

SORT OUT YOUR SOIL

2nd Edition

A practical guide to
Green Manures and
Cover Crops

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COTSWOLD
Grass Seeds
— DIRECT —

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Green manures are a well known way to add humus to soil to increase fertility so that chemical fertiliser use can be reduced.

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Ian Wilkinson

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Sam studied for his degree at Harper Adams University in Shropshire, after which he worked for four years on Swinbrook Estate, carrying out many duties including cultivation, spraying and drilling throughout the season. He joined Cotswold Seeds three years ago as Technical Advisor, providing farmers with advice on complex grass seed mixtures, as well as visiting farms all over the UK. He lives at Honeydale Farm where he takes an active role in managing the farm.



WHAT ARE GREEN MANURES AND COVER CROPS?

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, brassicas 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 insure 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, crimson and berseem clovers 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.

Long term soil nitrogen enhancement

Slower growing perennial legumes such as red and white clover, sainfoin and lucerne (alfalfa) are used to add nitrogen to the soil over a long period. These crops are relatively slow to establish but are persistent, so reduce the need for resowing. They are most commonly sown in a mixture with grasses, and are often used for silage or grazing in extensive livestock systems while they improve the soil.

Preventing nitrogen leaching

If soil is left bare for any length of time, rainfall will leach (or wash) nitrogen and other nutrients out, especially on lighter ground. In many situations reducing leaching is more important in maintaining soil fertility than fixing nitrogen. This is particularly true during the winter, when legumes are slow to establish and fix little nitrogen. Fast growing species with a deep root system are best for preventing leaching. Grazing rye (*Secale cereale*) – different from perennial ryegrass (*Lolium perenne*) – is one of the best species for this purpose, and mustard is also effective.

In many situations reducing leaching is more important in maintaining soil fertility than fixing nitrogen.

When soil is cultivated in late autumn it is very important to sow a fast-growing crop (such as grazing rye) in order to minimise the risk of nitrate leaching. Suitable species for this purpose can usually be drilled in late September or even into October, depending on local weather and conditions.

Soil Improvement

Improving soil structure

Green manures 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 can break through compacted soils or those with a plough pan. The fibrous root system of cocksfoot is good

A further advantage of green manures is that they can help prevent soil erosion

at improving soil crumb structure. 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 Micro-organisms. 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.

Ensuring the nitrogen needs of the next crop are met

Once a green manure is incorporated it releases nitrogen into the soil. The rate at which this nitrogen becomes available depends on the type of green manure and its growth stage at incorporation. Fleshy legumes like vetch release nitrogen quite fast making most of it available in the first few weeks after incorporation. Other plants, like grasses and grazing rye, are much slower to release nitrogen.

Knowing this about green manures means they can be manipulated to meet the needs of the next cash crop. For example, cauliflower is nitrogen-hungry over a short period so would benefit from a spring incorporation of over-wintered vetch.

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 mature mixture of clover and grass, would be best as it would break down slowly, releasing nitrogen over a longer period.

Carefully planning the integration of green manures into the rotation will maximise their benefits.

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.

Non-legumes can be used to 'hold' nitrogen. They mop it up from the soil and store it then, when incorporated, make this nitrogen available to future crops.

Organic Matter

The decaying remains of plant and animal life form soil organic matter which contains vital nutrients such as nitrogen and phosphate. 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.





First Hand

Riverford Organic Farms deliver 47,000 vegetable boxes across the UK each week. The 500 acre farm is based in Cambridgeshire and at any time half the acreage is down to a green manure ley. When Riverford took it over in 2005 a fertility building ley was sown across the whole farm for the two year organic conversion period. Now fully organic the farm grows over 30 types of vegetables as well as spring barley which is used to feed organic pigs. On one part of the farm a four year rotation has brassicas for the first year, then seasonal vegetables such as beans, courgettes, squash and chard. With the soil then depleted, one of the two green manure leys is sown and left in for two years. The leys are used to: fix nitrogen, the grasses increase soil organic matter and the ley as a whole suppresses weeds and improves soil structure. After four years of cropping Farm Manager Nigel Venni reported that the improvement in the soil was dramatic. It was much more workable, alive with beneficial soil micro-organisms and has become more moisture retentive. Yield targets were being met thanks to the green manure leys.



GREEN MANURES FOR GRAZING AND BLACKGRASS CONTROL

Weed, pest and disease control

Fast growing green manures are very effective at suppressing weeds. Mustard 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 33) 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.

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.

Forage for livestock

Many green manures such as white and red clover, lucerne and sainfoin provide excellent high protein forage for livestock while also benefiting the soil. A major advantage of using legumes in grazing swards is that they will dramatically cut the need for nitrogen fertiliser and provide a cheap and healthy source of protein.

Grazing

Legumes are nearly always mixed with grasses to produce a balanced grazing sward and higher yields. 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.

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. Typical mixes include red and white clover and ryegrass. Short term, single season mixes of vetch and westerwolds 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.

The introduction of livestock and grass leys bring greater soil fertility, income and blackgrass control.



Bloat and Fertility

There is some risk of bloat with swards that have a very high percentage of clover, but good stockmen can manage this risk. Some plants like sainfoin and birdsfoot trefoil are bloat free. Ewes should also be taken off red clover six weeks before and after tugging as the plant contains phyto-oestrogens that can affect sheep fertility.

WILL GREEN MANURES SUIT YOU?

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 artificial 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 but 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.

The cost of growing a good green manure should be outweighed by the profitable yields of subsequent crops.

First Hand

Jonathan Boaz farms 600 acres including 150 acres of permanent pasture, much of which is on difficult lias clay, plus 130 acres of cereals, which are generally feed wheats or barley. The remaining acreage is made up of 3-4 year grass leys, which are grazed early in the season with the regrowth made into hay each year.

Jonathan has been endeavouring to maintain and improve organic levels in the soil for many years, having learned the lesson thirty years ago that, 'you can't take soil organic matter for granted'.

'If you keep on with cereal production and don't introduce any farmyard manure or grass leys the soil will basically die on you,' he says.

His experience is that grass leys and green manure brings it to life again.



Through experimentation he has learned that a mustard crop needs mulching finely to stop incorporation issues when its ploughed in and should be topped before setting seed to reduce volunteers in subsequent crops. Jonathan has also sown a bespoke mixture based on the Summer Quick Fix, which includes crimson, red and Persian clover with Italian ryegrass added to the mix, which adds grazing and a hay cut to the range of soil benefits.

Jonathan stresses that his decisions concerning the business are always 'profit led and must be commercially viable'. And so it has proved. Wheat crops with a yield of 10 tonne a hectare are not uncommon on the Boaz farm, even in difficult conditions.

Right: Example of a 6-8 year rotation showing the importance of deep rooting, fertility building leys (top half), ahead of cash crops.

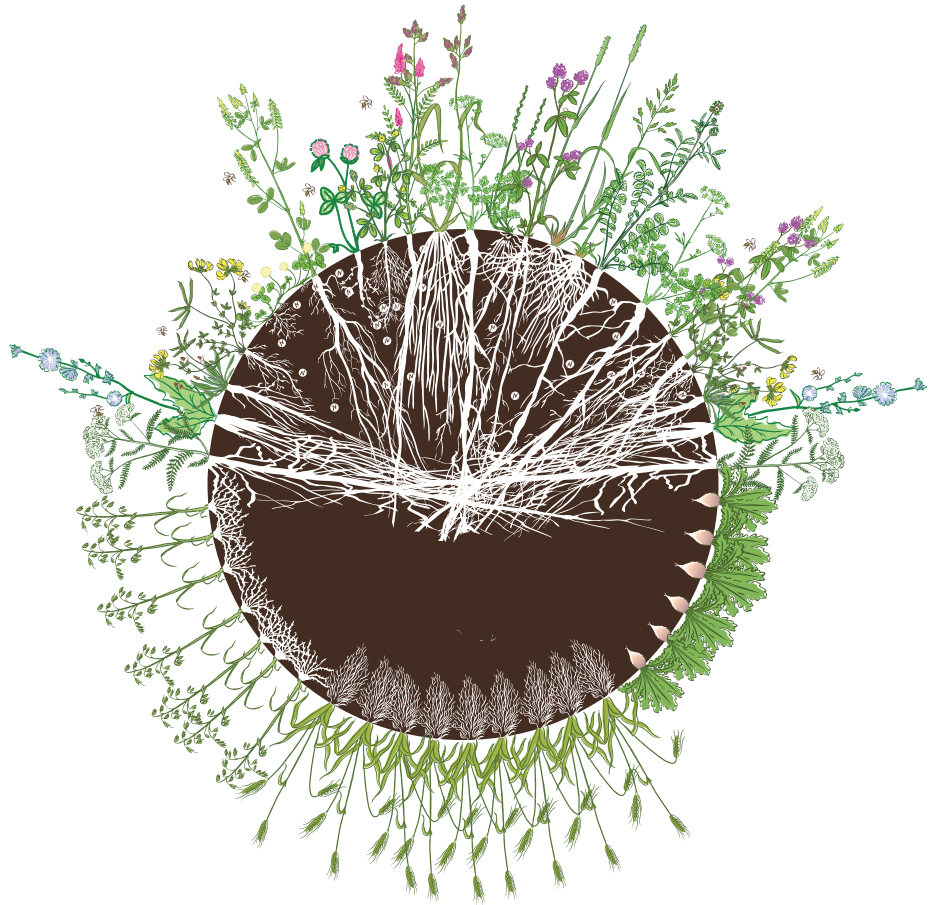
Bottom: Rye & vetch

Will green manure management clash with workload 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% for single species or 70% for seed mixtures (although this figure may change).

Availability of seed can be checked on www.organicxseeds.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

Large

Grazing rye, vetch, sainfoin

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

MANAGING GREEN MANURE CROPS

Green manures can be slotted in between main crops, intercropped at the same time as cash crops or sown for longer periods.



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 an early, spring-sown cereal then it is best to choose a green manure which will prevent

overwinter leaching, such as grazing rye. A late sown 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.

If the overwinter green manure is going to be followed by a crop to be sown later in the year, such as vegetable transplants in June, then a fast growing legume (such as vetch) would be the correct choice as there will be time for considerable nitrogen fixation to take place from March onwards.

How to sow and establish

Green manures can be broadcast or drilled. If the ground is level, then drilling controls seed depth better. However broadcasting distributes seed more evenly. The depth of sowing is very important and the correct sowing depth is given for each green manure later in this guide.

Undersowing

Undersowing (or inter cropping) 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.



Legumes and inoculation

It is the symbiotic relationship that legumes have with Rhizobium bacteria which results in nitrogen fixation. 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 and sweet clover – where the correct bacteria is unlikely to be present and these need to be 'inoculated' with Rhizobium meliloti. 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 vetch. Luckily this crop establishes rapidly and competes well against weeds, making mowing unnecessary.

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

Sweet clover and crimson clover should only be topped at a moderate height (16-20cm), which can be an issue if weeds are a problem. Cutting also helps promote lush vegetative growth and delays the crop going to seed. Without topping most crops will become woody and difficult to incorporate.

Ideally it is best to remove cuttings as this encourages more nitrogen fixation in legumes. When leaving the cuttings, the rotting material will release nitrogen which suppresses nitrogen fixation. In reality this is not often practical, but should be done wherever possible. When cuttings are not removed, a flail mower should be used to distribute the cut material evenly.



White clover and yellow trefoil undersown into a brassica

INCORPORATION

ARABLE with MACHINERY

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 7).

Crimper Roller

The No Till Crimper Roller is standard farm machinery in some parts of America as a way of terminating cover crops and green manures with no till; by avoiding the need for spraying, mowing and ploughing, it's a much cheaper and faster method. It relies on having a bulky cover crop which is then crushed, the flattened plants forming a mulch on top of the soil which keeps weeds at bay and also allows new seeds to come through after disc drilling.

Below: Honeydale Farm. Crimper roller experiment used to control a winter cover crop of rye and vetch. Trying to find the 'Goldilocks Moment' when the plants are just right to terminate. In other words when they are just old enough to remain flat once rolled, but not too old to seed. Made by agricultural engineers, following plans from The Rodale Institute, at a cost of £1700.



GRAZING

MIXED FARM with LIVESTOCK

The best way to graze green manures is mob grazing

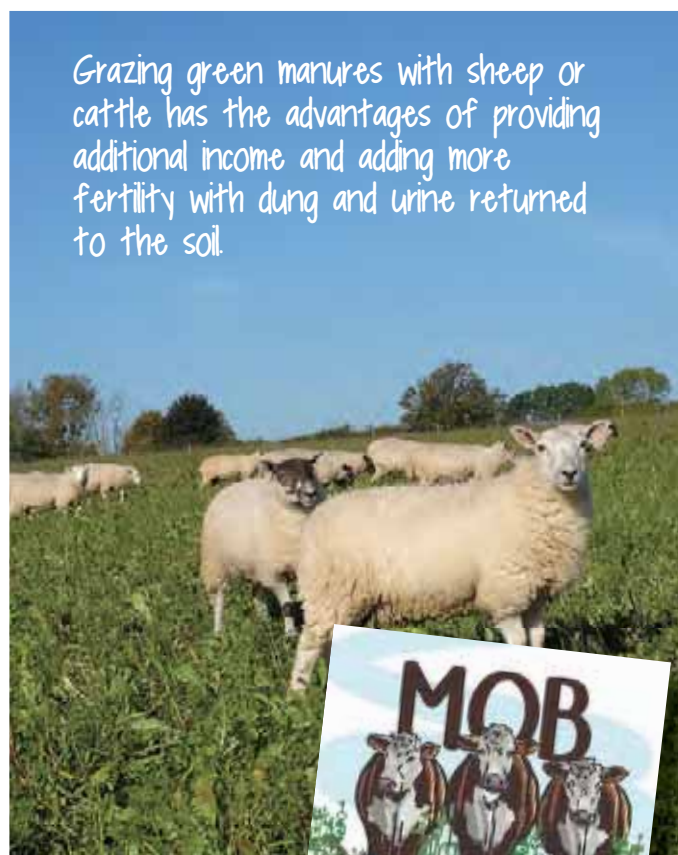
Mob-Grazing, sometimes referred to as cell-grazing, is a term used to describe a method of grazing and frequently moving livestock systematically around a field to graze different sections in rotation in order to improve soil. It goes hand in hand with growing diverse leys like green manures.

Animals eat about half to two thirds and what they don't eat they trample. This trampled forage is continually returned to the surface, helping to feed the soil, along with the manure.

Farmers are increasingly talking about mob grazing, an extension of a livestock based farming system that has stood the test of time, due to current economic problems (low commodity prices and high input costs), poor soil quality and the need to find a cheaper farming system that will improve soils, food quality and profits.

When this system was popular in the past it was made possible by hedges which were lost in the 1940s and 50s due to intensification. Recent agricultural advances in electric fencing and modern water troughs and pipe connections for water supply - have now made this a viable option once again.

Arable and horticultural farms have the option to 'borrow' or 'rent a mob' from a livestock farmer looking for additional crops to graze.



Grazing green manures with sheep or cattle has the advantages of providing additional income and adding more fertility with dung and urine returned to the soil.



More information is available in Cotswold Seeds' 'Mob Grazing - A Farmers Guide' available from www.cotswoldseeds.com

First Hand

Charles Hunter-Smart has held the position of Farm and Estate Manager at Bradwell Grove for nearly 30 years, running a business which includes arable cropping, a beef suckler unit and a joint sheep enterprise. The common thread linking these operations is enhancing the soil, which provides the



building blocks for the cereal and forage crops. Over the years there has been a sustained effort to increase soil fertility and adapt the rotation to fully incorporate cover crops and grass leys. Short term plants like mustard or radish are used for

slotting-in fast establishing cover crops at either end of the arable rotation, while longer term diverse mixtures of grasses, legumes and forage herbs are left in place for 2-3 years to really build root mass and organic matter in the soil.

This system of soil improvement has made the land easier to work, with less cultivation passes needed to achieve a fine seed bed. It has also increased the soil's resilience to extremes of weather, causing it to act as a sponge after rainfall but hold moisture in dry summers. Another advantage of the conversion has been the reduction in inputs costs throughout the system. Charles has been looking at ways of improving crop establishment and sustaining P and K levels, including using green waste compost as a soil improver.

Bradwell Grove is under the custodianship of the 4th generation of the same family and improving soil health is viewed as a crucial element of asset-building for future generations.

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.

Long term mixes

Grass clover mixes

Growing a mix of red and white clover with perennial ryegrass is a very good option for improving soil fertility and structure. To realise its full potential the mix should be grown for at least one full year before incorporation. Red and white clover can fix up to 300 kg N/ha which is released rapidly after incorporation. The ryegrass acts to delay the release of this nitrogen, as it is higher in carbon and acts like a sponge, holding the nitrogen for longer. This is especially important when the green manure is to be followed by an autumn sown crop such as winter wheat where

the highest demand for nitrogen can be six or seven months after the green manure has been incorporated.

Cocksfoot

For leys that will be in the ground for longer than two years, using cocksfoot instead of ryegrass with the clover will increase the benefits significantly. The deep roots of cocksfoot improve soil structure and add massive amounts of organic matter. Another bonus with this species is its drought resistance. This can mean it needs topping more often, but this extra management is paid for by the increased organic matter gained.

Winter mixes

Grazing rye or westerwolds ryegrass and vetch mix

Growing a nitrogen holder such as grazing rye and a fixer such as vetch together is a good way of improving soil in the months over winter. Grazing rye and vetch are excellent companions and can be sown from mid September until mid October, a later sowing window than other green manures. Incorporation is carried out from February until late April. Although grazing rye is the best nitrogen holder, westerwolds ryegrass can be used as an alternative to bring the seed cost down.

Summer mixes

Diverse annuals mix

There is often an opportunity during warm weather to grow a fast-growing, annual green manure. These crops

add organic matter, hold surplus soil nitrogen, suppress weeds and act as a break crop by interrupting pest and disease cycles. Suitable mixtures can comprise up to four or five crops such as mustard, crimson clover, phacelia and Persian clover.

Summer green manure mixtures are planted from late spring onwards on bare ground or immediately after whole crop silage or any early cereal harvest in June or July. A good summer green manure will be ready for turning in after only 8 – 10 weeks and will therefore be incorporated before the sowing of a winter cash crop.

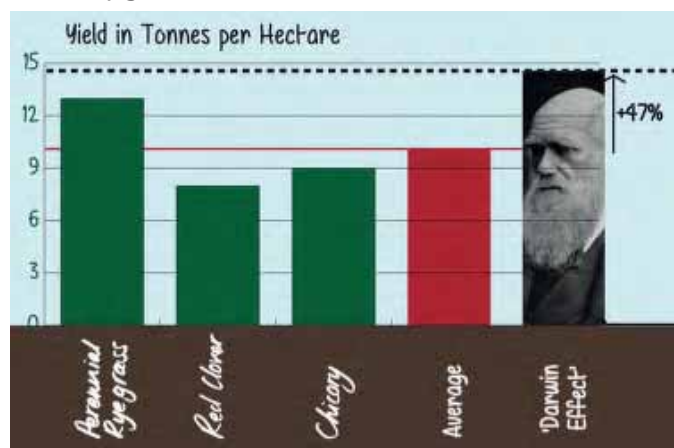
These crops give good leaf canopy cover to block out light, suppressing weed growth. They are easy to establish with many species able to grow on the soil surface without the need for cultivation. The seed is cheap and the crops are usually very reliable.

One further advantage of these fleshy annual plants is that incorporation is simple. The mixture should be worked into the soil at least three weeks before sowing the next cash crop. This will allow for the allelopathic effect to wear off (a shorter time with these species than with other green manures where plants are more woody when incorporated). It is important to ensure all summer green manures are destroyed before setting seed to prevent weed problems in the next crop.



Over-Yielding Effect of Mixtures

Two hundred years ago, Charles Darwin recognised what happened when different species of plants are grown together. You might assume that the potential average yield from, say, three different plants could be calculated by simply adding up the yield of each and dividing by three. But that's not what happens. You get an overyielding factor - the Darwin Effect - as a result of the different species overlapping in terms of root depth, aerial growth and the time they grow.



This is regularly seen when using mixtures and this is backed up by several recent scientific studies which have demonstrated how mixtures of plants increase yield by around 50%, half as much again as when using a single species.

Love Your Earthworms

Earthworms are indicators of soil health. They oxygenate soil, eat soil, and play a huge role in returning CO₂ to the soil. Intensive farming, frequent tillage, pesticide use, artificial fertilisers and unavailability of manures/compost have all contributed to declines in soil organic matter and soil health and ultimately declines in earthworm populations which in turn has impacted on the many species of wildlife which eat earthworms including lapwing, curlew, buzzards and even foxes! Did you know it's even thought that worms may interact and form herds?

Cultivations systems such as Min Till and Zero Till tend to reduce the loss of earthworms. Compacted soil reduces earthworm mobility, impedes crop root growth and in turn leads to increased risk of soil run-off during heavy rainfall. Run-off takes with it soil, pesticides and nutrients such as phosphate, watercourses clog up, aquatic plant growth is suppressed, oxygenation is reduced and fish are robbed of spawning habitat.

Meanwhile, earthworm castes contain 5 times more nitrogen, 7 times more phosphorous, 11 times more potash, and 1.5 times more calcium than surrounding soil. At Lower Smite Farm we work with our earthworms and feed them. Two to four year species diverse herbal leys receive manure or compost whenever we can get our hands on it. This has led to increased soil organic matter, improved moisture retention and generally better soil structures. We also leave areas of these leys uncut rotationally to benefit pollinators and birds.

Look after your earthworms and they will look after you.

First Hand



Caroline Corsie, a trained agronomist, believes that farming starts from the soil up. She has run Lower Smite Farm for The Worcestershire Wildlife Trust for the last eight years. She believes that crop diversity which provides better habitats is also extremely beneficial to the farm's bottom line.

One of the objectives of the farm is to demonstrate ways of making a small acreage viable. There are part fields with cereals and other cash crops but there is also phacelia, mustard, trefoil, sainfoin, lucerne and deep rooting humus building leys that contain cocksfoot, red clover and chicory. The policy here is quite deliberate. Caroline is improving the soil by growing green manure crops, raising organic matter levels and the rest - including farm profitability - should follow.

Caroline scrupulously analyses soil before and after green manures and has found some big changes. After what she refers to as 'investment' period in a field of up to four years she has an increased organic matter (OM) by 0.5%. This may not sound much but from a base of 3.5% that is a huge increase and that's without FYM or compost. In other areas where household compost and manure have been used OM levels have been increased by up to 3%.

Alsike clover

(Trifolium hybridum)

N fixer, short to medium term

Alsike clover is a short term perennial typically lasting 2-3 years, it is a low growing species potentially useful for undersowing beneath cash crops. A legume that is more suited than some to slightly heavier, lower pH soils. Compared to many annual clovers it can be the slowest to flower after a spring sowing.



LEGUME



Sowing rate: 15 kg/ha or 1.5 g/m²

Clover seed is small and sensitive to depth, it is critical to shallow sow or surface broadcast, with good seed bed consolidation, small seeds prefer a firm well worked seedbed.

Ideal sowing time

The majority of clovers should be sown into warm soils in the spring or before soils start to cool in the autumn, the establishment is less reliable after the middle of September.

Suitable varieties

Variety choice for alsike clover is limited, the majority of seed is produced in Canada.

Frost tolerance

Unlike the annual clover, this species will survive during the winter unless temperatures are exceptionally cold.

Weed competitiveness

Alsike clover can be slow to establish initially, however due to its low growth habit it can successfully suppress weeds once established in the bottom of a sward or mixture.

Biomass

Less bulky than the annual clovers or red clover, but still provides reasonable biomass and ground cover.

Nitrogen fixing potential

Little information is available for N fixing

Persistence

This short lived perennial will last for 2-3 years and due to its prostrate rather than erect form can tolerate light livestock grazing.

Topping regime

As a perennial alsike clover can be topped or grazed, and will regrow for a few years.

Pest and diseases

Alsike clover will suffer from the majority of other clover based pests or diseases such as mildew, but less susceptible to sclerotinia and crown rot, growing it in rotation will help to reduce pest and disease pressures.



Berseem Clover

(Trifolium alexandrinum)

N fixer, short term

This is a short term annual clover, also known as Egyptian Clover. It provides fast growing biomass and nitrogen fixation, when sown in warm soils.



LEGUME

Sowing rate: 15 kg ha - 1.5 g/m²

As with other clover seeds, it is critical to sow this seed to a shallow depth on a fine, firm seedbed. Sowing too deep will dramatically affect plant establishment.

Ideal sowing times

Berseem clover should be sown when the soils are warm (the soil should be no less than a constant 7 degrees temperature and on the rise). This is usually from late March through to early September, with adequate soil moisture.

Suitable varieties

A number of varieties are available, most commercial varieties are the multi-cut type which offer regrowth if left in situ.

Frost tolerance

This is the least winter hardy of the true clovers, so late autumn sowings should be avoided, its low frost tolerance can be used as a tool to kill the plant off over the winter months.

Weed competitiveness

Due to its quick growing nature, it can be very useful at suppressing weeds, shallow sowing is critical to get seedlings off to a vigorous start.

Biomass

Berseem clover is a high biomass species, producing very fleshy plant growth, coupled with its low frost tolerance the green material can break down quickly, making it easy to incorporate before the following crop.

Nitrogen fixing potential

Although information is scarce, estimates have shown that an incorporated crop of berseem clover made 125-200 kg ha of nitrogen available to the following Barley crop. Although some recommendations state that higher N fixation is more likely if the seed is treated with a strain of rhizobium inoculant.

Persistence

This species has a vigorous establishment phase and high biomass, but will normally be killed by typical winter frosts in the UK.

Topping regime

The vigorous nature of the plant allows regrowth if the plant is cut during early maturity, cutting after flowering or late in the season will give little regrowth.

Pest and disease problems

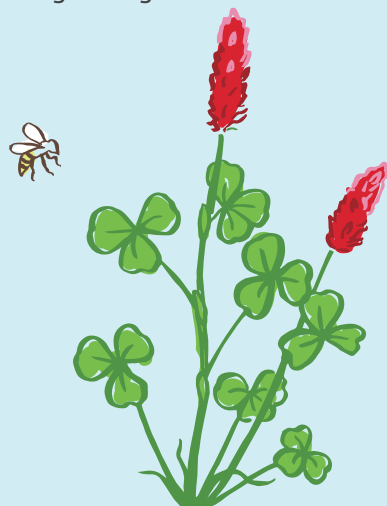
Stem rot and mildew can affect Berseem Clover.

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.



LEGUME



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

Frost tolerance

Crimson clover sown in autumn will survive as small plants through frosts over the winter in milder climates in the south of England. In spring the growth rate increases and a full canopy will form.

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

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.

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

Lucerne should be sown at 1cm. The soil should be rolled after sowing to increase soil moisture contact with the seed.

Ideal sowing time

For a spring sowing, March – May is ideal. Seeds 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.

Frost tolerance

Foliage of lucerne dies off over winter, but resumes growth from its crown in the spring.

Weed competitiveness

Lucerne is slow to establish 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 but 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 11).

Persistence

Lucerne shows good persistence, and is ideally grown for a period of 2 – 3 years although it can be grown for longer. Its persistence depends on 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.

Pest and disease problems

Observations suggest that lucerne is slightly more susceptible to downy mildew and attack from sitona 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. Varieties should be selected to have good resistance to V. wilt.

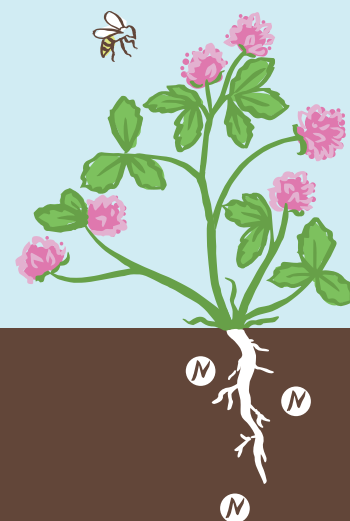
Persian clover

(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.



LEGUME

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

From an autumn sowing, phacelia often survives through mild winters however prolonged frost will normally kill the plant.

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 westerwold 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.

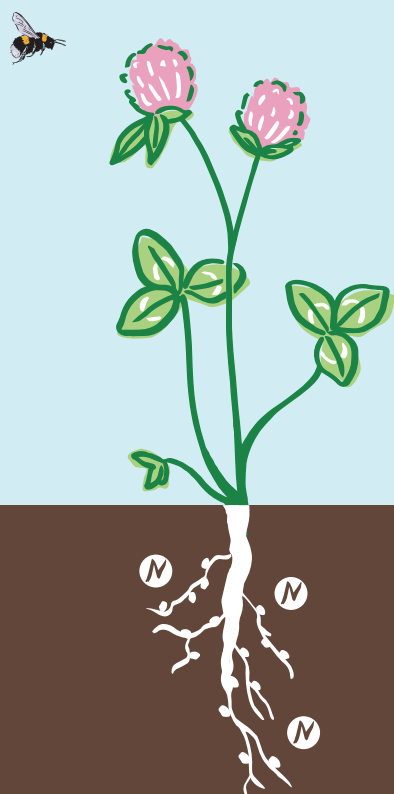
Pest and disease problems

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.



Red Clover

(Trifolium pratense)



N fixer, short to medium term

Red clover is one of the most tried and tested green manures for short to medium term leys, especially popular with organic farmers. Once established, it is capable of rapid growth and shows reasonably good persistence up to three years. Red clover silage has very good protein levels and is a valuable by-product.



LEGUME

Sowing rate: 15 kg/ha or 1-5 g/m²

Clover seed 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 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 only if there is sufficient moisture in the soil. 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

Considerable resources have been devoted to developing varieties of red clover. Milvus is one of the most commonly grown. Merviot produces large amounts of biomass and has shown some resistance to Sclerotinia rots. AberRuby also produces very large amounts of biomass.

Frost tolerance

The plant over-winters as crowns. This structure should be tolerant of all but the most severe frosts.

Weed competitiveness

Although not the most rapid to establish, red clover generally competes well against weeds. Once established, it produces large amounts of biomass that smother weeds. It also grows back rapidly after topping, which is important in out-competing weeds.

Biomass

This green manure is one of the most productive, typically producing an annual dry matter yield of 10 t/ha. Biomass can be increased significantly by sowing with grass.

Nitrogen fixing potential

150kg N/ha per year is a typical figure for a ley that is cut and mulched, but this could be considerably increased if the material is removed for silage as cutting and removal stimulates N fixation.

Persistence

The crop should persist for two years, and with varieties such as Milvus may extend beyond this, although the population tends to decline if left longer. It is survival of the plant crowns that determine the longevity of the crop. These gradually deteriorate over time, becoming diseased, damaged by cutting, trafficking or trampling by livestock.

Topping regime

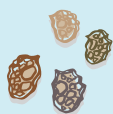
Red clover should be mown regularly whenever it reaches a height of 30cm. The first cut may be before this if there is a severe weed problem. On a dry sandy soil, it may only need cutting twice in the season. Conversely, on a fertile soil in a warm wet summer, it may need cutting as frequently as once every ten days.

Pest and disease problems

Red clover is more susceptible than other species to the soil borne disease Sclerotinia trifoliorum and the stem nematode, Ditylenchus dipsaci, responsible for the widespread clover sickness in the 1970s and 80s. For this reason, there should be a four year gap between red clover crops. Other fertility-building crops such as white clover can be used as an alternative.

Sainfoin

(Onobrychis viciifolia)



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.

LEGUME



Sowing rate: 87.5 kg/ha or 8.75 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 accessions, some 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.

Persistence

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.



Sweet Clover

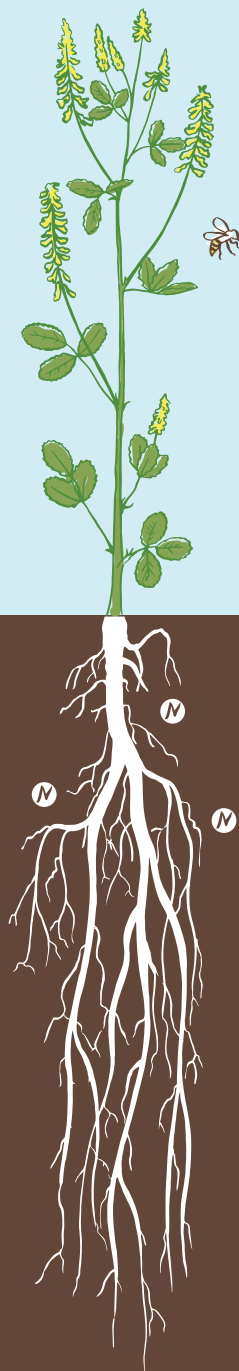
(*Melilotus officianalis*)



LEGUME

N fixer, short to medium term

Sweet clover (Also known as yellow blossom) 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: 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 11).

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.

Topping regime

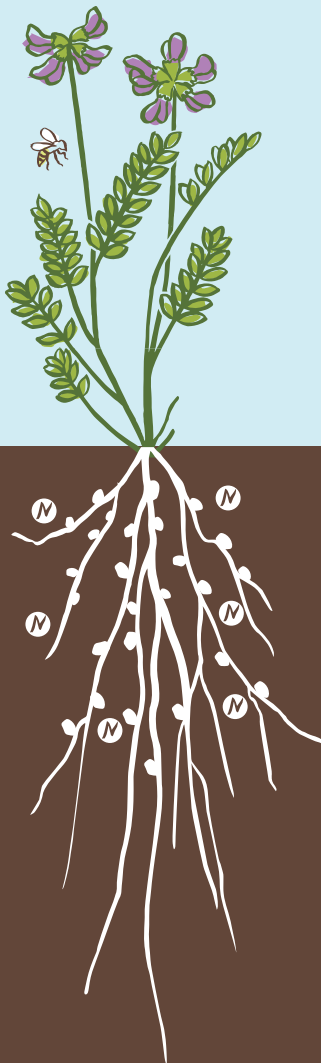
Sweet clover does not take kindly to hard topping, so should be topped 10cm above the ground. This may limit the options for weed control.

Pest and disease problems

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

Vetch

(*Vicia sativa*)



LEGUME

N fixer, short term

Vetch (also known as tares) is very popular, providing a rapid fix of nitrogen. It is particularly good at competing against weeds.



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.

Suitable varieties

Early English is a commonly grown variety which is winter hardy. Other varieties are also sown but it is important to use winter hardy 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 7). 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.



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.



LEGUME

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 only if there is sufficient moisture in the soil. 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.

Small leaved varieties: best for hard grazing by sheep. Varieties include AberAce or S184.

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

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

Frost tolerance

The plant over-winters as an underground stolon structure. This structure should be tolerant of all but the most severe frosts.

Weed competitiveness

White clover is slower to establish than some green manures and 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 at around 7t DM/ha, but persists for a greater number of years. It may be mixed with grass which increases biomass to 13t+ DM/ha.

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.

Persistence

White clover is one of the most persistent of the green manure crops and will commonly last for 7– 8 years.

Topping regime

White clover should be mown regularly whenever it attains a height of 30cm but can be cut before this if weeds are a problem.

Pest and disease problems

A lot of breeding effort has gone into varieties of white clover and, as such, many have good tolerance to the common pests and diseases such as Sclerotinia and stem nematodes.

Yellow Trefoil/Black Medick

(*Medicago lupulina*) 

N fixer, short to medium term

Yellow trefoil (or black medick) is a short-lived annual/biennial with a low growth habit making it a common choice for undersowing.



LEGUME

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.

Biomass

This crop produces a slightly smaller annual biomass than red clover.

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

Yellow trefoil should be mown regularly whenever it attains a height of 20cm. The first cut may be before this if there is a severe weed problem. Mowing is important to maintain the viability of a yellow trefoil crop. The frequency of mowing will vary widely between sites. On a dry sandy soil, it may only need cutting twice in the season. However, on fertile soil in a warm wet summer, it may need cutting more often.

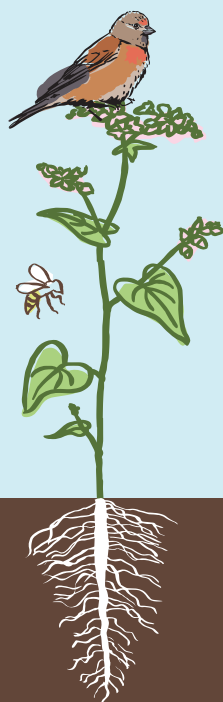
Pest and disease problems

The information on pest and disease tolerance in yellow trefoil is limited. Observations on the variety Virgo Pajbjerg suggest that it is slightly more susceptible to Sitona weevil and downy mildew than red or white clover, but neither of these is considered serious.



Buckwheat

(Fagopyrum esculentum)



Weed suppressor and P provider, short term

Buckwheat does not fix nitrogen but is a very rapidly growing annual crop. It is good at scavenging for phosphate in the soil, breaking it down and then making it available to subsequent crops after incorporation, especially useful on soils that suffer from phosphate lockup.

NON-LEGUME

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

Buckwheat does not fix N but will prevent it leaching. It is also thought to make phosphate more available to subsequent crops.

Persistence

Buckwheat has good growth over the summer from a spring sowing. It will continue producing leaves and flowering throughout the summer until it is killed off by the first frosts.

Topping regime

Buckwheat does not generally need topping

Pest and disease problems

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



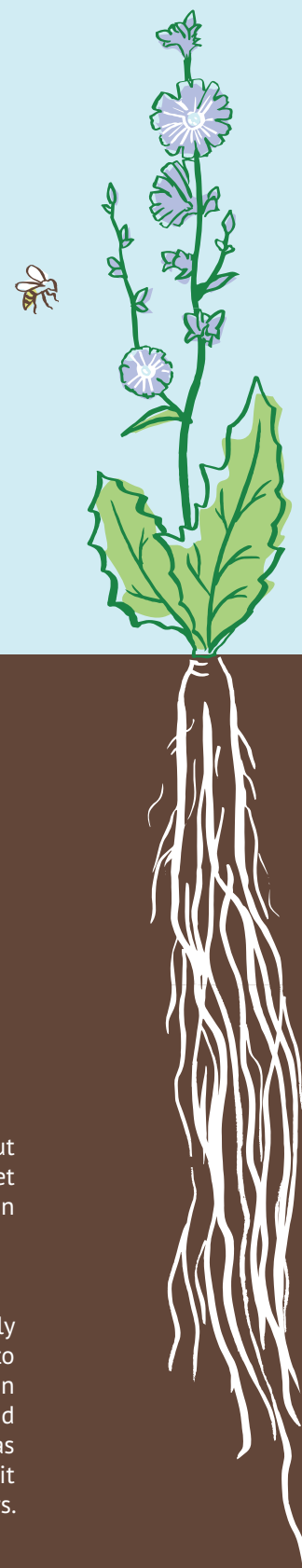
Chicory



(*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.



NON-LEGUME

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 early 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 reliably lasts 3 - 4 years but can last for up to ten. 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.

Cocksfoot

(Dactylis glomerata)



N holder, medium to long term

Cocksfoot does not fix nitrogen but is a good storer 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.



NON-LEGUME



Sowing rate: 20 kg/ha or 2 g/m²

Cocksfoot seed is small and should be sown to 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.

Biomass

Cocksfoot will produce 13t DM/ha per hectare annually.

Nitrogen fixing potential

Cocksfoot does not fix N. It is a good storer, however, and releases N over a long period of time when ploughed in.

Persistence

Cocksfoot is very persistent and is suitable for between 2-10 years.

Topping regime

Cocksfoot will need topping or frequent grazing for weed control and to prevent it flowering. If left it can become stemmy and develop into tussocks.

Pest and disease problems

There are generally few pest and disease problems with cocksfoot.

Fodder Radish

(Raphanus sativus)



Soil structure, short term

Also commonly known as oil radish, fodder radish is not a legume, but it will hold any residual nitrogen in the soil, which it will then release as it breaks down over time. This species is slower to flower and go to seed than mustard and produces a deeper root system.



NON-LEGUME

Sowing rate: 15 kg/ha 1.5 g/m²

This small brassica seed should be broadcast or shallow sown on to a fine seedbed, it should be rolled immediately after sowing.

Ideal sowing time

Sow in the spring summer or autumn into warm soils.

Suitable varieties

As the popularity of these types of crops increase, more varieties are beginning to become available, some claiming increased nematode control and clubroot disease resistance.

Frost Tolerance

Fodder Radish is more tolerant to lower temperatures than Mustard, however it is not frost hardy and several nights of a sharp frost will usually kill off the plant.

Weed Competitiveness

This quick growing species is competitive against weeds, forming early ground cover in a basal rosette before gaining height and producing a flower head after 6-8 weeks.

Biomass

Large amount of biomass can be produced and incorporated to the soil.

Nitrogen fixing potential

Fodder radish is not a nitrogen fixer.

Persistence

Fodder radish is an annual brassica, typically flowering later than mustard and taking longer to set seed.

Topping regime

This annual brassica is not normally topped except to destroy it for incorporation.

Pest and disease problems

It can suffer from the usual pests and diseases connected to brassicas, although its quick growing nature can help to grow away from these issues.

Grazing Rye

(Secale cereale)



N scavenger, short term

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



NON-LEGUME

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 7). 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

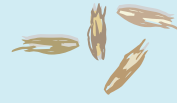
Grazing rye may need topping in March or early April, either for weed control or to prevent it flowering and becoming stemmy.

Pest and disease problems

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

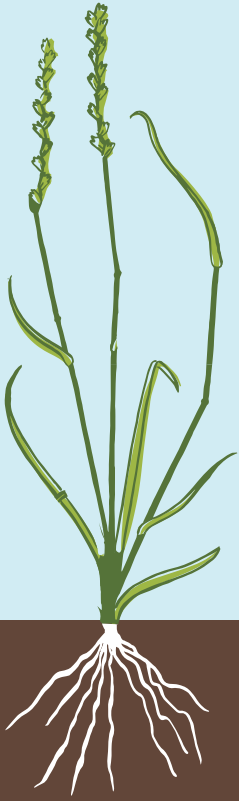
Italian Ryegrass

(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.



NON-LEGUME

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 18t 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 and difficult to incorporate. 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 leatherjackets, 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.



NON-LEGUME

Sowing rate: 20 kg/ha or 2 g/m²

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

Ideal sowing time

Either autumn or any time after March as a short term crop.

Suitable varieties

There are many varieties of mustard available. Caliente type mustards have been bred to reduce various soil borne pests and diseases (see page 7). Their effectiveness depends very much on growing conditions and the manner in which they are incorporated.

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.

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

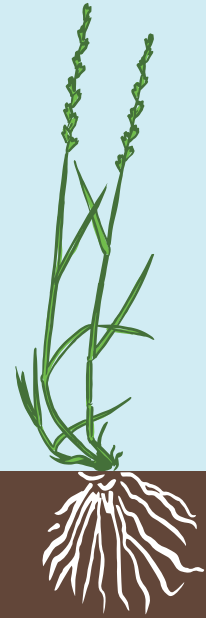
It is not usual practice to top mustard, except immediately prior to incorporation.

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 (*Plasmodiophora brassicae*) so should be grown in the brassica part of the rotation.

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.

NON-LEGUME

Sowing rate: 35 kg/ha or 3.5 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, Twystar, Aberdart and Tivoli.

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.



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.

NON-LEGUME

Sowing rate: 10 kg/ha or 1 g/m²

Seed of phacelia is small and should be shallow sown at no more than a few mm or surface broadcast.

Ideal sowing time

Any time after March.

Suitable varieties

Cultivars are imported from Europe and Balo is a common strain. There are many good varieties to choose from.

Frost tolerance

From an autumn sowing, phacelia often survives through mild winters however prolonged frost will normally kill the plant.

Weed competitiveness

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

Biomass

Biomass production is prolific above ground but breaks down quickly after mulching 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.

Topping regime

Phacelia generally does not need topping.

Pest and disease problems

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

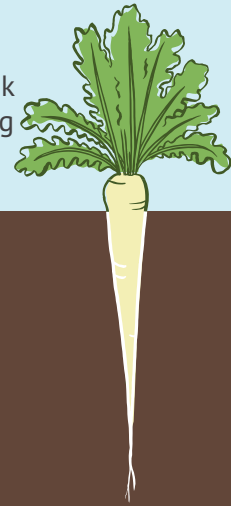


Tillage Radish

(Raphanus sativus)

Deep rooted annual for improved soil structure

Tillage Radish is a short term annual brassica, it has a deep rooting ability to break through compacted layers and plough pans, creating a better soil structure and improving drainage and air movement within the soil.



NON-LEGUME

Sowing Rate: 7.5 kg/ha or 0.75 g/m²

This small brassica seed should be broadcast or shallow sown on to a fine seedbed, it should be rolled immediately after sowing.

Ideal sowing time

Sow from April onwards, this quick growing species will produce a more significant taproot if allowed to grow during the spring and summer when the soils are warm, be aware that excessively hot weather 6- 8 weeks after sowing can cause plants to bolt and go to seed more quickly than normal. If autumn sowing plant in mid to late August in warm soils to get the most growth before the weather gets cooler in the autumn.

Suitable varieties

Structurator is one of the most popular varieties, however other breeders are developing their own varieties.

Frost tolerance

Not a strictly winter hardy species, several nights of freezing temperatures will normally kill it off, especially forward leafy crops.

Weed competitiveness

This fast growing annual can compete well with weeds, also smothering out emerging weed seedlings as it develops a thick green canopy in warm temperatures, however if left over winter it may die away leaving the ground open to weed invasion.

Biomass

It produces good levels of both green biomass above ground and root biomass below the ground.

Nitrogen fixing potential

This species does not fix nitrogen, but it will mop up and hold any excess n in the soil and release it as it breaks down over time.

Persistence

This annual will last through the summer from a spring planting, late autumn planting should be avoided as little taproot is produced.

Topping regime

This species is not normally topped unless it is to be incorporated

Pest and disease problems

Tillage Radish will suffer from the same disease pressures as other brassicas, it is a hungry species so good soil fertility will encourage strong growth, it can also be affected by and is a potential host for clubroot.





Westerwolds Ryegrass

(*Lolium westerwoldicum*)

N holder, short term

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



NON-LEGUME

Sowing rate: 35 kg/ha or 3.5 g/m²

Westerwolds seed should be drilled to a depth of 1cm. 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 overwinter 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 Lifloria 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 18t 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.

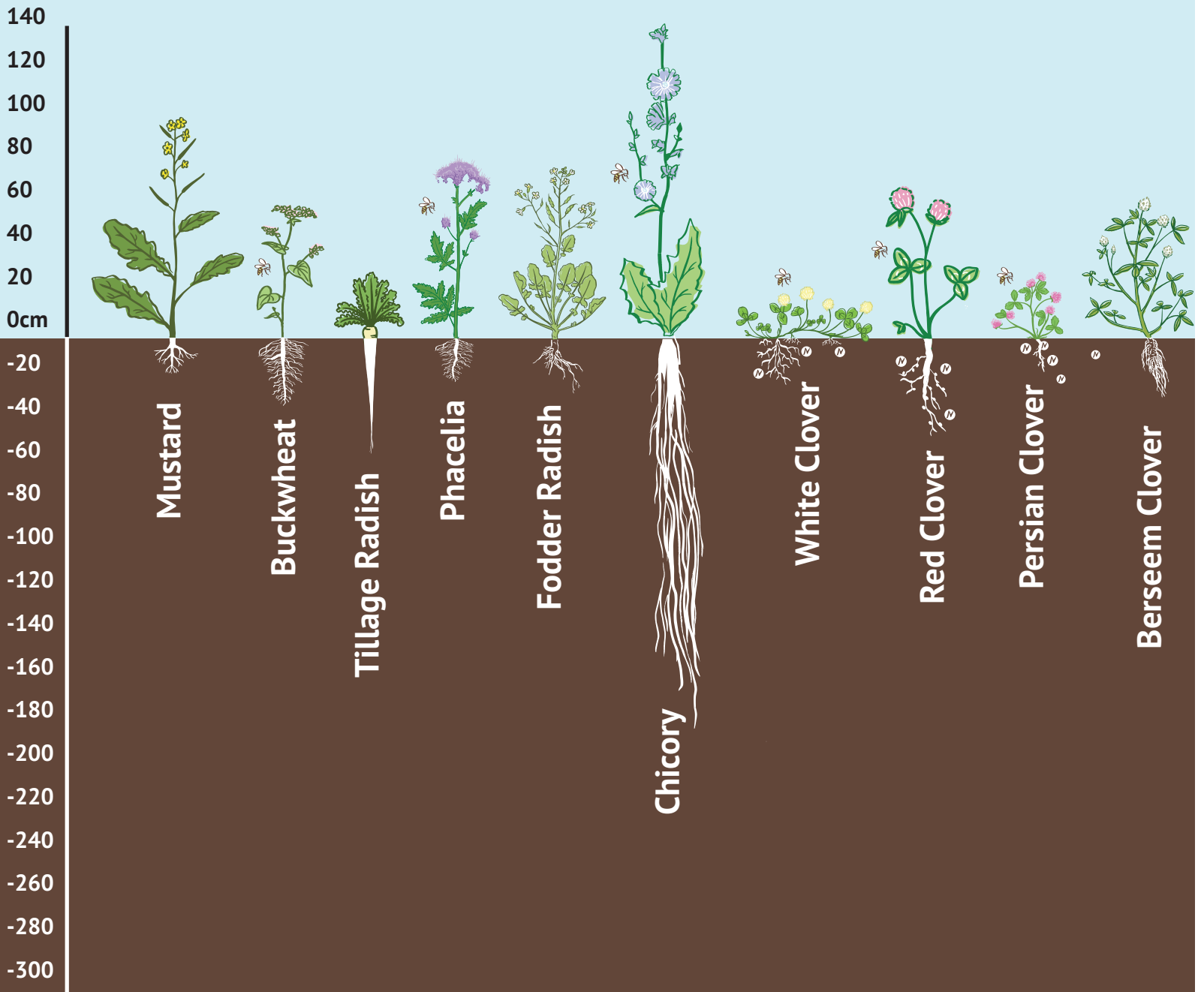
Topping regime

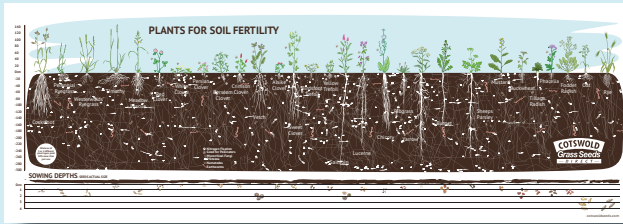
Westerwolds ryegrass will need topping or grazing either for weed control or to prevent it flowering and becoming stemmy.

Pest and disease problems

There are generally few pest and disease problems with westerwolds.

GROWTH HEIGHTS and root depths





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