SORT OUT YOUR SOIL

A practical guide to Green Manures

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A green manure is a crop grown to improve the soil. Although they may generate a profit, in most cases their sole purpose is to benefit subsequent crops. Once grown, they are usually incorporated into the soil shortly before sowing the next cash crop.

With rising nitrogen fertiliser prices and an ever-increasing requirement to farm in an environmentally sustainable way, green manures are fast becoming a viable way to cut input costs, add fertility and improve the soil.

There is a wide variety of green manures to choose from including clovers, medicks, mustards and grasses. Legumes (such as clover) are very popular as they fix nitrogen. However other species offer benefits such as improved soil structure and weed suppression.

Green manures can be grown for widely differing periods to suit particular needs. These can vary from six weeks, for a short break in an intensive vegetable rotation, to many years as a grass ley.

Green manures have many different benefits but no one species will offer all of these. Grown as a single species, or in mixtures, the right choice of green manure depends on the aims and circumstances of each individual farmer or grower.

**What is a cover crop?**

A cover crop protects the soil, particularly over the winter. It helps insures against soil erosion, nutrient loss through leaching and competition from weeds. Within this guide, however, the term ‘green manure’ is used to encompass the benefits of cover crops as well as all the other advantages of green manures.
### WHY USE GREEN MANURES?

Green manures can be used for a whole range of reasons as their benefits are very diverse. When choosing which to grow, each farmer needs to analyse his or her specific aims and circumstances and use these to help make the right decision. The key variables include soil type, farming system, previous cropping, future cropping plans and climate.

The key benefits of green manures are:

**Nitrogen management**

**Short term soil nitrogen boost**

Fast growing green manures such as Persian clover, crimson clover and fenugreek can be grown in short breaks between cash crops to boost soil nitrogen. These annual legumes are often used in intensive horticultural systems between vegetable crops. As legumes will only fix nitrogen when the soil is above 8°C they are effective between April and August.

### Soil Improvement

**Improving soil structure**

Green manure can improve soil structure in a number of ways. Any crop which is grown then incorporated into the soil will add organic matter. This will aid soil aeration, increase water and nutrient retention (on light soils) and improve drainage (on heavy soils). Organic matter also releases acids which make some plant nutrients more readily available to the next crop.

Some green manures species are particularly good at improving problems with soil structure. Lucerne, chicory and sweet clover have a strong tap root that organic matter. This will aid soil aeration, increase water and nutrient retention (on light soils) and improve drainage (on heavy soils). Organic matter also releases acids which make some plant nutrients more readily available to the next crop.

A further advantage of green manures is that they can help prevent soil erosion. The root structure of a green manure can bind soil particles, greatly reducing the loss of top soil through wind blow or run off. In addition, a leaf canopy offers very good protection to the soil during heavy rain as it slows down the speed of water movement.

**Improving soil microbiology**

Organic matter is a food source for microbiological life which thrives in healthy, well aerated soil. When soil is low on organic matter it is more susceptible to becoming anaerobic which can lead to a build up of toxins emitted by soil microorganisms. Under the right conditions, these micro-organisms play a key role in nutrient availability and disease containment within farming systems. This is an area that is still little understood and, although green manures are undoubtedly beneficial, there is still much work to be done in quantifying this.

### Overview of green manure plants

<table>
<thead>
<tr>
<th>Green Manure</th>
<th>Plant Type</th>
<th>N potential</th>
<th>Duration</th>
<th>N release rate</th>
<th>Fix or hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Clover</td>
<td>Legume</td>
<td>Large</td>
<td>1–4 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>White Clover</td>
<td>Legume</td>
<td>Moderate</td>
<td>2–5 yrs</td>
<td>Fast</td>
<td>Fix</td>
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<tr>
<td>Yellow Tofield/Black Medick</td>
<td>Legume</td>
<td>Small</td>
<td>6–18 mths</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Persian Clover</td>
<td>Legume</td>
<td>Large</td>
<td>6–10 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Sweet Clover</td>
<td>Legume</td>
<td>Large</td>
<td>6–18 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>Legume</td>
<td>Moderate</td>
<td>6–9 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Vetch</td>
<td>Legume</td>
<td>Large</td>
<td>6–10 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Lucerne/Alfalfa</td>
<td>Legume</td>
<td>Large</td>
<td>2–4 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Legume</td>
<td>Moderate</td>
<td>3–6 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Sainfoin</td>
<td>Legume</td>
<td>Large</td>
<td>2–4 yrs</td>
<td>Fast</td>
<td>Fix</td>
</tr>
<tr>
<td>Grazing Rye</td>
<td>Cereal</td>
<td>Large</td>
<td>6 mths</td>
<td>Slow</td>
<td>Hold</td>
</tr>
<tr>
<td>Mustard</td>
<td>Brassica</td>
<td>Large</td>
<td>2–4 mths</td>
<td>Slow</td>
<td>Hold</td>
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<tr>
<td>Buckwheat</td>
<td>Polygonaceae</td>
<td>Moderate</td>
<td>4–6 mths</td>
<td>Moderate</td>
<td>Hold</td>
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<tr>
<td>Phacelia</td>
<td>Borage</td>
<td>Moderate</td>
<td>4–6 mths</td>
<td>Slow</td>
<td>Hold</td>
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<tr>
<td>Perennial Ryegrass</td>
<td>Grass</td>
<td>Moderate</td>
<td>1–5 yrs</td>
<td>Slow</td>
<td>Hold</td>
</tr>
<tr>
<td>Italian Ryegrass</td>
<td>Grass</td>
<td>Moderate</td>
<td>1–2 yrs</td>
<td>Slow</td>
<td>Hold</td>
</tr>
<tr>
<td>Westerwolds</td>
<td>Grass</td>
<td>Moderate</td>
<td>6–12 mths</td>
<td>Slow</td>
<td>Hold</td>
</tr>
<tr>
<td>Chicory</td>
<td>Composite</td>
<td>Moderate</td>
<td>1–5 yrs</td>
<td>Moderate</td>
<td>Hold</td>
</tr>
<tr>
<td>Cockshorn</td>
<td>Grass</td>
<td>Moderate</td>
<td>2–5 yrs</td>
<td>Slow</td>
<td>Hold</td>
</tr>
<tr>
<td>Red/White clover, and Ryegrass</td>
<td>Mixture</td>
<td>Large</td>
<td>1–3 yrs</td>
<td>Slow</td>
<td>Fix &amp; Hold</td>
</tr>
<tr>
<td>Rye/Vetch (or Ryegrass/Vetch)</td>
<td>Mixture</td>
<td>Large</td>
<td>6 mths</td>
<td>Slow</td>
<td>Fix &amp; Hold</td>
</tr>
<tr>
<td>Mustard, Crimson/Rad/ Persian/Sweet Clover</td>
<td>Mixture</td>
<td>Large</td>
<td>4–6 mths</td>
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<td>Fix &amp; Hold</td>
</tr>
</tbody>
</table>

### Ensuring the nitrogen needs of the next crop are met

**Winter growth**

Winter cereals, on the other hand, have a very different nitrogen requirement. Massive amounts of nitrogen released from a green manure in the autumn are not beneficial for a newly emerging cereal seedling. This would result in excess winter growth but a lack of nitrogen when the cereal really needs it in spring and early summer. In this case, a slower releasing green manure, such as a mixture of clover and grass, would be best as it would break down slowly, releasing nitrogen over a longer period.

### Legumes and Nitrogen

Nitrogen is one of the most important nutrients required for plant growth and development. Plants from the legume family can take nitrogen from the atmosphere and fix it so it becomes available for other crops. This is done through ‘nodules’ on the roots, home to nitrogen-fixing bacteria which can be seen if the plant is carefully dug up. The exploitation of legumes can help farmers make dramatic reductions in nitrogen fertiliser costs.

### Organic Matter

The decaying remains of plant and animal life form soil organic matter which contains vital nutrients such as nitrogen and phosphorus. Each year a crop uses between 2–5% of the soil’s organic matter and on many farms in the UK, especially stockless ones, levels have become seriously depleted. Nothing improves soil more than adding organic matter. Green manures are unsurpassed in this, adding both fertility and organic matter after they are incorporated. This contrasts with costly inorganic fertilisers which only contain nutrients, adding nothing to soil structure.

Green manures rich in nitrogen, such as legumes, decompose quickly whereas grasses break down more slowly and so have a longer term impact on the soil. Manipulating mixtures means nutrient release can be phased to meet the needs of the next cash crop (see page 16).
Weed, pest and disease control

Fast growing green manures are very effective at suppressing weeds. Mustards and phacelia produce good ground cover rapidly and so are excellent for this. Other species, such as red clover and Persian clover, that can be mown frequently, will also result in fewer weeds.

Allelopathy

When some green manures, including many clovers and grazing rye, are destroyed and incorporated their presence in the soil is ‘allelopathic’, preventing the germination of weed seeds in the soil. Although this is very useful for weed control, it must be managed carefully as it can also inhibit the establishment of the next crop, particularly those that are direct drilled. If drilling a cash crop next, as long as six weeks must be left between incorporation of the green manure and drilling for the allelopathic effect to subside.

Pest and disease suppression

Some mustards (caliente types see page 32) have been shown to reduce soil pests and diseases. However, for them to be effective, the conditions under which they are incorporated are critical and these are not easy to control on a farm. To attempt it, large amounts of biomass must be grown then chopped, incorporated, irrigated and covered with plastic rapidly to realise the benefits.

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Blackgrass

Blackgrass is a major issue on many arable farms. Growing a two year ryegrass or ryegrass/red clover green manure will significantly reduce this issue. As blackgrass is an annual, leaving the green manure in for two years suppresses germination of the blackgrass so reducing the population. On arable farms, using ryegrass in this way can also produce a cash crop of excellent quality hay or silage.

Silage

Many green manures can be cut for silage. As with grazing, crops for silage are most commonly grown as mixtures to give a balanced and high yielding forage (see page 16). Typical mixes include red and white clover and ryegrass. Short term, single season mixes of vetch and westermolds ryegrass are also used. Cutting time is key with clover and grass mixtures as they provide a more palatable and nutritious silage if cut before flowering.

If cutting a crop for silage some of the nutrients in the plant are, of course, exported out of the field to the clamp. This must be taken into account when calculating the benefits of the green manure. On the plus side, cutting the crop and removing the fodder will stimulate growth and more nitrogen fixation by the legumes in the mix. However, taking silage cuts will always deplete potash and phosphorus, so levels of these essential nutrients should be monitored frequently and boosted when needed.

Forage for livestock

Many green manures such as white and red clover, lucerne and sainfoin provide excellent high protein forage for livestock while also benefitting the soil.

A major advantage of using legumes in grazing swards is that they will dramatically cut the need for nitrogen fertiliser, so saving considerable input costs.

Grazing

Legumes are nearly always mixed with grasses to produce a balanced grazing sward and higher yields (see page 16). In recent years perennial ryegrass has been the most popular species, but there are many other grasses that can be included (such as timothy, cocksfoot and fescues).

As livestock have differing grazing habits, the choice of species for forage is vital. For example, sheep tend to graze close to the ground so the small and medium leaved varieties of clover are best, as they tolerate this. The higher yielding large leaved varieties can be grazed by cattle.

Bloat and Fertility

There is some risk of bloat with swards that have a very high percentage of clover, so this should be watched. Sainfoin, however, is bloat free.

Ewes should also be taken off red clover six weeks before and after tupping as the plant contains phyto-oestogens that can affect sheep fertility.

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When considering using green manures, there are many issues to think about. Some of the most important are explored below.

Why grow a green manure when a cash crop could be grown instead?
Sowing a green manure instead of a cash crop can seem like a loss of income. However, when put in the context of rising nitrogen prices, this is less clear cut. It is hard to quantify exactly how much nitrogen a green manure delivers in comparison to bagged fertiliser, especially as green manures deliver significant additional benefits in soil improvement. However, it is best to think about green manures as a long term investment in future crops, rather than a short term quick fix. The cost of growing a good green manure should be outweighed by the profitable yields of subsequent crops.

Will a green manure create extra work?
Growing a good green manure crop is more than just buying and drilling some seed. Nearly all but the shortest term species will require cutting to control weeds, stimulate growth and reduce the number of flowering and seeding heads. The amount of cutting needed will depend on the particular growing season and soil type. Where possible, using livestock to graze the crop will help reduce the need for mowing.

Won’t it be too late to sow a green manure after harvest?
Many crops, particularly horticultural ones, continue to produce well into October. This can create a dilemma: continue to harvest the crop, or turn it in and sow a green manure.
In reality, as most vegetable crops produce much more slowly towards the end of the growing season, it can often be worth sacrificing the last of the cash crop in order to get a green manure well established before winter as this will boost subsequent cash crops in the rotation.
If the cash crop is left in the soil as long as possible it is likely to be too cold afterwards to drill a leguminous green manure. However, in this situation, grazing rye is a very good option as this will establish into October and effectively prevent leaching over the winter.
As some vegetable crops, such as sweetcorn and runner beans, lend themselves to undersowing this is another very good option. The green manure can then be sown at the right time while the cash crop is still productive. In this case, it is a good idea to experiment to find the optimum sowing time for the particular farming system and green manure crop.

Will green manure management clash with work on cash crops?
Cash crops will nearly always be prioritised over green manures. During periods of peak labour, such as June in horticultural systems, it is important not to neglect green manures. Early mowing is often important for weed control in green manures and can really make the difference between a good and bad crop. This management time should be factored in when planning workloads.

Does the cost of seed justify the benefits?
The cost of green manures varies widely depending on the species and the sowing rate. Generally speaking, larger seed is sown at a higher rate, making it more expensive per acre.

When calculating the cost of a green manure, the huge saving on N fertiliser is a major factor.

Organic seed
The need to use organic seed can also increase costs. On certified farms, organic seed must be used, where available, at 100% in straights or 65% for mixtures (although this figure may change). Availability of seed can be checked on www.organicseeds.com. Organic seed is generally available for the more commonly used species such as clover and vetch, but not for the more unusual green manures such as Persian clover.

Seed Sizes
Small
All clovers, lucerne and trefoil species
Medium
Mustard, fenugreek
Large
Grazing rye, vetch, saffron
Grazing rye, a large seed, is sown at a high seed rate, making it relatively expensive to grow. However as it is by far the best species for preventing nitrogen leaching, the benefits far outweigh the costs.

WILL GREEN MANURES SUIT YOU?
When to sow

Spring or autumn are the best times to sow green manures. This is mainly to ensure there is sufficient moisture for germination. If there is enough rainfall or an irrigation system, summer planting can therefore be an option. Most legumes will not establish successfully after the beginning of September as the soil temperature will be falling quickly.

If sowing must be done late in the year, grazing rye is the best option. This establishes rapidly and is very good at preventing nitrogen leaching over the winter. It is generally a bad idea to plant other green manures late as the necessary cultivations can increase the risk of leaching.

What to grow over winter

The choice of green manure to grow over winter is usually determined by plans for the next crop. If the green manure is going to be followed by a rich cereal as a nurse crop in the early stages, it is best to choose a green manure which will prevent overwinter leaching, such as grazing rye. A legume would not be the right choice in this instance as the soil will be below 8°C for the majority of the time the green manure is in the soil, preventing nitrogen fixation.

Legumes and inoculation

It is the symbiotic relationship that legumes have with Rhizobium bacteria which results in nitrogen fixation (see page 7). The bacteria take nitrogen from the air and turn it into compounds which plants can use. This process only takes place when the soil temperature is above 8°C, so fixation generally occurs from March till September. In many species of green manure – such as red and white clover, vetch, crimson clover, Persian clover and yellow trefoil – the correct species of bacteria, Rhizobium trifolii, is already in the soil.

However, there are some species – such as lucerne, sweet clover and fenugreek – where the correct bacteria is unlikely to be present and these need to be "inoculated" with Rhizobium mellitii. This culture is bought in sachets and mixed with the seed at the time of sowing. It is a relatively simple process and only needs doing once per crop. Mowing

Mowing is an essential part of growing most green manures. It is very important in weed control, especially when the crop is young. Early mowing can make the difference between a well-established green manure and one which is persistently weedy. Most species – including red clover, white clover, lucerne, Persian clover and yellow trefoil – can tolerate being topped close to the ground to control weeds.

However, not all species of green manure can be mown. It is most likely to kill off fenugreek and vetch. Luckily both of these crops establish rapidly and compete well against weeds, making mowing unnecessary.

Incorporation

Incorporation of a green manure can be done by rotavating or ploughing. Before doing this it is generally best to cut the crop with a flail mower (which will chop up the cuttings) as this makes the job much easier. When sowing the next crop after incorporation the allelopathic effects of some crop residues should be taken into consideration (see page 9).

Early mowing can make the difference between a well-established green manure and one which is persistently weedy.

Undersowing

Undersowing is a very efficient way of ensuring that a green manure is established as quickly as possible after harvesting a cash crop. This is most commonly done with cereals, although it can work well with other crops too.

When undersowing a cereal it is best to use one of the less aggressive green manure species such as white clover or yellow trefoil. The green manure should be sown into a spring cereal when it is around 15cm high (normally around April). This technique is popular on organic farms as sowing can be combined with mechanical weeding. The green manure should establish and grow slowly before the cereal is harvested. Then, once the cash crop is removed, it will grow much more quickly.

The success of undersowing can vary with site, but in many cases undersown crops perform better than pure stands as the cereal acts as a ‘nurse’ crop, protecting the green manure in its early stages.
CHOOSING A GREEN MANURE CROP

The first stage in deciding which species or mixture to grow is to determine your aims. These will then help you make the right choice. Sowing a mixture of plants will combine the benefits each offers.

All green manures will add organic matter

**AIM:**
- Improve soil structure
- Fix N

**SOIL TYPE**

- Acid soils – most legumes do not grow well on acid soils
- Alkaline soils – sainfoin and lucerne thrive on soils with a higher pH and were traditionally grown on the chalky downs of Southern England.
- Neutral soils – most green manures thrive on soils with a neutral pH
- Free-draining soil – with this type of soil deep-rooting grasses like cocksfoot and/or tap-rooted legumes like sainfoin and red clover should be selected. Lucerne prefers a free-draining soil and will not grow under waterlogged conditions. Plentiful rainfall is fine, as long as the soil is free draining.

**AIM:**
- Improve soil & fix N
- Lift N & control weeds

**Overwinter Summer**
- Grazing rye
- Vetch
- Sweet clover
- Red clover
- Yellow trefoil
- Crimson clover
- Buckwheat
- Fenugreek
- Red clover
- Sainfoin
- Lucerne
- Sweet clover
- White clover

**1-12 months**
- 1Yr
- 1Yr plus

**Overwinter Summer**
- Mustard
- Grazing rye
- Vetch
- Sweet clover
- Persian clover
- Cockfoot
- Red clover
- Chicory
- Sweet clover
- Sainfoin
- Lucerne
- Red clover
- Vetch
- Sweet clover
- Y ellow trefoil
- Crimson clover
- Buckwheat
- Fenugreek
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- Red clover
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- Lucerne

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- Buckwheat
- Fenugreek
- Red clover
- Sainfoin
- Sweet clover
- Lucerne

**1-12 months**
- 1Yr
- 1Yr plus

**Overwinter Summer**
- Mustard
- Phacelia
- Westerwolds ryegrass
- Buckwheat
- Perennial ryegrass
- Cocksfoot
SINGLE SPECIES
OR MIXTURE?

As no one green manure species can offer every benefit, it is very common to drill a mixture. By doing this multiple advantages can be exploited simultaneously.

The strength of mixtures is most obvious with a grazing rye/vetch mix or clover/grass ley where two or more different species will grow successfully together performing quite separate functions, the legumes fixing nitrogen and the other species improving soil structure.

A mixture also offers more weed competition and removes the risk of a single species failure.

Very short term and competitive green manures like mustard or phacelia are in the ground for only a few weeks and are usually sown on their own.

LEGUMES

Crimson Clover

[Trifolium incarnatum]

N fixer, short term

Crimson clover is a short term annual grown to provide a rapid boost to soil fertility. It is commonly used for short breaks in intensive horticultural systems. It also produces a spectacular array of flowers, which is often cited as a reason for growing it.

Sowing rate: 15 kg/ha or 1.5 g/m²

Seed of crimson clover is small and should be broadcast or drilled at a shallow depth (not more than 10mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled before sowing to increase soil moisture contact with the seed.

Ideal sowing time

March – May is the ideal time for sowing in the spring. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Establishment is less likely to be reliable if sowing extends too far into September.

Suitable varieties

There is limited information on varietal performance. Contea is a commonly grown variety which gives satisfactory results.

Frost tolerance

Crimson clover does not take kindly to hard topping, so should be topped 10cm above the ground. This may limit the options for weed control.

Weed competitiveness

Once established, crimson clover rapidly produces a canopy that is effective against weed control. This canopy often recedes at the onset of flowering allowing some weed growth, and the plant then dies away once flowering is finished.

Biomass

This crop produces around 3-4t/ha of biomass, less than red clover.

Nitrogen fixing potential

It is not clear how much N is fixed but according to estimates it is between 100-150kg N/ha annually.

Persistence

There is limited information on varietal performance. Contea is a commonly grown variety which gives satisfactory results.

Frost tolerance

Being an annual, this crop is finished after flowering, so it is short lived. It has often flowered then died back by July – August.

Topping regime

Crimson clover does not take kindly to hard topping, so should be topped 10cm above the ground. This may limit the options for weed control.

Pest and disease problems

The information on pest and disease tolerance in crimson clover is limited. Its tolerance to sitona weevil and downy mildew are similar to red clover. It is not attacked by the same types of stem nematode as red clover, so can form an alternative crop in the rotation to prevent the build up of this soil pest.
Fenugreek

[Trigonella foenum-graecum]  
N fixer, very short term

Fenugreek is one of the most rapidly establishing 
green manures, and produces a quick boost to soil 
fertility in just a few months. It is not commonly 
grown but has potential to fill short breaks in 
intensive horticultural systems.

Sowing rate: 25 kg/ha or 2.5 g/m²
Seed of fenugreek is slightly larger than clover seed, so can be 
sown deeper (1cm is ideal). The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time
Fenugreek is generally sown in the spring, March – May is ideal. 
It will germinate in the summer, but frequently there is insufficient moisture in the soil. For an autumn sowing, 
August is the best time. Later sowings in September are less 
likely to establish well as the soil temperature cools.

Suitable varieties
There is limited information on varieties, with growers frequently 
just accepting what is available.

Frost tolerance
Despite being a Mediterranean crop, fenugreek will show a 
surprising resilience to hard frosts.

Weed competitiveness
Fenugreek grows extremely rapidly, so will compete well against 
weeds. It does have quite an erect growth habit, so may need 
sowing at higher rates on weedier sites to provide adequate 
ground cover.

Biomass
This crop rapidly produces large amounts of biomass.

Nitrogen fixing potential
There is very limited information on N fixation with just one figure 
of 30kg N/ha annually. It must be borne in mind that this crop has 
an extremely short life cycle, so the figure for annual N fixation will 
be lower than that of a perennial crop. To fix N, this legume requires 
seed inoculation with an effective strain of Rhizobium meliloti at the 
time of sowing (see page 13).

Persistence
This crop has a very short persistence, as it will start to flower 
and set seed after a few months. It is only suitable as a short term 
green manure.

Topping regime
It is best not to top fenugreek at all as, in most cases, this will kill it. 
Its growth is vigorous enough to compete against weeds without the 
need for cutting.

Pest and disease problems
Fenugreek has few pest and disease problems.

Lucerne/ 
Alfalfa

[Medicago sativa]

N fixer, longer term

A superb high protein forage crop, lucerne is usually 
grown on its own and is very good on drought-prone 
soils. It establishes relatively slowly, producing significantly 
more biomass in the second and third years. It is particularly 
well suited where it will be used as a silage or hay crop 
as well as a green manure. Lucerne should only be grown 
on free-draining, alkaline soil (minimum pH 6.2).

Sowing rate: 20 kg/ha or 2.0 g/m²
Seed of lucerne is slightly larger than clover seed, and should be 
sown at 1cm. The soil should be rolled after sowing to increase soil 
microbe contact with the seed.

Ideal sowing time
Lucerne can be sown in spring or summer. For a spring sowing, 
March – May is ideal. It will germinate in the summer, providing there 
is sufficient moisture in the soil. For an autumn sowing, 
August is the best time. Later sowings in September are less 
likely to establish well as the soil temperature cools.

Suitable varieties
Currently, the most commonly used varieties are Verko, Mercedes 
and Vela, although other lesser known varieties such as Daisy, 
Diane, Marshal and Pondus also produce good yields.

Frost tolerance
Foliage of lucerne dies off over the winter, but it survives as a tap 
root which resumes growth in the spring.

Weed competitiveness
Lucerne is slow to establish initially, but once it gets going shows 
good competition against weeds. It will withstand being topped for 
weed control.

Biomass
Lucerne is slow to produce biomass initially but this increases 
over the second and third years with 15t DM/ha possible once fully 
established.

Nitrogen fixing potential
There are a wide range of estimates for N fixation in lucerne ranging 
from 125 – 500kg N/ha annually. A typical figure is 150kg N/ha. 
To fix N this legume requires seed inoculation with an effective 
strain of Rhizobium meliloti at the time of sowing (see page 13).

Persistence
Lucerne shows good persistence, and is ideally grown for a period 
of 2 – 3 years although it can be grown for longer than this. Its 
persistence depends on factors affecting survival of the tap roots. 
It will not thrive on waterlogged soils and poaching or wheel 
damage will also impact on its longevity.

Topping regime
Lucerne will generally need topping 2 – 3 times per growing season. 
The frequency depends very much on season and soil type.

Pest and disease problems
Observations suggest that lucerne is slightly more susceptible 
to downy mildew and attack from altona weevil than red clover. 
It can also suffer from stem nematode and Verticillium wilt. There 
should therefore be a four year break between lucerne crops. Some 
varieties such as Vela have been shown to have good resistance to 
both of these disorders.
**Persian Clover**  
*Trifolium resupinatum*

**N fixer, short term annual**  
Persian clover is an annual capable of rapid growth, ideal for providing a quick boost to soil fertility where there is a window of 5-12 months. Most growers in the UK are not familiar with Persian clover, which, like many legumes, originates from the Middle East. It grows on most soils and was adopted commercially in Australia in the 1970s and is grown successfully in other countries with similar climates to ours such as New Zealand.

**Sowing rate:** 10 kg/ha or 1 g/m²  
Clover seed is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**  
March – May is the ideal time for sowing in the spring. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Persian clover will not establish under cold temperatures and is unlikely to be successful if sowing extends too far into September.

**Suitable varieties**  
There are a number of cultivars in production. One of these, Laser, has been tested in the UK and has performed reliably under a range of conditions. Others from Australia, Greece and Italy are also being imported.

**Frost tolerance**  
The leaf cover of Persian clover will be knocked back by frost, but will recover to provide a reliable crop.

**Weed competitiveness**  
On emergence this plant produces very small leaves, but after the 4 – 5 leaf stage, expansion is rapid, producing a thick canopy that is extremely competitive against weeds.

**Biomass**  
This crop produces large amounts of biomass very quickly. The stem material has less tendency to turn woody than many other green manures, making it easy to incorporate. Biomass can be increased if grown with aggressive short-lived western red or Italian ryegrass.

**Nitrogen fixing potential**  
There is little information on the N fixing potential of this crop, with only one estimate of 100kg N/ha annually published.

**Persistence**  
This crop is an annual but shows greater persistence than other annuals such as crimson clover. It will start to die off by October from a spring sowing in April.

**Topping regime**  
Persian clover is usually only cut once and may be cut at an early stage if weed control is required. If cut at full flowering there will be little regrowth.

**Pest and disease problems**  
The pest and disease problems of Persian clover are not well documented in the UK. As stem nematode races are very species specific, it is unlikely to suffer from the same nematode problems as red clover. Therefore alternating this crop with red clover may reduce the chances of stem nematode populations building up in the soil. This crop may be slightly more susceptible to damage from the Sitona weevil than other clovers, although this does not significantly reduce productivity.
Sowing rate: 15 kg/ha or 1.5 g/m²
Seed of sweet clover is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time
March – May is the ideal time for sowing in the spring. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Establishment is less likely to be reliable if sowing extends too far into September.

Suitable varieties
There are no varieties available. Seed is sold as ‘commercial’ which means it is not a particular cultivar. Seed can contain both white and yellow types.

Frost tolerance
Sweet clover will survive over winter as a tap root and by the end of the winter leaves will be absent.

Weed competitiveness
Sweet clover has an erect growth habit, resulting in an open canopy that is not suited to competing on soils with high weed burdens. It also does not favour being cut too low to the ground, which restricts the options for early weed control.

Biomass
If this crop establishes well, it is one of the most prolific for producing biomass rapidly.

Nitrogen fixing potential
Sweet clover can fix large amounts of N, around 150kg N/ha. To fix N this legume requires seed inoculation with an effective strain of Rhizobium meliloti at the time of sowing (see page 13).

Persistence
As this is a biennial, it will die off after flowering. It can set seed and come back in subsequent crops and, although the plants are very conspicuous, they tend to be in relatively small numbers, so their impact on the next crop is limited. However, volunteers should not be allowed to contaminate subsequent cereal crops. Even a very small amount can cause a coumarin taint, which can lead to rejection of malting barley.

Sweet Clover
[Melilotus officianalis]

N fixer, short to medium term
Sweet clover is a tall biennial plant. There are two forms, one white flowered and one yellow, with little difference between them. Once established, it is aggressive, producing a large tap root and significant biomass.

Sowing rate: 70 kg/ha or 7.0 g/m²
Sainfoin seed is large and should be drilled to a depth of 2cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time
Sainfoin is traditionally sown as a spring crop, so ideal sowing time is April – May. Adequate moisture is essential for good establishment, so sowing later in the summer may be less reliable.

Suitable varieties
There is limited information on varieties, although the EU ‘Healthy Hay’ project collected 355 samples, many of which are being evaluated for their potential.

Frost tolerance
Sainfoin is extremely tolerant to frosts.

Weed competitiveness
Sainfoin can be slow to get going, but produces enough ground cover to compete against weeds once it is well established.

Biomass
This crop produces up to 15t DM/ha once it is established.

Nitrogen fixing potential
There is very little information on the N fixing potential of sainfoin, although it is thought that it fixes slightly less than red clover.

Persistance
This crop has the potential to persist for 3 – 4 years, provided its tap roots are not damaged. It is best to avoid heavy grazing and poaching which can reduce the population of viable tap roots.

Topping regime
Sainfoin will generally need topping 2 – 3 times a season, although this may vary considerably with season and soil type.

Pest and disease problems
Sainfoin can be susceptible to crown rot, which can reduce the persistence of the crop.

Topping regime
Sweet clover does not take kindly to hard topping, so should be topped 10 cm above the ground. This may limit the options for weed control.

Pest and disease problems
The information on pest and disease tolerance in sweet clover is limited. Observations suggest that it is considerably more susceptible to stona weevil and downy mildew than red or white clover.

N fixer, medium term
Sainfoin is a perennial with an erect growth habit, producing characteristic pink flowers. It is extremely palatable to animals and has a very good nutritional balance. It can be grazed, or fed as hay or silage. It is suitable for the large area of chalk and limestone soils in England.

Sainfoin
[Onobrychis viciifolia]

Sowing rate: 70 kg/ha or 7.0 g/m²
Sainfoin seed is large and should be drilled to a depth of 2cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time
Sainfoin is traditionally sown as a spring crop, so ideal sowing time is April – May. Adequate moisture is essential for good establishment, so sowing later in the summer may be less reliable.

Suitable varieties
There is limited information on varieties, although the EU ‘Healthy Hay’ project collected 355 samples, many of which are being evaluated for their potential.

Frost tolerance
Sainfoin is extremely tolerant to frosts.

Weed competitiveness
Sainfoin can be slow to get going, but produces enough ground cover to compete against weeds once it is well established.

Biomass
This crop produces up to 15t DM/ha once it is established.

Nitrogen fixing potential
There is very little information on the N fixing potential of sainfoin, although it is thought that it fixes slightly less than red clover.

Persistance
This crop has the potential to persist for 3 – 4 years, provided its tap roots are not damaged. It is best to avoid heavy grazing and poaching which can reduce the population of viable tap roots.

Topping regime
Sainfoin will generally need topping 2 – 3 times a season, although this may vary considerably with season and soil type.

Pest and disease problems
Sainfoin can be susceptible to crown rot, which can reduce the persistence of the crop.
**Vetch**

*Vicia sativa*

- **N fixer, short term**
  - Vetch (also known as winter tares) is very popular, providing a rapid fix of nitrogen. It is particularly good at competing against weeds.

- **Suitable varieties**
  - Early English is a commonly grown variety. Other varieties are sown but it is important to use winter types when sowing in the autumn.

- **Frost tolerance**
  - Winter vetch has good frost tolerance and will maintain a canopy over the winter.

- **Weed competitiveness**
  - Vetch is extremely competitive against weeds, forming an aggressive canopy rapidly. When incorporated, the residues also have an allelopathic effect, inhibiting germination of new seeds (see page 9). This effect persists for around six weeks, and an adequate interval should be left if drilling direct sown crops after incorporating vetch.

- **Biomass**
  - This crop rapidly produces large amounts of biomass.

- **Nitrogen fixing potential**
  - Estimates of annual N fixation range from 100 – 250kg N/ha. A typical figure is 150kg N/ha.

- **Persistence**
  - Being an annual, this crop is finished after flowering, so it is short lived. It has often flowered then died back by July – August.

- **Topping regime**
  - It is best not to top vetch at all, as it does not recover well. Its growth is vigorous enough to compete against weeds without the need for cutting.

- **Pest and disease problems**
  - Generally vetch has few pest or disease problems. Sitona weevil can attack it during its early stages, but this generally has little effect on the subsequent success of the crop. Pigeons can sometimes set back the development of the crop if there is little else for them to eat. There is a suggestion that growing vetch results in fewer slugs in the subsequent crop, although further work needs to be done to verify this.

- **Sowing rate**: 85 kg/ha or 8.5 g/m²

  - Seed of vetch is larger than clover seed, so should be sown deeper, (1-2 cm is ideal). The soil should be rolled after sowing to increase soil moisture contact with the seed.

- **Ideal sowing time**
  - March – May is the ideal time for sowing in the spring. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. September is the best time for an autumn sowing. It can be reliably sown later than clovers.

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**White Clover**

*Trifolium repens*

- **N fixer, medium to long term**
  - White clover is one of the most tried and tested of all the green manure species. It does not establish rapidly but once it gets going it produces respectable amounts of biomass over an extended period. It is commonly used for medium to long term leys, especially where livestock is grazed. The less aggressive varieties are also particularly suitable for undersowing in cereal or vegetable crops.

- **Suitable varieties**
  - Medium leaved varieties: can be grazed by cattle or lightly grazed by sheep, also good for a cutting mix. Varieties include AberHerald, AberConcorde and Crusader.

  - Large leaved varieties: most productive and best suited to cutting or non intensive grazing. Varieties include Alice and Barblanca.

- **Frost tolerance**
  - The leaf cover of white clover will die back over the winter, and the plant over-winters as an underground stolon structure. This structure should be tolerant of all but the most severe frosts.

- **N fixer, short term**
  - White clover is slower to establish than some green manures and providing a rapid fix of nitrogen. It is particularly good will benefit from early topping to control weeds. However biomass increases later in the season and in subsequent years, offering good weed control. The larger leaved varieties are more aggressive against weeds than the smaller.

- **Biomass**
  - This crop produces a slightly less annual biomass than red clover but it is important to use winter types when sowing in the autumn. This crop rapidly produces large amounts of biomass.

- **Nitrogen fixing potential**
  - Estimates for N fixing potential of white clover vary very widely from 50 to 450kg N/ha annually. A typical figure is 150kg N/ha if cut and mulched.

- **Pest and disease problems**
  - White clover is one of the most persistent of the green manure species. It proliferates through an underground stolon structure, so even if one part becomes damaged the crop can regenerate.

- **Persistence**
  - White clover is an annual, this crop is finished after flowering, so it is short lived. It has often flowered then died back by July – August.

- **Topping regime**
  - This crop rapidly produces large amounts of biomass. White clover should be mown regularly whenever it attains a height of 30cm but can be cut before this if weeds are a problem. The frequency of mowing will vary widely between sites and seasons.

- **Pest and disease problems**
  - White clover is one of the most persistent of the green manure species. It proliferates through an underground stolon structure, so even if one part becomes damaged the crop can regenerate.

- **Sowing rate**: 10 kg/ha or 1 g/m²

  - Clover seed is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.

- **Ideal sowing time**
  - March – May is the ideal time for sowing in the spring. If undersowing a spring cereal, it should be sown in April or May. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Establishment is less likely to be reliable if sowing extends too far into September.

- **Suitable varieties**
  - There is more variety choice for white clover than any other green manure. The growth habits of varieties vary considerably, and are grouped into small, medium and large leaved types. These are used for different purposes:

  - Small leaved varieties: best for hard grazing by sheep. Varieties include AberAce or ST84.

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**Clover seed is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.**

**White clover**

- **Suitable varieties**
  - Medium leaved varieties: can be grazed by cattle or lightly grazed by sheep, also good for a cutting mix. Varieties include AberHerald, AberConcorde and Crusader.

  - Large leaved varieties: most productive and best suited to cutting or non intensive grazing. Varieties include Alice and Barblanca.

- **Frost tolerance**
  - The leaf cover of white clover will die back over the winter, and the plant over-winters as an underground stolon structure. This structure should be tolerant of all but the most severe frosts.

- **Biomass**
  - This crop produces a slightly less annual biomass than red clover but it is important to use winter types when sowing in the autumn. This crop rapidly produces large amounts of biomass.

- **Nitrogen fixing potential**
  - Estimates for N fixing potential of white clover vary very widely from 50 to 450kg N/ha annually. A typical figure is 150kg N/ha if cut and mulched.

- **Pest and disease problems**
  - White clover is one of the most persistent of the green manure species. It proliferates through an underground stolon structure, so even if one part becomes damaged the crop can regenerate.

- **Persistence**
  - White clover is an annual, this crop is finished after flowering, so it is short lived. It has often flowered then died back by July – August.

- **Topping regime**
  - This crop rapidly produces large amounts of biomass. White clover should be mown regularly whenever it attains a height of 30cm but can be cut before this if weeds are a problem. The frequency of mowing will vary widely between sites and seasons.

- **Pest and disease problems**
  - White clover is one of the most persistent of the green manure species. It proliferates through an underground stolon structure, so even if one part becomes damaged the crop can regenerate.

- **Sowing rate**: 10 kg/ha or 1 g/m²

  - Clover seed is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.

- **Ideal sowing time**
  - March – May is the ideal time for sowing in the spring. If undersowing a spring cereal, it should be sown in April or May. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Establishment is less likely to be reliable if sowing extends too far into September.

- **Suitable varieties**
  - There is more variety choice for white clover than any other green manure. The growth habits of varieties vary considerably, and are grouped into small, medium and large leaved types. These are used for different purposes:

  - Small leaved varieties: best for hard grazing by sheep. Varieties include AberAce or ST84.
Yellow Trefoil/
Black Medick

Sowing rate: 10 kg/ha or 1 g/m²
Seed of yellow trefoil is small and should be broadcast or drilled at a shallow depth (not more than a few mm). Sowing too deep will reduce the germination dramatically. The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time
March – May is the ideal time for sowing in the spring. If it is to be undersown in a spring cereal, it should be sown in May. It will germinate in the summer, but frequently there is insufficient moisture in the soil to allow this. Mid to late August is the best time for an autumn sowing. Establishment is less likely to be reliable if sowing extends too far into September.

Suitable varieties
There is limited information on varieties and, particularly on organic units, growers frequently just accept what is available. Virgo Pajbjerg is the only variety currently used in the UK.

Frost tolerance
Yellow trefoil will survive over the winter and flower the following year.

Weed competitiveness
Yellow trefoil shows reasonable competition against weeds. It is not the most rapidly growing of species but its low growth habit is good for covering the ground and smothering weeds.

Buckwheat

Sowing rate: 70 kg/ha or 7 g/m²
Buckwheat seed is relatively expensive and as it is a short-lived green manure it has limited commercial appeal.

Ideal sowing time
Any time after April / May when there is no risk of frost.

Suitable varieties
Presently there is little choice of varieties available.

Frost tolerance
Buckwheat has very poor frost tolerance and will break down at the first sign of frost.

Weed competitiveness
Buckwheat has large leaves which are good for suppressing weeds, although ground covering weeds such as chickweed often survive under it.

Biomass
Buckwheat grows vigorously and will produce relatively large amounts of biomass if allowed to grow throughout the summer.

Nitrogen fixing potential
Although there is very little scientific information on the N fixing potential of this crop, practical experience from growers suggests that it is as good as white clover.

Persistence
This is a short-lived plant which will die off after flowering. However, it sets large quantities of viable seed very rapidly, making the crop behave as if it were perennial. Although seeds may come back as weeds, they are rarely a major problem.

Topping regime
Buckwheat does not generally need topping.

Pest and disease problems
This crop is generally free from problems with pest and disease.
**Chicory**  
[Cichorium intybus]

*Deep rooting pan buster, medium to long term*

This herb has roots capable of penetrating to great depth. The main root looks like a long thin carrot and there are many pencil-like projections from it. These roots will break through plough pans and leave the soil aerated, aiding drainage and crop root development.

**Sowing rate:** 15 kg/ha or 1.5 g/m²

Chicory is a relatively small seed and should be sown at around 1cm deep. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**

It is important to sow into a warm seedbed either between March and early May or in the autumn between August and September. Sowing later than this is risky as chicory is relatively slow to establish when conditions cool down.

**Suitable varieties**

There are a limited number of varieties. The commonly used variety is Puna, which is imported from New Zealand.

**Frost tolerance**

Chicory is tolerant to frost.

**Weed competitiveness**

Initially weeds can be a problem during establishment, but this is a long term crop and most annual weeds will disappear once a mowing or grazing regime becomes established.

**Biomass**

There is little data on chicory biomass. Estimates put yield around 11-13t DM/ha.

**Nitrogen fixing potential**

Chicory does not fix N.

**Persistence**

Chicory lasts for up to ten years. In order to get the full effect it should be left in situ for at least two years.

**Topping regime**

Chicory will need topping regularly at around three week intervals to control growth. Alternatively it can be grazed by sheep or cattle and makes an excellent forage. It has anthelmintic properties making it useful to ruminant livestock farmers.

**Pest and disease problems**

There are generally few pest and disease problems with chicory.

**N holder, medium to long term**

Cocksfoot does not fix nitrogen but is a good store of it. It is usually sown with red clover as a ley for around four years, providing good grazing. Its root structure is excellent for improving soil and it grows well in drought-prone areas.

**Sowing rate:** 20 kg/ha or 2 g/m²

Cocksfoot is small and should be sown at a depth of 1cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**

In common with other grasses, cocksfoot should be sown between March – early May or in the autumn between August and September.

**Suitable varieties**

There are many varieties available. Commonly used are Prairial, Sparta, Abertop and Niva.

**Frost tolerance**

Cocksfoot is extremely tolerant to frost.

**Weed competitiveness**

Cocksfoot is a dominant grass which, when grown with red clover, is very good at suppressing weeds.
**Grazing Rye**

[Secale cereale]

N holder, short term

Grazing rye does not fix nitrogen but is one of the most effective crops for reducing leaching over the winter.

**Sowing rate:** 180 kg/ha or 18 g/m²

Grazing rye seed is large and should be drilled to a depth of 2 – 3 cm. The soil should be rolled after sowing to increase soil moisture contact with the seed. It is sown at a high rate, making it an expensive crop to establish, so particular care should be taken to ensure that sowing conditions are optimal.

**Ideal sowing time**

Grazing rye is usually sown in the autumn in order to establish over-winter cover. It has an advantage over legumes in that it will still grow successfully if sown in September or October. This is useful if a cash crop is still being harvested in autumn.

**Suitable varieties**

There is limited information on varieties

**Frost tolerance**

Grazing rye is extremely tolerant to frost.

**Weed competitiveness**

Grazing rye establishes very quickly and competes against weeds effectively. The residues, when dug in, have an allelopathic effect against germination of seed (see page 9). This should be taken into consideration when sowing direct drilled crops after grazing rye and an interval of six weeks should be left.

**Biomass**

Grazing rye rapidly produces large amounts of biomass.

**Nitrogen fixing potential**

Grazing rye does not fix N but is one of the best crops for preventing it leaching over the winter.

**Persistence**

Grazing rye is a short lived cover crop, and is normally incorporated in March after an autumn sowing.

**Topping regime**

Grazing rye may need topping in March or early April, either for weed control or to prevent it flowering and becoming stemmy.

**Pest and disease problems**

There are generally few pest and disease problems with grazing rye.

**Italian Ryegrass**

[Lolium multiflorum]

N holder, medium term

Italian ryegrass is one of the most rapidly growing grasses and is commonly grown in mixes with red clover or vetch.

**Sowing rate:** 30 kg/ha or 2-3 g/m²

Optimum sowing depth is 1-2cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**

Italian ryegrasses can be sown in March and April but, for optimum spring yields, is best sown in August or by late September.

**Suitable varieties**

There is a wide range of varieties available.

**Frost tolerance**

Italian ryegrass will grow through the winter, but frost tolerance is improved if surplus growth is removed in the autumn.

**Weed competitiveness**

Italian ryegrass grows very rapidly so is competitive against weeds. As it benefits from early cutting this can also help combat weeds.

**Biomass**

Italian ryegrass produces large amounts of biomass over a growing season. Yields can be as high as 15t DM/ha.

**Nitrogen fixing potential**

Italian ryegrass does not fix N but is effective at reducing leaching provided there is a well established canopy.

**Persistence**

Italian ryegrass has a shorter persistence than perennial ryegrass, generally only lasting from 1–2 years, depending on conditions. Persistence can be reduced by drought.

**Topping regime**

Italian ryegrass needs topping or grazing regularly to prevent it seeding and becoming stemmy. It benefits from being cut or grazed earlier than perennial ryegrass. Frequency depends on soil fertility and growing conditions.

**Pest and disease problems**

Italian ryegrass is susceptible to a number of pests and diseases, including mildew, and ryegrass mosaic virus. It can also build up pest problems such as leather jackets, slugs and wireworms that can pose problems in subsequent crops.
**Mustard**

*Sinapsis alba*

**N holder, short term**

Mustard does not fix nitrogen but is a rapidly growing annual nitrogen lifter for growing over the summer. It is also very good at suppressing weeds.

**Biomass**

Mustard rapidly produces large amounts of biomass.

**Nitrogen fixing potential**

Mustard does not fix N but is effective at preventing it leaching.

**Persistence**

Mustard has a very short persistence and can start to flower after 4 – 6 weeks.

**Topping regime**

It is not usual practice to top mustard, except immediately prior to incorporation.

**Pest and disease problems**

Mustard will suffer from all the pests and diseases normally associated with growing brassicas. If sown in spring, flea beetle can hamper the establishment, although most crops will grow through this. As with all brassicas, pigeons can cause devastation at any stage. It is important to bear in mind that mustard is susceptible to clubroot (Fusarium brassicae) so should be grown in the brassica part of the rotation.

**Frost tolerance**

Mustard’s frost tolerance is relatively poor, with leaves breaking down after a few mild frosts. This can be useful as it allows the crop to be easily incorporated.

**Weed competitiveness**

Mustard is vigorously competitive against weeds from an early stage, and most mustard crops have very few weeds.

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**Perennial Ryegrass**

*Lolium perenne*

**N holder, long term**

Perennial ryegrass is the most commonly grown grass, particularly in grazed grass/clover leys. It shows good persistence, lasting for up to six years.

**Sowing rate**: 35 kg/ha or 3 g/m²

Ideal germination depth is 1-2cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**

Ideal times are April or September when there is adequate moisture for establishment.

**Suitable varieties**

There is a wide range of perennial ryegrass varieties available, with many bred especially for their palatability and digestibility. Varieties that seed later in the season are best for green manuring as these are less likely to create issues for the next crop. Varieties include Calibra, Tivoli, Aberdart and Twystar.

**Frost tolerance**

Perennial ryegrass will withstand most frosts throughout the winter.

**Weed competitiveness**

Annual and perennial weeds may be a problem during establishment, but the crop will gain a competitive advantage when mown.

**Biomass**

Perennial ryegrass produces around 13t DM/ha of biomass over a growing season.

**Nitrogen fixing potential**

Ryegrass does not fix N but is effective at reducing leaching, provided there is a well established canopy.

**Persistence**

Perennial ryegrass will persist for at least 5 – 6 years.

**Topping regime**

Perennial ryegrass needs topping or grazing regularly to prevent it flowering and becoming stemmy and difficult to incorporate. Frequency depends on soil fertility and growing conditions.

**Pest and disease problems**

Perennial ryegrass can suffer from crown rust or mildew. It can also build up pest problems such as leatherjackets, slugs and wireworms that can pose problems in subsequent crops.
**Westerwolds Ryegrass**

[**Lolium westerwoldicum**]

**Sowing rate**: 35 kg/ha or 3.5 g/m²

Ryegrass seed should be drilled to a depth of 1 cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

**Ideal sowing time**

Westerwolds can be sown in the autumn in order to establish over-winter cover. It has an advantage over legumes in that it will still grow successfully if drilled in September or October. This is useful if a cash crop is still being harvested in autumn. Alternatively it may be sown in the spring as a short term summer green manure.

**Suitable varieties**

There are many varieties available. Hellen, Mendoza and Lifl oria are commonly sown.

**Frost tolerance**

Most varieties of westerwold ryegrass are tolerant to frost.

**Weed competitiveness**

Westerwolds ryegrass establishes very quickly and competes against weeds effectively.

**Biomass**

Westerwolds ryegrass rapidly produces large amounts of biomass. If left in situ for the spring and summer (after an autumn sowing) it can produce 15 t DM/ha.

**Nitrogen fixing potential**

Westerwolds ryegrass does not fix N but is one of the best crops for preventing it leaching over the winter.

**Persistence**

Westerwolds ryegrass is a winter-hardy annual. If it runs to seed it will stop growing.

**Topping regime**

Westerwolds ryegrass will need topping or grazing either for weed control or to prevent it flowering and becoming stemmy.

**Pest and disease problems**

There are generally few pest and disease problems with westerwolds.

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**Phacelia**

[**Phacelia tanacetifolia**]

**N holder, weed suppressor, short term**

Phacelia does not fix nitrogen but is a very rapidly growing annual nitrogen holder crop for growing over the summer. It is particularly good at attracting bees, hoverflies and wasps into the area.

**Biomass**

Biomass production is less prolific than in other green manures as much of the canopy comprises a fine leaf structure.

**Nitrogen fixing potential**

Phacelia does not fix N but is effective at preventing it leaching.

**Persistence**

Persistence over the summer is good, and it will continue producing leaves and flowering until it is killed off by the first frosts.

**Topping regime**

Phacelia generally does not need topping.

**Pest and disease problems**

This crop is generally free from problems with pest and disease.

**Frost tolerance**

Phacelia has poor tolerance to cold and will break down after a moderate frost.

**Weed competitiveness**

Phacelia has a fine leaf structure but nonetheless grows vigorously showing good weed suppression.

**Suitable varieties**

Cultivars are imported from Europe and Balo is a common strain.

**Pest and disease problems**

There are generally few pest and disease problems with phacelia.

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**Sowing rate**: 10 kg/ha or 1 g/m²

Seed of phacelia is small and should be shallow sown at not more than a few mm or surface broadcast.

**Ideal sowing time**

Any time after March.

**Frost tolerance**

Phacelia has poor tolerance to cold and will break down after a moderate frost.

**Weed competitiveness**

Phacelia has a fine leaf structure but nonetheless grows vigorously showing good weed suppression.
Legumes

Buckwheat
This will reach a height of up to 90cm.

Chicory
After leaf development at around 60cm, the plant will quickly bolt to produce a flowering head at 100 – 150cm. This is unsightly, although the flowers attract many insects.

Cocksfoot
This will attain a height of at least 80cm.

Grazing Rye
This will attain a height of at least 1m.

Italian Ryegrass
This can easily attain a height of over 1m, but should be topped before this to maintain palatability and prevent it becoming tough and difficult to incorporate.

Mustard
Depending on the cultivar, a mustard canopy will attain a height of up to 2m, but should be topped before this to maintain palatability and prevent it becoming tough and difficult to incorporate.

Phacelia
This grows to a height of around 60cm, or higher if grown in conjunction with a cereal (e.g. grazing rye) or used to provide support.

Westerwolds Ryegrass
This will attain a height of at least 80cm.

Non-Legumes

Crimson Clover
This can reach a height of 70cm if not cut.

Fenugreek
This will grow to a height of around 1m.

Lucerne
The crop will attain a height of at least 1m if not mown, but should be cut before this to avoid an abundance of woody material.

Red Clover
This will reach a height of at least 60cm if left unchecked. Allowing the crop to produce too much plant material runs the risk of smothering the crop if cut and mulched.

Sainfoin
This will grow to a height of around 1m.

Sweet Clover
This can grow to a height of over 2m, depending on leaf size. Allowing the crop to produce too much plant material runs the risk of smothering the crop if cut and mulched.

White Clover
This will reach a height of 20 – 30cm, depending on leaf size. Allowing the crop to produce too much plant material runs the risk of smothering the crop if cut and mulched.

Yellow Trefoil
This will reach a height of 20 – 30cm if not mown.

Vetch
This will grow to a height of around 50cm, or higher if grown in conjunction with a cereal (e.g. grazing rye) or used to provide support.

Persian Clover
This will reach a height of at least 60 – 70cm if left unchecked. It is normally mown at this point.

Sainfoin
This will grow to a height of around 1m.

Sainfoin
This will grow to a height of around 1m.

Sweet Clover
This will reach a height of at least 60cm if left unchecked.

Red Clover
This will reach a height of at least 60cm if left unchecked.

Perennial Ryegrass
This will reach a height of at least 60 – 70cm if left unchecked. It is normally mown at this point.

Italian Ryegrass
This can easily attain a height of over 1m, but should be topped before this to maintain palatability and prevent it becoming tough and difficult to incorporate.
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Cotswold Seeds

Cotswold Seeds was founded in 1974 and deals with over 8,000 farmers throughout the UK. The company has a specialist interest in grass and legumes and offers advice on growing and managing these crops to those working in the livestock, arable and horticultural sectors. The company is also involved in a wide range of research projects across the EU.

www.cotswoldseeds.com

Garden Organic

Garden Organic, the UK’s leading organic growing charity, has been at the forefront of the organic horticulture movement for 50 years and is dedicated to researching and promoting organic gardening, farming and food.

www.gardenorganic.org.uk