soil, where a serious weed problem has built up or for crops such as potatoes. Choosing cultivations to fit crop and seasonal needs can incur high capital costs. The incidence of herbicide-resistant black-grass tends to be higher on land, which has been minimally cultivated, rather than ploughed, for several years.

**Some practical suggestions**

- Match cultivation technique to crops grown in the rotation.
- Consider ploughing less frequently and less deeply to reduce energy input.
- Take account of prevailing weather and soil conditions.
- Use low pressure tyres or tracked vehicles to reduce wheeling damage.
Reducing intensity of cultivation has many benefits, both economic and environmental.

**Weeds**

Ploughing buries most weed seeds below 10 cm. It can effectively control brome and black-grass. Grass weed resistance may occur more often in minimally cultivated fields. Most seeds occur in the top 5 cm. Hence, autumn weed flushes and higher autumn weed populations are common. Stale seedbeds allow a broad-spectrum herbicide to be used. Rotational set-aside can also help contain weeds. Grass weeds are most efficiently controlled by chemicals in broad-leaved crops and broad-leaved weeds in cereals.

Cultivations stimulate germination of weeds which can be controlled using cultivations or herbicides. Mechanical weeding releases soil N through mineralisation, which may promote crop growth in spring. It can sometimes stimulate further weed seed germination, particularly during autumn in warm soils.

**Diseases**

Generally, soil management does not directly affect disease levels. However, disease tends to be less severe on well-established crops with good root systems, provided growth is not too dense. Inoculum on surface straw may infect emerging susceptible crops with trach-borne diseases, eg eyespot. Take-all and mildew can also be spread by a ‘green bridge’ effect, eg weed flushes from stale seedbeds, or natural regeneration left as cover crops.

**Environment**

Earthworms and other beneficial soil organisms thrive under minimal cultivation. Food sources and habitats for several bird species are improved. Overwintered stubbles and spring ploughing can benefit farmland birds. Mechanical weeding can kill nesting birds and soil surface invertebrates.

**Action/key issue**

- Avoid intensive cultivations.
- Time cultivations carefully.
- Match cultivations to crop, weeds, soil type and season.
- Reduce cultivations on steep slopes and season.
- Cultivate across slopes.

**Benefit**

- Reduced costs and energy inputs.
- Less wear and tear on machinery.
- Improved soil structure with less damage from machinery.
- Reduced soil erosion and pollution risk.
- Beneficial invertebrates and earthworms encouraged.
- Reduced mineralisation of nitrogen and leaching risk.
- Improved workrates and weed control.
- Good crop establishment leading to optimum yields.
- Reduced soil erosion and pollution risk.
- Stable crop establishment.
- Reduced soil loss and clean-up/legislative costs.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Direct energy (MJ/ha)</th>
<th>Indirect energy (MJ/ha)</th>
<th>Total energy (MJ/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plough</td>
<td>1160</td>
<td>890</td>
<td>2050</td>
</tr>
<tr>
<td>Heavy disc</td>
<td>860</td>
<td>700</td>
<td>1560</td>
</tr>
<tr>
<td>Power harrow</td>
<td>840</td>
<td>750</td>
<td>1590</td>
</tr>
<tr>
<td>Seed drill</td>
<td>280</td>
<td>200</td>
<td>480</td>
</tr>
<tr>
<td>Fertiliser spreader</td>
<td>32</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>Sprayer</td>
<td>51</td>
<td>34</td>
<td>85</td>
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</tbody>
</table>

This data demonstrates the difference in energy inputs in cultivation and crop establishment operations that can occur between a conventional and an integrated system. In this example, only two passes were used on the integrated system – the first was a cultivator drill unit followed by simple harrowing. In contrast on the conventional system, five passes including a plough, power harrow, tined cultivator, seed drill and separate light harrow were used. The figure also shows how much energy was used for seed, fertiliser and pesticide inputs.

Direct energy - that used in operating equipment on farm.

Indirect energy - an estimate of that used in manufacturing inputs and machinery.
3 ESTABLISHMENT

The right choice of variety, sowing date and seed-rate can significantly reduce crop protection costs.

### Potential problems
As establishment decisions are complex and inter-related, some compromise is inevitable. The skill of the integrated approach is to balance advantages and disadvantages from both economic and environmental aspects. For example, the variety that best fits a particular rotational position may not be best for the intended market. Growing several varieties helps reduce disease pressure. It enables efficient work scheduling, but complicates storage and marketing. See page 16 for effects of sowing date: advantages and disadvantages of early or late sowing of winter crops and effects of sowing conditions on establishment of spring crops. Decisions on seed-rate have to take the other decisions into account and are based on an assumed percentage establishment. It is easy to over or under-estimate this.

### Some practical suggestions
- Assess all variety characteristics before making a choice.
- Where possible take account of disease resistance and agronomic aspects.
- Balance advantages and disadvantages of early or late sowing.
- Determine seed-rate for chosen variety and sowing date, as well as current seasonal and field conditions.

### Principles
Establishing or sowing a crop involves deciding on:
- variety - primarily driven by market needs and yields, but pest and disease resistance, competitive ability and some agronomic characteristics, eg lodging resistance, are also important.
- sowing date - influenced by variety, site-specific factors, eg soil, weather, preceding crops, soil erosion and nitrate leaching risks, and pest, disease and weed threats.
- seed-rate - influenced by specific weight and sowing date. Seed-rate and subsequent plant population influence crop structure and competitiveness against weeds, lodging risk and pest, disease and weed pressure.

### ‘Ideal’ establishment decision(s)
In practice, variety is the first decision, followed by sowing date and seed-rate. Each influences the next.
- The ideal variety suits the specific needs of site and intended market. Specific varieties perform best in some regions as well as rotational position.
- Farm-specific decisions depend on the sowing date and affect many other factors.
- Seed-rate interacts with sowing date. It may be best to use a lower seed-rate with early-sown crops and a higher rate with late-sown crops, if slug pressure is high or if mechanical crop weeding is planned. Generally, the ideal seed-rate produces a canopy which maximises yield potential.

### Interactions

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sowing date</th>
<th>Seed-rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>Choice of crop determines sowing date.</td>
<td>Seed-rate may need to be higher for some crops, eg seed potatoes.</td>
</tr>
<tr>
<td>Soils</td>
<td>Local soil conditions and establishment method determine sowing date.</td>
<td>Seed-rate is increased in poorer soil conditions.</td>
</tr>
<tr>
<td>Nutrition</td>
<td>N, P and K inputs vary with market and quality requirements. Lodging resistance is related to soil fertility and N inputs and determines the need for routine PGR use.</td>
<td>Early-sown autumn crops may require autumn N top-dressing, especially after minimal soil disturbance, if leaching risk is low. Delaying sowing for weed control may increase nitrate leaching. The crop is less able to use N reserves which mineralise late in autumn.</td>
</tr>
<tr>
<td>Weeds</td>
<td>Variety growth habit (vigour and ground cover) determines how effectively crops, especially broad-leaved, compete with weeds.</td>
<td>Late autumn sowing of cereals allows crop volunteers and weeds to emerge. These can be killed using cultivations or non-selective herbicides. Higher seed-rates result in added crop cover and competition. Seed-rates may be increased to cover crop losses from mechanical weeding.</td>
</tr>
<tr>
<td>Pests</td>
<td>Varietal resistance to pests, eg potato cyst nematode, is important.</td>
<td>Early sowing avoids slugs, but late autumn sowing delays infestation by some pests, eg aphid vectors of BYDV, frit fly and gout fly. Seed-rates may be increased to cope with plant or tiller loss caused by slugs, wheat bulb fly or flea beetle.</td>
</tr>
<tr>
<td>Diseases</td>
<td>Variety choice is a key line of defence to minimise disease risk in a wide range of crops.</td>
<td>Diseases are usually more serious on early-sown cereals and oilseeds, so these crops may need different management to those sown later. Sowing cereals later (mid-October) reduces take-all risk. High seed-rates can exacerbate diseases - higher humidity leads to increased stem-base and foliar diseases, eg potato blight.</td>
</tr>
</tbody>
</table>

---

13 ESTABLISHMENT
3 ESTABLISHMENT

It is most important to get sowing date right with autumn-sown crops; with spring crops the more vital factor is seedbed conditions.

### Advantages and disadvantages of early or late autumn sowing of winter cereal crops

<table>
<thead>
<tr>
<th>Early sowing</th>
<th>Late sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ A</td>
<td>Yield</td>
</tr>
<tr>
<td>✓ A</td>
<td>Opportunities for cultivation/spraying</td>
</tr>
<tr>
<td>✓ A</td>
<td>Crop vigour &amp; competition</td>
</tr>
<tr>
<td>✓ B</td>
<td>Seed-rate</td>
</tr>
<tr>
<td>✓ B</td>
<td>Nitrate leaching</td>
</tr>
<tr>
<td>✓ B</td>
<td>Slug damage</td>
</tr>
<tr>
<td>✓ A</td>
<td>Workload spread</td>
</tr>
<tr>
<td>✓ A</td>
<td>Weeds</td>
</tr>
<tr>
<td>✓ A</td>
<td>Diseases</td>
</tr>
<tr>
<td>✓ A</td>
<td>Pests</td>
</tr>
<tr>
<td>✓ A</td>
<td>Pesticide costs</td>
</tr>
</tbody>
</table>

A = increase  B = decrease  ✓ = advantage  ✗ = disadvantage

### Action/key issue

#### Benefit

- **Variety**
  - Grow resistant varieties wherever possible.
  - Lower pest and disease incidence.
  - Reduced crop protection inputs.

- **Sowing date**
  - Where appropriate (site-specific) sow winter cereals early.
  - Reduced nitrate leaching on high risk sites.
  - Improved workload spread.
  - Lower seed costs.
  - Higher yields.

  - Where appropriate (site-specific) sow winter cereals late.
  - Opportunity to use stale seedbeds to improve weed control.
  - Reduced risk of BYDV as aphid vectors are more prevalent on early-sown crops.
  - Less autumn disease pressure.
  - Improved workload spread.
  - Lower crop protection inputs.

#### Seed-rate

- Consider reducing seed-rates in some circumstances.
  - Healthier crops.
  - Reduced lodging risk.
  - Reduced input costs.
  - Improved yields and gross margins.

- Consider increasing seed-rates in some circumstances.
  - Insurance against slug damage and losses from mechanical weeding.
  - Greater competition against weeds.

### Effects of sowing conditions on establishment of spring crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Optimum period</th>
<th>Seedbed requirements</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring barley</td>
<td>February - May</td>
<td>Firm &amp; fine</td>
<td>Early-sown isolated crops can suffer bird damage.</td>
</tr>
<tr>
<td>Spring oats</td>
<td>February - April</td>
<td>Firm &amp; fine</td>
<td>Sow early to avoid frit fly.</td>
</tr>
<tr>
<td>Spring oilseed rape</td>
<td>February - April</td>
<td>Fine &amp; firm</td>
<td>Soil moisture is important. Flea beetles can attack slow emerging crops in dry conditions.</td>
</tr>
<tr>
<td>Spring linseed</td>
<td>February - April</td>
<td>Fine &amp; firm without compaction</td>
<td>Warm, moist soil favours rapid establishment. Flea beetles can attack slow emerging crops in dry conditions.</td>
</tr>
<tr>
<td>Spring beans</td>
<td>February - April</td>
<td>Deep drilled or broadcast &amp; ploughed in</td>
<td>Late sowing can lead to late harvest. Birds can be a problem in drilled crops.</td>
</tr>
<tr>
<td>Dry peas</td>
<td>February - March</td>
<td>Fine, firm &amp; level</td>
<td>Delaysowing reduces yields and quality. Damping off may be a problem in cold, wet soil.</td>
</tr>
<tr>
<td>Potatoes</td>
<td>March - May</td>
<td>Deep tillled &amp; destoned</td>
<td>Soil condition and temperature are critical. Planting in cold conditions can lead to ‘little potato’.</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>March - April</td>
<td>Fine, firm &amp; level</td>
<td>Good soil conditions are important; good seed/soil contact and moisture is needed.</td>
</tr>
</tbody>
</table>
4 NUTRITION

Principles
All crops need major nutrients - nitrogen (N), phosphorus (P), potash (K) and sulphur (S) - plus a range of micro-nutrients, including magnesium (Mg), manganese (Mn) and zinc (Zn).

Planning aims to maximise nutritional benefits for crops throughout the rotation taking different crop needs into account. Availability is influenced by soil type, previous cropping, fertilisation and weather. Crop nutrient needs are determined as accurately as possible and then supplied from organic and inorganic sources. Fertiliser recommendations for agricultural and horticultural crops (RB209), MAFF (2000) is an essential guide.

‘Ideal’ crop nutrition
Nitrogen is paramount for most crops. Rotation planning must take account of factors as diverse as legumes fixing nitrogen, and the losses that occur through leaching, especially on sandy soils in winter, as well as volatilisation in cold, wet soils. The aim is to meet specific crop needs from both residual and applied sources - organic and inorganic - with minimal losses.

Inputs of P, K and Mg are calculated to balance crop requirements and offtake with previous crop residues and to maintain fertility without leaving excess. Other nutrient inputs are determined according to deficiency risk based on soil type, previous crop symptoms or confirmed deficiency.

Potential problems
Some benefits are not available if rotation options are limited. Weather conditions can influence the availability of nitrogen especially in cold, dry soils. Other nutrients may be affected by soil pH, eg Mn. Location affects atmospheric deposition, eg NH3. Nutrition management aims to maximise utilisation of applied fertiliser and soil reserves while minimising environmental losses.

Some practical suggestions
- Have soils tested regularly - annually for nitrogen on priority fields.
- Exploit rotation to maximise nutrient carry-over, avoiding excess for following crops.
- Utilise organic manures and take full account of their nutrient content.
- Calculate requirements for each crop, rather than using standard figures.
- Calibrate spreading equipment to avoid wastage.

Interactions

Rotation
Rotations are best planned so that crops with high N demands follow oilseed rape, legumes or grass.
P & K fertilisers are applied to the most responsive crops, eg potatoes, if soil analyses indicate need.

Cultivation intensity increases soil N mineralisation. Direct drilling has least effect while ploughing has the greatest.

Mineralisation reduces over-winter nitrate leaching. Nutrient loss rises if warm, moist soil is cultivated and drains flow.

Leaching risk varies with soil type, organic matter content and climate. In high-risk areas, practices which reduce mineralisation help, especially in Nitrate Vulnerable Zones and on underdrained land in water catchment areas.

Incorporating crop residues can lock up soil mineral nitrogen (SMN) temporarily in autumn. Cover crops reduce SMN loss over-winter but may release N unpredictably following the later season.

Reduced cultivations minimise soil erosion and so P loss.

Establishment
Adjusting rate and timing of N and choosing the right variety and seed rate can reduce need for routine plant growth regulator (PGR) use.

Weeds
High N levels due to residual soil fertility or applied fertiliser can change the weed spectrum by allowing competitive and aggressive weeds, eg cleavers, to proliferate.

Weeds may also take up applied N in spring ahead of the crop. This can exacerbate weed control difficulties.

Stale seedbed cultivations mineralise N but weed flushes take up nitrate and limit leaching risk. Mechanical weeding in spring also mineralises N.

Diseases
High N crops are more prone to many diseases, eg stem-base diseases and powdery mildew.

Higher early spring N applications encourage root recovery of take-all infected winter cereals.

Environment
N and P can cause water eutrophication, algal blooms and poor water quality, which can kill aquatic wildlife.

Nutrients reduce plant diversity in field boundaries.

Action/key issue
- Buy good quality fertiliser and calibrate spreader.
- Match nutrient inputs to the crop rotation.
- Have soil tests carried out when needed, depending on nutrient.
- Predict crop needs as accurately as possible by using techniques such as canopy management or chlorophyll testing.
- Adjust the timing and amounts of split applications as accurately as possible.
- Avoid fertiliser application to hedgerows.

Benefit
- Improved efficiency and financial benefit.
- Lower overall N requirements and targeted P and K and Mg inputs.
- Accurate prediction of crop needs. Knowledge of leaching risk reduces over-use. Financial benefit.
- Precision and timing of nitrogen doses.
- Reduced leaching risk, reduced disease pressure and lodging risk.
- Improved crop uptake, yields and quality.
- Financial benefit.
- Improved uptake, flexibility.
- Reduced waste and prevents noxious weeds.
- Avoids water pollution, and increases biodiversity.

N content of fertilisers and manures

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Nitrogen content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
<td>33.5-34.5%</td>
</tr>
<tr>
<td>Liquid N solutions</td>
<td>18.30% (w/w)</td>
</tr>
<tr>
<td>Calcium ammonium nitrate</td>
<td>26-28%</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>21% (also 60% SO3)</td>
</tr>
<tr>
<td>Urea</td>
<td>46%</td>
</tr>
</tbody>
</table>

Organic manures

<table>
<thead>
<tr>
<th>Manure</th>
<th>Dry matter</th>
<th>Total N content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle manure</td>
<td>25%</td>
<td>6 kg/t</td>
</tr>
<tr>
<td>Pig manure</td>
<td>25%</td>
<td>7 kg/t</td>
</tr>
<tr>
<td>Sheep manure</td>
<td>25%</td>
<td>6 kg/t</td>
</tr>
<tr>
<td>Duck manure</td>
<td>25%</td>
<td>6.5 kg/t</td>
</tr>
<tr>
<td>Layer chicken manure</td>
<td>30%</td>
<td>16 kg/t</td>
</tr>
<tr>
<td>Broiler/turkey litter</td>
<td>60%</td>
<td>30 kg/t</td>
</tr>
<tr>
<td>Pig slurry</td>
<td>2%</td>
<td>3 kg/m²</td>
</tr>
<tr>
<td>Sheep slurry</td>
<td>4%</td>
<td>4 kg/m²</td>
</tr>
<tr>
<td>Dairly slurry</td>
<td>6%</td>
<td>5 kg/m²</td>
</tr>
<tr>
<td>Dairy slurry</td>
<td>10%</td>
<td>4 kg/m²</td>
</tr>
</tbody>
</table>

Principles
Some weeds severely impair crop yield and/or quality; others pose little threat, but are valuable for wildlife. Weeds with dormant seeds or rhizomes present long-term problems. Weeds need to be managed, not necessarily eliminated, across the whole rotation, through both cultural and chemical means.

‘Ideal’ weed management
Cultural control includes use of crop rotation, primary cultivations, ‘stale seed-bed’ techniques, comb weeding, timing of sowing, inter-row cultivations, crop competition, in conjunction with appropriate chemicals. Weed species determine choice of pre- or post-emergence herbicides. More aggressive weeds are targeted on a whole field or patch basis. Some weeds, eg wild oats, can be hand-rogued. Other non-aggressive weeds, which do not threaten yield, can be left as food for wildlife.

Potential problems
Poor control of aggressive weed species can result in both current and future problems. However, occasional poor control may not reduce yields or have long-term effects if weeds are non-aggressive.

Some practical suggestions
- Regularly walk fields to assess weed species and populations.
- Make pre-harvest assessments to determine future control needs.
- Match control to weed aggressiveness; target aggressive weeds first but tolerate less competitive weeds as food for insects and birds.
- Consider and use all possible cultural control options, including variety choice, rotation, drilling date and rotational ploughing.
- Choose and use herbicides with care, assessing leaching, run-off, and persistence and herbicide resistance risks. Follow WRAG Guidelines.
- Determine dose on the basis of soil, weather, weed species present, weed size and later sprays that may be applied.
- Follow IPU Stewardship guidelines to avoid pollution of water.

Interactions

Rotation
Problem weeds can be controlled in rotational set-aside by cultural and chemical means. Mechanical weeding is particularly suitable in potatoes, sugar beet and other row crops.
Grass weeds can pose problems in winter crops, especially in winter cereal-dominated rotations. Crop volunteers contaminate seed and quality crops especially, and are best managed through the rotation.
Some residual herbicides persist long enough to affect following crops - check manufacturers’ recommendations.

Soils
Ploughing buries most weed seeds to below 10 cm. Ploughing maximises brome and black-grass control as long as seeds are buried deeply and are not dormant. In minimal cultivation systems, most weed seeds remain in the top 5 cm. Cultivations stimulate autumn weed flushes, so higher autumn weed populations are common. Further cultivations or non-selective herbicides provide control. Mechanical weeding mineralises N, which may benefit crop and weeds, but can also be leached. It also encourages weed seeds to germinate but, wrongly timed, may kill nesting birds and other wildlife living on the soil.

Tolerance index of some common arable weeds (numbers of plants which reduce winter wheat yields by less than 5%)

<table>
<thead>
<tr>
<th>Tolerance index</th>
<th>Weed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - not tolerated</td>
<td>barren brome, black-grass, cleavers, couch, Italian ryegrass, meadow brome, wild oats</td>
</tr>
<tr>
<td>1 - up to 20 weeds/m²</td>
<td>chickweed, mustard, mayweed, oilseed rape, poppy, thistle</td>
</tr>
<tr>
<td>2 - 20-49 weeds/m²</td>
<td>campion, chickweed, lettuce, forget-me-not, redshank</td>
</tr>
<tr>
<td>3 - 50-99 weeds/m²</td>
<td>annual meadow grass, bedstraw, foxtail, fumitory, groundsel, hawkweed, mallow, meadow rue, red campion, scarlet pimpernel, sow thistle, speedwell, wild onion</td>
</tr>
<tr>
<td>4 - more than 100 weeds/m²</td>
<td>black bindweed, field pansy, parsley, plantain, rue, vetch, vetchling, glass</td>
</tr>
</tbody>
</table>

Establishment
Vigour and competitiveness are varietal characteristics, which determine how effectively crops compete with weeds.
Sowing date can be an effective tool for weed control. Early sown oilseed rape will out-compete weeds. In winter cereals, delaying drilling allows crop volunteers and autumn germinating weeds time to emerge. These can then be killed using a non-selective herbicide prior to drilling. Later sowing may result in increased nitrate leaching.
Higher seed-rates result in increased crop cover and competition against weeds. Seed-rates may be increased to cover crop losses from mechanical weeding.

Diseases
Weed growth at the crop base may exacerbate stem-base disease problems. Crop volunteers may encourage disease to spread between susceptible crops, eg potato blight, or act as a ‘green bridge’ for mildew, take-all, eyespot or BYDV. Weed flushes from stale seedbeds, or natural regeneration, may encourage such infections.

Environment
Conservation headlands with reduced levels of weed control can help to improve biodiversity in field margins. Residual weed populations in crops provide food for farmland birds, mammals and invertebrates. Herbicide use or drift in crop margins can reduce floral diversity of hedgerow species and promote aggressive weeds, eg cleaners and sterile brome.
Mechanical weeding at critical times may kill nesting birds and soil surface dwelling invertebrates. Avoid weeding: between mid-April and mid-July for Skylarks; from late-March onwards for Lapwings.

Residual weeds in the base of a crop up to harvest may have little direct impact on the standing crop but may encourage slugs to breed before following crop establishment.

Nutrition
High N levels as residual soil fertility or applied fertiliser can change the weed spectrum by allowing competitive and aggressive weeds, eg cleaners, to proliferate.
Weeds may also take up applied N in spring and therefore be more difficult to control, while the crop itself is N-starved.

Pests
Weeds provide food and shelter for natural enemies, eg beetles, which may eat crop pests. Volunteer crop weeds may act as a ‘green bridge’ between susceptible crops for aphids and potato cyst nematode.

Benefit
- More effective use of herbicides.
- Reduced risk of herbicide resistance.
- Reduced costs.
- Reduced costs.
- Less risk of herbicide leaching.
- Improved plant and animal biodiversity.
- Improved biodiversity in margins.

Action/key issue
- Plan rotational strategy to take weed control into account.
- Use cultural control where appropriate.
- Consider leaving residual levels of non-aggressive weeds in crops for benefit to wildlife.
- Consider establishing conservation headlands managed to keep aggressive weeds under control.
**6 PESTS**

**Principles**
In natural ecosystems, plant pests and predators reach a balance. Pest control decisions can impact across the whole farm as crops are large areas of a single plant species and provide ideal conditions for pests to proliferate with minimal natural challenge. Insecticides kill pests but if inappropriately chosen may also harm natural enemies. Improved habitats for beneficial species may enhance natural biological control and reduce the need for insecticides.

**‘Ideal’ pest management**
Cultural control uses rotation, variety, sowing date and seed-rate to avoid pests or minimise their effects. It encourages beneficial predators and parasites living in field margins, conservation headlands and specially created ‘beetle banks’. All these help reduce chemical control needs.

Chemical control is secondary. Decisions, wherever possible, are based on thresholds (see pages 24 and 25); prophylactic treatments are avoided. Products with minimal environmental impact are chosen and reduced rates used appropriately.

**Potential problems**
BYDV, carried by aphids, can seriously reduce winter wheat and barley yields. Thus omitting an autumn treatment is vital. Sampling during critical pest attack periods. Is natural biological control key to an integrated strategy?

**Interactions**

**Rotation**
Crop rotation is crucial to prevent carry-over of pests, especially nematodes. Crop distribution can exacerbate pest problems, especially if vulnerable crops are planted adjacent to the previous year’s vulnerable crop — many pests can fly and walk.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Susceptible crops</th>
<th>Suggested intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>potato cyst nematode</td>
<td>potatoes</td>
<td>no PCN – 4 to 7 years PCN infested – 6 to 13 years</td>
</tr>
<tr>
<td>beet cyst nematode</td>
<td>sugar beet, fodder beet, field brassica, oilseed rape</td>
<td>&gt; 2 years for sugar beet</td>
</tr>
<tr>
<td>stem nematode</td>
<td>oats, rye, sugar beet, beans, peas, red clover</td>
<td>&gt; 2 years, longer for red clover</td>
</tr>
</tbody>
</table>

**Soils**
Slugs and the aphid vectors of BYDV are the most troublesome pests associated with soil management. Often lower BYDV levels occur in minimal cultivation, rather than plough-based, systems.

Surface residues which reduce the contrast between seedlings and soil background may prevent aphids recognising host plants and encourage larger numbers of predatory beetles and spiders. This reduces aphid survival and secondary virus spread at the critical early crop establishment phase.

Slugs damage, irrespective of cultivation system, is normally minimised by deeper sowing of cereals (4 cm), consolidation and destroying green matter pre-drilling. However, treatments need to take account of how a crop is established.

Cultivation timing interacts with the egglaying phases of frit fly after grass and leatherjackets.

**Establishment**

Varietal resistance to pests can enhance control of soil-borne pests, eg PCN, where control is difficult even with pesticide treatments. Some wheat varieties which tiller well can help where wheat bulk fly risk is high.

Sowing date can delay infestation by certain pests, eg later sowing of autumn cereals avoids BYDV aphid vectors. In contrast, early sowing may encourage more vigorous crop growth to withstand attack from slugs or wheat bulk fly.

In high risk situations seed-rates may be increased to cope with slug grazing and plant removal.

**Nutrition**
Crops with high nitrogen content may suffer more from aphid feeding, which reduces yield and quality.

Natural regeneration, used as a cover crop to prevent aphid feeding, which reduces yield and quality.

**Soils**
Suggested intervals between untreated pest-susceptible crops

**Action/key issue**
- Plan rotation to minimise pest problems.
- Use pest resistant varieties if available.
- Identify crops at risk by forecasting, sampling, monitoring or trapping and use thresholds.
- Use a narrow-spectrum pesticide where possible.
- Encourage beneficial enemies, eg improve field margin areas and set-aside strips.

**Benefit**
- Maximised yields.
- Reduced pesticide inputs and lower costs.
- Reduced risk of environmental impact.
- Reduced pesticide inputs and lower costs.
- Reduced risk for non-target species.
- Increased insect biodiversity and natural biological control.

**Weeds**
Volunteer crop control will reduce the potential for pests, eg PCN, to multiply between susceptible crops. Volunteer plants may act as sources of plant viruses, which can be spread by pest vectors.

Some weeds left within a crop are beneficial for insect biodiversity. High predator and parasite numbers may reduce the need for pesticides.

**Diseases**
Pests may subsequently lead to higher disease levels, eg fungi may colonise plant tissue damaged by pests. Also, excretions from pests may provide food sources for moults to develop, eg honeydew from grain aphids can increase sooty mould levels on grain ears and impair quality.

**Environment**
Using broad-spectrum insecticides, nematicides and molluscicides can harm non-target species which provide natural biological control of crop pests, or food for farmland birds.

Improved areas for wildlife, eg field margins, hedgerows, beetle banks and conservation headlands, can increase biodiversity of insect and bird species.
## 6 PESTS

### Integrated pest management involves using thresholds intelligently as the basis for control strategies.

<table>
<thead>
<tr>
<th>Crop and pest</th>
<th>Threshold</th>
<th>Treatment strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cereals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autumn aphids</td>
<td>High risk of aphids and BYDV forecast. Aphids in crop in late Oct/early Nov.</td>
<td>Delay drilling until mid-Oct. Destroy previous crop residues to remove 'green bridge'. Apply spray treatments 5-6 weeks after crop emergence if mean daily temperatures &lt; 9°C and remain low sprays may not be required.</td>
</tr>
<tr>
<td>Summer aphids</td>
<td>&gt; 50% stems infested and increasing at stem extension to flag leaf emergence. 60% of ears/stems infested and increasing at flowering to waxy ripe.</td>
<td>Use half-rate selective insecticide if threshold is exceeded, parasitoid activity is low and &lt; 2% aphids are mummified. Do not treat if &gt; 5% are mummified.</td>
</tr>
<tr>
<td>Wheat bulb fly</td>
<td>Millions of eggs/ha &lt; 1 - no action. 1-2.5 - damage possible on late-sown crops. 2.5-5 - economic damage very likely. &gt; 5 - damage inevitable.</td>
<td>Do not cultivate fields due for wheat from late July to end of wheat harvest. Increase seed rate and choose variety more suited to high-risk situations. Use seed treatment or egg hatch spray if necessary. Consolidate soils after earlier cultivation to avoid rough till.</td>
</tr>
<tr>
<td>Orange wheat blossom midge</td>
<td>Coconuts/kg soil 11-40 - moderate risk.  &gt; 40 - high risk.</td>
<td>Monitor at ear emergence if risk is high - soil is wet and &gt; 1°C in May. Consider an insecticide at ear emergence if threshold is exceeded.</td>
</tr>
<tr>
<td>Frit fly</td>
<td>&gt; 10% of plants attacked at 1-2 leaf stage (wheat after grass).</td>
<td>Destroy grass or grass weed infested stubbles at least 6 weeks before drilling. Only apply insecticide at 1-2 leaf stage if threshold is exceeded.</td>
</tr>
<tr>
<td>Leatherjackets</td>
<td>5 leatherjackets/m of row – highest risk with spring cereals but only when drilled after ploughed out grass.</td>
<td>Monitor susceptible crops soon after grass for first month after crop emergence.</td>
</tr>
<tr>
<td>Oilseed rape</td>
<td>5 larvae/plant/row/twenty 50 or 50% petioles scarred. Damage by adults is most severe on slow-emerging or poorly established crops.</td>
<td>Only apply treatment if adult damage is very severe at the cotyledon stage, and/or threshold is exceeded later in autumn.</td>
</tr>
<tr>
<td>Cabbage stem flea beetle</td>
<td>5 larvae/plant/kvadrich or 50 petioles scarred. Damage by adults is most severe on slow-emerging or poorly established crops.</td>
<td>Only apply treatment if adult damage is very severe at the cotyledon stage, and/or threshold is exceeded later in autumn.</td>
</tr>
<tr>
<td>Pollen beetle</td>
<td>Beetles/plant 15 at green/yellow bud stage on winter crops. 5 on slow-growing, backward crops, restored hybrids and varietal associations. 3 on spring crops.</td>
<td>Apply pyrethroid insecticide if threshold is exceeded.</td>
</tr>
<tr>
<td>Cabbage seed weevil</td>
<td>Weevils/plant 2 - during flowering on winter crops. 1 - in northern England and Scotland. 0.5 - in the north if a fungicide required or significant pod damage likely. 2 - at any time from green bud to late flowering on spring crops.</td>
<td>Apply a pyrethroid at the correct timing if threshold is exceeded.</td>
</tr>
<tr>
<td><strong>Peas and beans</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pea &amp; bean weevil</td>
<td>Damage most likely on spring beans, less on winter beans and peas. How emerging crops are particularly susceptible.</td>
<td>Only treat with an approved pyrethroid if leaf-notching is severe and growing points are attacked.</td>
</tr>
<tr>
<td>Pea aphid</td>
<td>20-30% of shoots infested between first flower and pod-set on 4th. truss (combining peas).</td>
<td>Apply a single pirimicarb spray if threshold is exceeded. Take numbers of natural enemies into account.</td>
</tr>
<tr>
<td>Black bean aphid</td>
<td>5% plants infested on south-west headlands pre-flowering. 2.5% of plants infested across whole field, and colonies spreading to pods.</td>
<td>Treat spring beans with pirimicarb if above threshold pre-flowering. From flowering onwards treatment is only required if colonies are so large as to spread down stems and onto pods. Do not treat winter beans.</td>
</tr>
<tr>
<td>Pea moth</td>
<td>&gt; 10 moths in one of a pair of pheromone traps on two consecutive occasions.</td>
<td>Apply an approved pyrethroid spray if threshold is exceeded (combining peas for seed or ware for human food).</td>
</tr>
<tr>
<td><strong>Potatoes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato cyst nematode (PCN)</td>
<td>Eggs/g soil 1-30 - no treatment.  &gt; 5-8 - treat intolerant varieties. 11-60 - treat all varieties. &gt; 60 eggs/g – treatment essential and significant yield loss is still likely.</td>
<td>Ensure crop is well-fertilised and watered to limit damage. Apply full-rate nematicide to crops where threshold is exceeded, even to PCN-resistant varieties.</td>
</tr>
<tr>
<td>Potato aphids</td>
<td>Seed crops: zero tolerance. Ware crops: no threshold as crops generally tolerate infestation provided no false top-roll occurs.</td>
<td>Seed crops: apply routine treatment programme from 80% crop emergence. Ware crops: monitor varieties prone to false top-roll and treat with pirimicarb if rapid increase in aphid numbers. Treat other varieties if &gt; 30 aphids/leaf.</td>
</tr>
<tr>
<td><strong>Sugar beet</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peach potato aphid</td>
<td>Aphids/plant 0.25 - plants with &lt; 12 leaves. 1 - plants with &gt; 12 leaves.</td>
<td>Use combination of seed treatment, granular insecticides/nematicides at planting and foliar sprays (usually pirimicarb). Do not treat plants with &gt; 14 leaves.</td>
</tr>
<tr>
<td>Black bean aphid</td>
<td>&gt; 25% of plants infested and colonies increasing.</td>
<td>Use combination of seed treatment, granular insecticides/nematicides at planting and foliar sprays (usually pirimicarb). Do not treat plants with &gt; 14 leaves.</td>
</tr>
<tr>
<td>Free-living nematicodes</td>
<td>200 nematodes/litre of soil can be damaging. Mainly a problem on light sandy soils and in a cool, wet spring.</td>
<td>Analyse soils for nematodes. Apply nematicide if levels are sufficiently high.</td>
</tr>
<tr>
<td><strong>All crops</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs</td>
<td>Higher risk on heavy soils with surface trash, especially if direct drilling. Thresholds are difficult with slugs. For cereals pre-drilling catches of 4 or more slug/crop over 3 days indicate a high risk of damage.</td>
<td>Use baited traps to monitor slugs. Ensure good drilling conditions. Roll seedbeds. Test bait susceptible potato varieties in wet seasons. Apply molluscicides when slugs are active. Consider using metaldehyde.</td>
</tr>
</tbody>
</table>

Source: Dr Bill Parlowe, ADAS Wrington.
Principles
Complete disease control may not be justified to maximise margins. Cultural measures, eg rotation, variety choice, nitrogen and seed rate, as well as chemical control using fungicides, all play a part. The wheat disease management guide, HGCA (2000) provides useful information on optimising disease control through timing, dose and product choice.

‘Ideal’ disease management
Chemical control is secondary to cultural options, especially variety, rotation and general crop hygiene. Fungicides are believed to be relatively benign in the environment. However, there is scope to minimise use and save costs, eg by using threshold and forecasting information, reducing doses and omitting sprays. Doses can often be adjusted to take account of varietal resistance. Routinely monitoring crop and weather conditions and disease risk improves decision-making.

Potential problems
In some years, weather changes result in ‘explosive’ diseases, putting crops with limited protection at greater risk. This most often applies to stem-base diseases and Septoria tritici because spray decisions are taken when there is little visible evidence of the disease. Such potential risks must be included in disease control decisions.

Prophylactic use of fungicides is still required for control of potato blight but opportunities to reduce doses and extend spray intervals can be taken in the right conditions.

Some practical suggestions
- Choose varieties with care, taking most account of resistance to diseases prevalent in your area.
- Exploit varietal resistance in different ‘diversification groups’.
- Apply other cultural control measures where appropriate.
- Adjust fungicide dose to variety resistance.
- Use prediction systems, forecasts, in-crop monitors and decision support systems where appropriate.
- Plan fungicide strategy and adjust to meet current risk and conditions.

7 DISEASES

Interactions

Rotation
Crop rotation is very important. It helps to prevent disease build-up or carry-over between crops, especially for trash-borne diseases, eg take-all, Sclerotinia, clubroot, potato blight, powdery scab and some virus diseases. Ensuring appropriate intervals between crops helps to minimise problems.

Suggested intervals between disease-susceptible crops

<table>
<thead>
<tr>
<th>Disease</th>
<th>Susceptible crops</th>
<th>Suggested interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>take-all</td>
<td>wheat, barley</td>
<td>minimum 1 year</td>
</tr>
<tr>
<td>Sclerotinia</td>
<td>oilseed rape, field brassicas, spring beans, peas, potatoes, sugar beet, carrots, celery</td>
<td>4 years</td>
</tr>
<tr>
<td>clubroot</td>
<td>oilseed rape, other brassica crops</td>
<td>8 years</td>
</tr>
<tr>
<td>stem canker</td>
<td>potatoes</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>black scurf</td>
<td>potatoes</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>powdery scab</td>
<td>potatoes</td>
<td>&gt; 9 years</td>
</tr>
<tr>
<td>foot rot</td>
<td>peas, beans, oilseed rape</td>
<td>4 years</td>
</tr>
</tbody>
</table>

Establishment
In many crops, variety choice is vital to minimise disease risk.

Autumn crops are usually sown early to minimise the likelihood of adverse weather delaying whole-farm drilling plans. Early sowing of cereals and winter oilseed rape can increase the risk of autumn disease and subsequent management may have to be altered as a result.

Lower seed rates and altered cultivation techniques can reduce some risks. Sowing cereals later (mid-October) reduces take-all threat. Disease risks need to be balanced against other benefits and drawbacks from early sowing.

In spring crops, earlier sowing may reduce risk of mildew and BYDV. However, it may increase the threat of Rhychosporium.

High seed-rates produce dense populations which can exacerbate disease problems.

Nutrition
High N applications make crops more disease-susceptible.

Higher humidity at soil level in lush, dense crops increases risks from stem-base diseases.

In winter barley and oats, delaying the main N top dressing until April or May, respectively, may reduce foliar disease severity sufficiently for effective control with a single fungicide spray. For other crops, N amount rather than timing has most impact on disease severity.

Higher N rates may be needed where take-all threatens cereals, and if strobilurin fungicides are used on cereals.

Soils
Generally, soil management does not directly affect disease. However, well-established crops with good root systems are least affected by diseases, provided growth is not too dense. Trash-borne diseases may spread from crop residues left on the soil surface to newly-emerged susceptible crops.

Action/key issue
- Plan the rotation to minimise disease problems.
- Use disease-resistant varieties for the most prevalent diseases in the locality.
- Use the appropriate dose for the target disease, variety and weather conditions.
- Avoid early-sown, lush dense crops.
- Maintain good inter-crop hygiene.

Benefit
- Maximised yields.
- Lower fungicide inputs and costs.
- Lower fungicide inputs and costs.
- Lower fungicide inputs and costs.
- Prevent disease carry-over from crop to crop.

Environment
Most fungicides have a low environmental impact, although some active ingredients, eg MBCs, may adversely affect earthworms, and should be avoided if possible.

Weeds
Green weeds in the base of crops may influence the microclimate and lead to increased stem-base disease problems.

Crop volunteers may act as a focus for disease spread between susceptible crops, eg potato blight, or act as a ‘green bridge’ for diseases like mildew, take-all, eyespot and BYDV. Problems may occur due to stale seedbed weed flushes, or natural regeneration left as cover crops.

Pests
Interactions between disease and pest management focus on control of virus vectors, such as nematodes and aphids, as well as control of sap-feeding pests, eg aphids, which can lead to sooty moulds on cereals. Good pest control through cultural or chemical means will reduce secondary disease incidence.

7 DISEASES
### 7 Diseases

#### Crop and Disease Occurrence Threshold Treatment Strategy

**Wheat**
- **Take-all**
  - Associated with light, alkaline soils.
  - None
  - Consider seed treatment if growing consecutive wheat crops. Apply N early in spring to stimulate root growth and N uptake. Choose early developing varieties; these will suffer less yield loss.
- **Seed-borne diseases**
  - Treat seed if testing reveals 5% or more [Fusarium or one bunt spore/seed].
  - Seed treatment is generally routinely applied to seed, although disease incidence is low. For non-seed crops, there is scope to treat according to need if seed is tested.
- **Eyespot**
  - Favoured by long periods of cool, wet weather, and intensive cereals.
  - Assess at least 25 tillers/field from GS 31 to GS 37.
  - 25% of tillers with lesions penetrating beyond outer leaf sheath.
  - Apply fungicide if threshold reached and risk is high.
- **Foliar diseases**
  - Treat seed if testing reveals more than 2% leaf tissue.
  - Seed treatment is generally routinely applied to seed, although disease incidence is low. For non-seed crops, there is scope to treat according to need if seed is tested.

**Barley**
- **Seed-borne diseases**
  - Treat seed if testing reveals more than 2% leaf stripe or 0.5% loose smut.
  - Seed treatment is generally routinely applied to seed, although disease incidence is low. For non-seed crops, there is scope to treat according to need if seed is tested.
- **Eyespot**
  - Favoured by long periods of cool, wet weather, and intensive cereals.
  - Assess at least 25 tillers/field from GS 31 to GS 37.
  - 25% of tillers with lesions penetrating beyond outer leaf sheath.
  - Apply fungicide if threshold reached and risk is high.
- **Mildew**
  - Favoured by cool, wet weather. Attacks after GS 37 most damaging.
  - Winter barley: Autumn – 3% leaf area of lower leaves affected.
  - Spring – disease on new spring growth.
  - Summer – disease on top 3 leaves before ear emergence.
  - Spring barley: When disease first seen or becomes obvious on top three green leaves before GS 45.
  - Monitor disease levels regularly. Spray if threshold reached.
- **Rhyzochorium**
  - Favoured by warm weather. Lush, rapidly growing plants with high levels of N are particularly susceptible.
  - Winter barley: Autumn – 10% lower leaves affected.
  - Spring – present on lower leaves.
  - Summer – present on any of top 3 leaves up to GS 59.
  - Spring barley: Disease on susceptible varieties, or on any of top 3 leaves up to GS 59 on others.
  - Combine treatments with mildew control if required.
- **Net blotch**
  - Disease favoured by wet weather.
  - Winter barley: Autumn – 10% plus of lower leaves affected.
  - Spring – up to GS 31 if disease readily found between GS 37 & 69 if disease on top 3 leaves.
  - Spring barley: Rarely a problem.
  - Combine treatment with control for other diseases if needed.
- **Oats**
  - Crown rust
    - Favoured by warm moist weather. Rarely develops until late in season.
    - At first sign of rust pustules after GS 30.
    - Consider fungicide if disease is found before GS 50 up to GS 75.
    - Apply a fungicide up to GS 45 (boots swollen). If disease present at time of herbicide application tank mix fungicide.
  - Mildew
    - Favoured by warm dry weather. Severe attacks occur mainly late May to June.
    - None
    - Apply a fungicide up to GS 45 (boots swollen). If disease present at time of herbicide application tank mix fungicide.

**Oilseed rape**
- **Phoma leaf spot**
  - Favoured by carry-over from previous crop in stubbles and trash.
  - 10-20% of plants with leaf spots after crop emergence (monitor crops weekly).
  - Apply fungicide if threshold reached. Consider second spray 6-8 weeks later if spotting reappears.
- **Light leaf spot**
  - Favoured by carry-over from previous crop in stubbles and trash.
  - Autumn – disease present.
  - Spring – 25% plants affected at early stem extension.
  - Apply fungicide in autumn/winter if disease found. Apply at threshold.
- **Sclerotinia**
  - Risk based on previous experience and petal testing at early mid and late flowering.
  - More than 50% petals infected in wet conditions.
  - Apply fungicide if threshold is reached and conditions are wet and warm.
- **Alternaria**
  - Disease on pods up to 3 weeks after flowering.
  - Treat if disease spreads to pods if no Sclerotinia treatment applied.

**Beans**
- **Chocolate spot**
  - Mainly affects winter beans.
  - Spotting on lower leaves during flowering.
  - Apply 2-spray programme, early and late flowering if disease actively spreading.
  - Aim to keep leaves on fertile nodes healthy.
- **Dowry mildew**
  - Favoured by warm, humid conditions. Mainly on spring beans.
  - Active patches on leaves before and during flowering.
  - Use 2-spray programme if disease actively spreading.
- **Rust**
  - Favoured by prolonged high temperatures.
  - If disease actively developing during flowering.
  - Apply fungicide if weather favourable for disease.
- **Peas**
  - **Aphanomyces root rot**
    - Occurs mainly in poorly drained or compacted soils.
    - Builds up in short rotations (less than 5 years).
    - No threshold.
    - Soil test potential vining pea sites.
  - **Ascochyta complex foot rots**
    - No threshold.
    - Use certified seed or tested home-saved seed. Treat seed if problems with foot rots expected.
  - **Botrytis pod rot**
    - Wet conditions during pod set.
    - No threshold.
    - Apply protectant fungicide when first pods appear if wet during flowering.
  - **Leaf and pod spot**
    - Wet conditions during pod set.
    - No threshold.
    - Apply protectant fungicide 14 days after first pods seen if wet during flowering.

**Potatoes**
- **Blight**
  - Treatment strategies depend on locality, risk and level of infection. Potato dumps and volunteers pose high risk to nearby crops.
  - No threshold. Monitor crops routinely.
  - Monitor forecasting systems for disease incidence and spread. Use in-crop monitors to determine blight risk. Consider first precautionary fungicide when tops meet in the row but before they meet across rows. Maintain programme thereafter – extend interval between sprays if low risk; reduce interval if high risk.
- **Sugar beet**
  - **Powdery mildew and rust**
    - No threshold.
    - Treat within a week of first symptoms appearing. If both diseases present apply combined treatment, eg sulphur for powdery mildew, triazole for rust.
8 ENVIRONMENT

Principles
The productive farm unit is sustainable and profitable over the longer term, whilst contributing to overall wildlife and landscape diversity. Non-cropped land and a diverse rotation provide food and breeding areas for beneficial insects and farmland birds. Earthworms and many arthropods, eg ladybirds, spiders and parasitic wasps are beneficial to crops because they improve the soil or eat pest species. Habitats for plant or animal species may be found in both non-cropped and cropped areas, without necessarily compromising productive capacity.

‘Ideal’ environmental management
Environmental management can bring real benefits through improved biodiversity and pest control, eg field margins and ‘beetle banks’. In contrast, flooding environmental regulations, such as LERAPS, can carry serious financial and ecological penalties. Headlands, non-cropped areas or woodlands attract grants, making such land use financially viable. Greater public use of the countryside for recreation may pay dividends in increasing long-term mutual understanding. Increasing public access will increase the need to demonstrate farmers’ environmental awareness.

Potential problems
Initially, management demand will be high on establishing environmental features, such as hedgerows, margins, ‘beetle banks’ or farm woodlands. This need diminishes with time. More record taking, field walking and sampling are also needed to allow greater use of thresholds in pest and disease control.

Some practical suggestions
- Seek information on environmental improvement grants (page 35).
- Take all income sources into account in assessing farm budgets, setting environmental grants against crop revenue foregone.
- Set up an environmental land management plan for the farm and target areas for improvement.
- Use a mix of rotation and wild bird cover for maximum wildlife benefit on set-aside.

Interactions

Rotation
Crop choice has far more impact on beetle and spider numbers than any pesticide input. Over-winter stubbles are important for farmland birds. Spring-sown crops favour some invertebrates less due to shorter cropping periods. Set-aside options provide nesting and feeding sites for birds. Potatoes generally benefit wildlife less than cereals. Soil disturbance at planting and lifting increases erosion risk. Root crops often need more pesticides.

Soils
Minimum cultivation systems create improved habitats for several bird species and encourage earthworms and beneficial soil fauna. Reduced soil erosion helps to improve water quality and avoids run-off pollution.

Nutrition
Careful nitrogen placement to avoid non-cropped areas helps prevent aggressive arable weeds invading crops from margins. Nutrients in field boundaries reduce biodiversity. Nutrient run-off into controlled waters is reduced. Organic manures encourage soil biodiversity and release nutrients slowly.

Weeds
Residual levels of certain non-aggressive weeds in crops and stubbles benefit biodiversity. They provide food sources for farmland birds, small mammals and invertebrates. Herbicide use, especially in crop margins, reduces hedgerow diversity and encourages aggressive crop weeds. These problems are minimised if conservation headlands are established wherever possible. Mechanical weeding can reduce herbicide use but can harm nesting birds, mammals and invertebrates at critical times.

Pests
Selective pesticides, avoidance of treating non-cropped areas and use of conservation headlands can help reduce potential negative effects on wildlife and the environment.

Food for farmland birds

Skylark
Adults: seeds and shoots of many weeds and crops especially cereals, grasses, docks, knotgrass and fat-hen; insects in the diet include larvae, beetles, ants, aphids, grasshoppers and spiders.

Grey partridge
Adults: grasses, cereal shoots, seeds of wide variety of weed species, especially knotgrass, black bindweed, common hemp nettle and chickweed.

Linnet
Adults: predominantly seed eaters, especially oilseed rape, charlock, chickweed, fat hen, thistle and dandelion.

Tree sparrow
Adults: mainly seed eaters, including goosefoot, knotgrass, bedstraw, chickweed, plantains, nettles, some grasses and cereals; insects include grasshoppers, caterpillars, aphids, flies, ants, beetles and spiders.

Chicks: completely depend on insects in first week, especially sawfly larvae.

Chicks: feed entirely on seeds.

Chicks: entirely depend on insects for the first week, including beetles, aphids, caterpillars and flies.

Action/key issue

- Increase and improve the non-cropped areas.
- Maximize the benefit of set-aside.
- Diversify the crop rotation.
- Manage the soil to increase earthworm numbers.
- Consider retaining some weeds in arable crops.
- Improve field margins.
- Establish conservation headlands.

Benefit

- Reduced inputs and costs.
- Increased payments for environmental measures.
- Enhanced landscape and more varied wildlife habitats.
- Increased biodiversity.
- Enhanced public image.
- Improved drainage, soil workability, faster and cheaper soil cultivations, and better crops.
- Improved breakdown of crop residues.
- Greater biodiversity. More farmland birds.
- Increased biodiversity.
- Protection of watercourses.
CASE STUDIES

In practice a detailed study is required to understand your current system of farming and to identify those areas and enterprises which will benefit from an integrated approach. Factors to be considered include: the physical nature of the farm, soil types, location and aspect; pollution risk, cropping pressures, especially disease and weed burdens; business resources, particularly labour and machinery; and market opportunities.

Case 1: Arable farm on heavy land in eastern England

Strengths
- Good moisture-retaining soil.
- High P&K indices.
- Potential for consistently high yields.
- Soil erosion not normally a problem.
- Stable soil structure is good for earthworms.
- Responds well to minimal cultivations.

Weaknesses
- Soil structure easily damaged in wet conditions.
- Narrow window for fieldwork.
- High energy demand for cultivations.
- Hard-to-control grass weeds usually present.
- Potential for herbicides to contaminate surface water.
- Suitable crop choice can be limited.
- Monocropping increases disease pressure.
- Intensive cropping limits biodiversity.

Opportunities

Cropping
- Extended rotations allow cultural control of difficult weeds.
- Diverse range of crops reduces disease pressure.
- Heavy land is suited to minimal cultivations provided grass weeds are controlled.

Environmental
- Beetle banks and field margins encourage beneficial invertebrates.
- More invertebrates encourage birds and enhance biodiversity.
- Minimal cultivations encourage earthworm populations.

Financial
- Minimal cultivations reduce energy demand.
- Diverse cropping reduces peak workloads and demands for labour, power and machinery.
- Set-aside and conservation headlands avoid wasted inputs on poor yielding areas.
- Payments available for environmental improvements.

Case 2: Mixed farm on medium soils in western England

Strengths
- Easily workable, well-drained soil.
- Soils suit wider range of crop enterprises, including spring combinable and root crops.
- Cultivation windows less restricted.
- Smaller fields have more field boundaries for environmental benefits.
- Livestock enterprises aid soil fertility.
- Grass weeds less of a problem in mixed rotations.
- Higher soil organic matter enhances stability, structure and fertility as well as earthworms and other soil organisms.

Weaknesses
- Higher rainfall leads to soil erosion and run-off of sediment, phosphate and pesticides, especially on newly cultivated land or after potatoes.
- Soil nitrogen and pesticides more susceptible to run-off.
- Higher soil organic matter enhances stability, structure and fertility as well as earthworms and other soil organisms.

Opportunities

Cropping
- Contour cultivations and buffer areas reduce risk of surface run-off.
- Careful N planning reduces risk of leaching and run-off.
- Minimal cultivations and cover crops reduce risk of run-off and erosion.
- Resistant cultivars reduce disease risk.
- Forecasing BYDV and blight risks can help input planning.

Environmental
- Mixed cropping enhances biodiversity.
- Over-winter stubbles encourage bird populations.
- Diverse habitats encourage beneficial predators and parasites of crop pests and wildlife in general.

Financial
- High value root crops can enhance overall output from rotation.
- Animal manures and legumes reduce artificial fertiliser inputs.
- Spring crops spread workload peaks.
- Diverse cropping helps reduce need for pesticide inputs.
- Payments available for environmental improvements.

Action/key issue
- Assess key strengths and weaknesses of farm business. Take account of weather, soils, cropping options and markets.

Benefit
- Realistic assessment of crop and environment options.
- Plan a rotation, which builds on strengths but minimises or ameliorates weaknesses.
- Calculate potential income from the rotation over a 5-year period, assuming best and worst case scenarios, and taking account of agricultural and environmental policy.
- Respond where necessary to changing needs without jeopardising overall farm profitability.
- Maximise rotation output, whilst removing constraints on productivity in some areas.
- Sound financial planning, albeit based on limited information on prices, area payments and environmental payments.
- Continuing sustainability of farming system.
The wheat growth guide

The LEAF handbook for Integrated Farm

Integrated crop management
A guide to managing crop establishment

Biological framework for

Pesticides and integrated farming

Introductory guide to malting barley

Guidelines for the management of field margins,

Other publications

Variety handbooks, NIAB (2000) various.


Managing livestock manures, booklets 1, 2 and 3, MAFF (1998) free.


Codes of good agricultural practice for air, soil and water, MAFF (1999) free.
Local environmental risk assessments for pesticides, a practical guide, MAFF (1999) free.
Pesticides and integrated farming, MAFF (1996) free.

Horticultural crops (RB209)


Food for thought – sustainable food production


Research and demonstration projects in the Integrated Arable Crop Production Alliance

LIFE (Less Intensive Farming and the Environment)
Based at IACR Long Ashton Research Station on 25 ha, also previously on two pilot farms in south-west England. This project, begun in 1990, is now in its second rotation. Funding: DEFRA (formerly MAFF) and the EU.

Contact: David Glen, IACR Long Ashton

LINK IFS (Integrated Farming Systems) Based on six sites in Hampshire (Manydown), Cambridgeshire (Boxworth and Sacrewell), Herefordshire (Lower Hope), Yorkshire (High Mowthorpe) and Midlothian (Pathhead), on approximately 50 ha on each farm. This project began in 1992 and field work was completed in 1997.

Contact: DEFRA, SEERAD, HGCA and Syngenta. Contact: Sue Ogilvy, ADAS High Mowthorpe

RPMS (Rhône-Poulenc Farm Management Study)
A long-term study, begun in 1994 on 57 ha in Essex, comparing integrated and conventional farming, alongside organic farming.

Contact: Steve Higginbotham, Aventis CropScience

BEAM (Balancing Environment and Agriculture in the Marches)
This five year project began in 1996 on a 285 ha mixed farm in North Herefordshire. Management of the three major enterprises – arable, sheep and beef - is integrated alongside management of landscape and environment. Business performance is monitored, as are environment and biodiversity improvements.

Funding: DEFRA and EU Objective 5b.

Summary of benefits from environmental management

<table>
<thead>
<tr>
<th>Feature</th>
<th>Birds</th>
<th>Beetles/spiders</th>
<th>Plants/Flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margins up to 10m wide</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Margins 20m or more wide</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Beetle banks</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Hedge restoration</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Ditch maintenance</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Over winter stubbles</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Conservation headlands (with restricted crop inputs)</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>Wildlife seed mixtures</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
</tbody>
</table>

*NB: Payment rates vary, including annual management or one-off capital sums. Certain options are available under the Arable Area Payments Scheme (AAP). Other options are included in the Countryside Stewardship Scheme (CSS) which will be widened (subject to EC approval) to include options previously available under the Arable Stewardship Scheme (ASS). For up-to-date information see www.defra.gov.uk or local offices or your conservation advisor.


Contact: Richard Laverick, ADAS Rosemaund

FOPD (Focus on Farming Practice)
A seven-year evaluation of integrated vs conventional farming on 60 ha on a commercial CWS farm in Leicestershire which began in 1993.

Funding: CWS Agriculture, Agrovista and Hydro Agri.

Contact: Peter Thompsoon, CWSAgriculture

LEAF (Linking Environment And Farming)
Launched in 1991, LEAF is at the forefront in promoting Integrated Farm Management. A network of LEAF demonstration farms throughout the UK shows IFM in practice and encourages farmers to become involved through membership and the LEAF audit.

Funding: Over 100 industry bodies and more than 1500 farmers.

Contact: Caroline Drummond, LEAF

TIBRE (Targeted Inputs for a Better Rural Environment)
An initiative developed by Scottish Natural Heritage concentrates on promoting and encouraging use of technologies to reduce the environmental impact of farming practices, whilst maintaining profitability but without significantly increasing management input.

Contact: Daniel Gots, Scottish Natural Heritage

FWAG (Farming and Wildlife Advisory Group)
FWAG promotes wildlife and landscape conservation on commercial farms throughout the UK. Practical advice on conservation issues is delivered through the Landwise whole farm reporting system.

Contact: Richard Knight, FWAG
For information on HGCA services, please contact the appropriate department.

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