Vegan-Organic Information Sheet #8 (60p)

Green Manures

Growing with concern for people, animals and the environment

Organic growing involves treating the soil, the growing environment and the world environment as a resource to be preserved for future generations, rather than exploited in the short term. Vegan-organics means doing this without any animal products at all, which is not difficult when you know how. *All soil fertility ultimately depends on plants and minerals - these do not have to be passed through an animal in order to work.* Fertility can be maintained by plant-based composts, green manures, mulches, chipped branch wood, crop rotations and any other method that is sustainable, ecologically benign and not dependent upon animal exploitation.

The guidelines below do not attempt to be fully comprehensive. *The extent to which you adhere to any system really depends on you, your conscience and circumstances.* We can only do our best with our available time and money. The Vegan-Organic Network has now published comprehensive Stockfree Organic Standards, which are available to commercial growers and can also be used as a reference for home growers. Of course, no one person or organisation knows everything about the subject, so constant co-operation and updating of ideas and information is needed.

Whilst conventional cultivation relies on synthetic chemicals and animal products, traditional organic production also generally relies on animal wastes and by-products. Both involve the exploitation of living creatures, and the inefficient use of land, water and energy resources. Vegan-organic methods minimise these drawbacks. Many people who are not themselves vegan or vegetarian are coming to appreciate that animal-free growing is the most sustainable system: it is the future of organics.

Introduction

Green manures are plants that are grown specifically to benefit the soil, replacing nutrients, improving soil structure and increasing organic matter content. All soil fertility cannot be derived from plant-based compost. Shortages of raw materials and the problem of removing crops from the garden, combined with losses due to leaching and oxidation means that there will always be a shortage of compost available[1]. To maintain organic matter levels in the soil therefore gardeners must also rely on extensive use of green manures, particularly legumes, for nitrogen and deep-rooting green manures for the recovery of phosphate and potash from the subsoil.

Fertility building with a ley

A ley is an area of your plot taken out of cropping production and replaced with growing green manures for fertility building. Some green manures are from the legume family and have the ability to take up nitrogen from the air, tapping a free source of soil fertility. Red clover and lucerne are the usual nitrogen-fixing green manures chosen for the ley, although mixtures including these and grasses are also widely used.

The green manure ley may grow for several years and has the benefit of improving soil structure, as the deep roots of a green manure like clover penetrate and break up the soil and the subsoil and the root channels remain long after decomposition. A grower cannot create such a complex and intricate network of tiny air pores and drainage channels with a fork. A subsequent crop will be able to take advantage of this improved soil structure.

A simplified rotation that you might like to try on your patch may be:

Plot 1 – Fertility building ley (lucerne or clover sown early spring)

Plot 2 – Potatoes (followed by an overwinter green manure, e.g. cereal rye)

Plot 3 – Brassicas (undersown with phacelia)

Plot 4 – Legumes / Alliums (followed by an overwinter green manure of vetch)

Plot 5 – Roots and salads

Summer sown green manure between rows of onion

How does nitrogen fixation work?
Nitrogen-fixation is essential to the cycling of nitrogen out of the atmosphere and into the environment occupied by living organisms. There are a group of nitrogen-fixing bacteria called rhizobia that have a special intimate relationship with leguminous host plants: peas, beans, pulses, peanuts, vetches, lupins, lucerne and clover.

The rhizobia live in a free state in the soil and exist quite happily in this way until a legume is planted into the ground close to where they are living. As the legume seedlings develop, their roots start to secrete substances into the soil, which attract the rhizobia nearby. The bacteria eventually enter the roots and stimulate the formation of swellings, called nodules, inside which the microbes multiply. At the same time, the bacteria take on different shapes to such a degree that they no longer look much like the soil rhizobia from which they came. For this reason, in the roots they are called 'bacteroids' and these now have the ability to fix nitrogen from the air.

In exchange for a share of the legume's sugars manufactured by the leaves and stems of the plants, the bacteroids pass on nitrogen in a usable form to the host plants and to adjacent plants and leave a surplus in the soil to be taken up by subsequent vegetables via rotation.

Carbon-rich green manures for building humus
Digging in young lush green manures will add immediate nitrogen and stimulate activity in the soil, but will not generally boost the organic matter levels. On the other hand, mature, dry and carbon-rich residues like cereals and straw will take longer to break down but will boost the humus reserves, releasing nitrogen over a longer period of time. Carbon-rich green manures will decompose faster if they are chopped, shredded and kept moist before digging in.

Choosing a green manure
Green manures increase fertility and get life back into the soil. Like any organic crops, green manures should not be

Table 1. Different green manures

Ley for longer-term fertility building before heavy feeding crops (e.g. potatoes) in rotation	Red clover, lucerne (pure stand) Grass mixes are not recommended prior to potatoes
Catch crop for maximising nitrogen fixation	Crimson red clover, vetch
Resistance to foot traffic soil damage in crops	White clover, trefoil
Paths	White clover various types
Undersowing outdoor crops	Red clover, lucerne, vetch, cereals
Undersowing greenhouse crops	Kent wild white clover, bird's-foot trefoil
Overwinter green manures that are winter killed	Phacelia, buckwheat, mustard
Late autumn sowings	Cereals in general, especially rye
Summer weed suppression	Phacelia, rye and buckwheat
Reducing wireworm populations	Mustard

Table 2. Recommended nitrogen 'fixers' by growers

Green manure	Suitability dates	Hand sowing per metre squared	Notes
Lucerne	April - July	2 grams	Good perennial ley up to 5 years that is drought resistant. Needs a high pH, well-drained soil and inoculum to establish. Can be grown as a pure stand or with non-aggressive grasses.
Red clover	April - E Sept	1 – 2 grams	Good perennial ley up to 3 years that can tolerate wetter conditions. Roots have many branches and a taproot, high yielding in terms of green material, rapid recovery after mowing. Ensure eelworm-free. Can be grown as a pure stand or with more aggressive grasses, e.g. ryegrass.
White clover	April - E Sept	1 – 2 grams	Shallow-rooted, low-growing clover suitable for paths for up to 9 years. Need strong-growing varieties to recover from mowing. Best established in spring.
Crimson red clover	July - E Sept	1 – 2 grams	Annual, best for N fixing between crops and is usually only grown for 2 – 3 months.
Vetch	April - E Sept	8 – 15 grams	Deep-rooted, quickly produces a large weight of green material especially in early spring. Suitable for undersowing when it is to be incorporated the following spring. Does not recover from constant mowing and should only be lightly topped once to control the first flush of weeds.
Kent W W Clover	April - E Sept	1 – 2 grams	Low-growing clover suitable for undersowing greenhouse crops. Trim with shears.
Bird-s-foot trefoil	April – E Sept	1 - 2 grams	Low-growing suitable for undersowing greenhouse crops and tolerant of shade. Trim with shears. Seeds can be expensive.

grown in endless monoculture, as they have their advantages and disadvantages for following crops in rotation.

Sowing a green manure by hand

Timing of sowing:

1. At the beginning of the sowing period (e.g. early May) generate a stale seedbed prior to sowing and broadcast the seed at the higher seed rate. The stale seedbed technique (also known as false seedbed) exhausts the weed 'seed bank' at the surface. The first flush of weeds is scratched out of the surface by a shallow cultivation. This will give the green manure more than a fighting chance against

Table 3. Recommended 'lifters' by growers

Green manure	Suitability date	Hand sowing per metre squared	Notes
Cocksfoot grass and chicory	April – late Aug	3 grams	Strong taprooted species for improving soil structure and building humus. Non-aggressive species that can be grown in a ley with red clover or lucerne.
Ryegrass	Sept -Nov	2 grams	Aggressive quick growing grass should be mulched back or dug in before seed heads appear. Good for foot traffic. Often included in ley with red clover.
Cereal rye	Sept -Nov	23 grams	The most winter hardy of cereals, which will germinate at 3ºC. Best root system of annual cereals, can reduce N leaching by two-thirds. Incorporate in April when the seed head can be felt at the base of the stem.
Barley	Sept - Nov	15 - 30 grams	Less hardy than cereal rye or winter wheat. Likes cool and dry conditions. Produces more biomass than other cereals and seeds are inexpensive
Oats	Sept -Nov	15 - 30 grams	More sensitive than barley, but can tolerate wider pH, good on all soil types, fibrous roots.
Buckwheat	April - E Sept	6 grams	Good for summer use and grows quickly, incorporate before it goes to seed. Will grow on infertile soil, frost-sensitive.
Rape	Mar – Sept	2 grams	Superior at mopping up nutrients, frost-sensitive, brassica family and can carry club root.
Mustard	Mar – Sept	2 grams	Frost-sensitive but provides large quantities of green material in 6 - 8 weeks. Brassica family and can carry club root, can be used to suppress wireworm populations in appropriate rotations, dig in before flowering.
Phacelia	April - August	1 grams	Fern-like leaf for weed suppression. Flowers attractive to beneficial insects especially bees. Incorporate after 2 months.

the weeds.

- Prepare a seedbed two weeks ahead of sowing the green manure.
- Once the fast emerging weeds appear (at about 10 days), carefully cultivate the area on a dry day by scratching it to a depth of 1cm using a metal rake, taking care to disturb only the very surface layer of the soil.
- Allow the weeds to wilt and die and

then sow the green manure seeds immediately.

• Repeat and prepare a stale seedbed for a second time if there has been a prolonged wet period.

2. At the height of the sowing period (summer), e.g. June and July, broadcast the seed at the lower seed rate.

3. At the end of the sowing period (late summer/early autumn), e.g. August and early September, broadcast the seed at the higher seed rate.

With all three timings:

• Rake the seed gently into the soil.

• Pat the soil down with a roller, your feet or the end of the rake.

Overwinter green manures

Wind and water erosion may be prevented by using green manures, as 'cover crops'. Since adverse weather conditions tend to be in winter, bare soil at this time is bad practice. The overwinter green manure roots hold the soil and the top growth prevents most damage from splashing and surface run-off.

Clover by Jenny Hall

It must be remembered that the *greatest loss of nutrients is due to leaching and not removing crops from your vegetable patch.* Vegetable growing makes heavy demands on the soil and there is no point in building fertility and then allowing it to wash away with the winter rains. Green manures will 'fix nutrients in carbon' in the aerial parts of the plants and, even if the green manure dies over the winter, the nutrients are stored until the soil micro-organisms break them down and are unlikely to be leached.

• The autumn-lifted crops which are not suitable for undersowing (see below) can be followed by a green manure once the soil is cleared. This will typically be potatoes and onions.

• Depending on the month it may be possible to sow:

• clover before early September;

• cereals from mid-September to early November.

Legumes **do not** fix nitrogen during the winter months. Therefore, non-legumes like cereals are more suited to the role of overwinter cover, as their early growth is vigorous and they can establish themselves quickly.

Undersowing green manures

When using overwinter green manures, clovers and vetches need to be sown by August to get good establishment. There is a conflict of land use, as crops may be growing at this time. One way of getting around this problem, popularised in the

UK by Iain Tolhurst and in the US by Eliot Coleman[2], is the technique of undersowing. Undersowing is where the green manure seed is sown underneath the growing crop. It is getting the best of both worlds - cropping and soil protection/increasing fertility. The undersown green manure provides places for foot traffic and other compaction damage when harvesting the vegetables.

Undersowing green manures will, even in a growing crop, add some nitrogen and organic matter to the soil. But, as Iain Tolhurst argues, its real value comes in ensuring that the soil is covered prior to the winter period, when so many nutrients will

Table 4. Crops suitable for undersowing (adapted from Iain Tolhurst[1])

Crop	Height	Preferred green manure	Dates green manure will germinate & cover	Optimum undersowing date
Brassicas	20cm / 8"	Red clover	April - E Sept	July or later
Leeks	When early leeks are fully grown	Cereals	Sept - Nov	Late Oct
Squashes & courgettes	6 leaves	Red clover	April - E Sept	July
Sweetcorn	25cm / 10"	Red clover	April - E Sept	July
Runner beans	50cm / 20"	Red clover	April - E Sept	July
Tomatoes	50cm / 20"	Kent Wild White clover / birdsfoot trefoil	April - E Sept	July
Cucumbers	50cm / 20"	KWW clover / b trefoil	April - E Sept	July
Melons	6 leaves	KWW clover / b trefoil	April - E Sept	July
Aubergine	20cm / 8"	KWW clover / b trefoil	April - E Sept	July

Table 5. Crops not suitable for undersowing

Potatoes	Too dense foliage
Onions	Cannot tolerate root competition (see 3.5.7 for strip method)
Carrots	Root crops cannot tolerate competition
Parsnips	Too dense foliage
Lettuce	Growing period too short
Winter salads	Cannot tolerate root competition
Spinach, etc.	Too dense foliage
Celery	Cannot tolerate root competition
Beetroot	Growing period too short – cannot tolerate root competition
Radish/turnips	Growing period too short – cannot tolerate root competition
Swede	Cannot tolerate root competition

be lost from the soil due to leaching. Their use is also likely to favour the following crop. Undersowing usually takes place at the beginning of July.

Technique for undersowing

Eliot Coleman's[3] tips for successful undersowing include:

- a clean, weed-free seedbed providing the motivation for regular weeding;
- weed at least three times using a hoe before undersowing;
- the last hoeing should be the day before undersowing;
- the crops are then undersown with the grower holding a container in their hands and scattering the seeds as evenly as possible.

Mowing the green manure

The good news is that green manures can generally out-compete the weeds, as long as they are sown evenly. It may be necessary to rogue the odd perennial weed. When managing clover or lucerne it is necessary to have a regime of mowing. The first mowing prevents the annual weeds from going to seed. Subsequent mowing depends on how quickly the plants are growing. It is important to prevent the green manure growing too long or they may be too much material for the mower to process and it might lie on the ground and be difficult to cut. Frequent mowing will ensure that the mulched material rapidly assimilates into the soil and provides the ideal conditions for earthworm breeding. However, it is a good idea to let strips of the green manure flower to encourage natural predators like hoverflies and lacewings.

Tomatoes undersown with trefoil at Hardwicke

Vetch by Jenny Hall

The equipment needed for mowing is either a general garden mower; a strimmer; a scythe or a pair of shears.

Principles of mowing:

- Make sure that the ground conditions are dry, so that the mower wheels/your feet do not compact the soil.
- Mow several times a year, making the last cut of the year in late September or early October.
- Do not allow the green manure to go to seed.
- Mow tightly - as close as possible to the base of the green manure stems to ensure that the annual weeds are also killed.
- If large quantities of material are deposited by the mower, this suggests that the green manure was too long before mowing. Ensure that in future you do not let the ley grow so long and spread the piles of material evenly with a rake so that the clumps do not kill the green manure underneath.
- Do not mow large areas at once. Insects will migrate to crops when green manure leys are cut and pests like aphids may increase because there is so much raw fertility. It is better to leave areas or strips for the insects to migrate to.

Digging in a green manure

- The green manure should be chopped and shredded at ground level several days before digging in to allow for wilting to take place. (As rye can be particularly difficult to kill, the green manure can be pulled up, laid flat on the soil surface to wilt and then dug in.)
- A green manure can be incorporated by inverting the soil using a 'turfing' technique.
- Cleanly cut the edge of the turf with a spade.
- Under cut the green manure turf at a depth of at least 10cm/4" until it breaks.
- Turn the turf over by hand ensuring that no greenery is present on the surface.
- Leave for at least two weeks before trying to create a seedbed with a rake.
- If the green manure regenerates turn it in again.

Avoiding nitrogen lock-up

How quickly the green manure breaks down will be affected by soil temperature, moisture content and the carbon : nitrogen (C:N) ratio of the green manure. When green manures are dug into the soil, soil organic matter is one of the products of their decomposition. When a carbon-rich green manure such as a cereal is turned in, the soil micro-organisms multiply rapidly to feed on the organic matter, decomposing it but also consuming a lot of nitrogen doing so. This process leaves less available soil nitrogen (nitrogen lock-up) for subsequent

crop growth, until breakdown has completed and the microbes begin to die and release their nitrogen to the soil.

A general rule of thumb is to leave the soil for at least two weeks after turning in the green manure, before attempting to create a seedbed for another crop. If you were to turn something in with an even higher C:N ratio than a green manure, for example sawdust, this might cause nitrogen lock-up for several years and should be avoided.

Weeds and green manures

If you have bare ground then weeds will generate. Therefore it is a good idea to have a green manure growing instead.

If you are reclaiming a weed-infested patch then it is a good idea to dig out all the weeds with a fork. Forking, which involves lifting, turning and breaking up the soil to remove the weeds, is the traditional way of clearing weed-infested ground. By loosening the soil and breaking it into crumbs, it is possible to remove the tiniest bits of roots. After all the weed roots are removed then sow a green manure straight afterwards (especially if digging prior to the onset of winter) and the green manure will also have a cleaning effect.

If you have a green manure ley (see above) in rotation then you will automatically be lowering your weed burden. After a ley break the weed population is likely to be at its lowest. However, establishing a ley can be very vulnerable to dock infestation, because there is the potential for huge numbers of dock seeds in the soil to germinate in spring and autumn. Fortunately, dock seedlings can-

Lucerne by Jenny Hall

not compete well with grasses at this stage and so having a clover and grass mix will reduce the likelihood of early invasion.

Cabbage white butterflies and undersowing white clover

Stan Finch[4] has pioneered research into the benefits of undersowing for reducing competing insect problems. Many researchers have shown that the numbers of competing insects found on brassica crop plants are reduced considerably when the crop is:

- allowed to become weedy,
- intercropped with another plant species, or
- undersown with a living mulch such as clover.

Stan Finch carried out laboratory and field cage tests to determine how undersowing brassica plants with subterranean clover *(trifolium subterraneum)* affected host plant selection by eight pest insect species of brassica crops. The pest species tested were:

- *Pieris rapae* – small white butterfly

- *Pieris brassicae* – large white butterfly
- *Delia radicum* – cabbage root fly
- *Phaedon cochleariae* – mustard beetle
- *Plutella xylostella* – diamond back moth
- *Evergestis forficalis* – garden pebble moth
- *Mamestra brassicae* – cabbage moth
- *Brevicoryne brassicae* – cabbage aphid

In all tests (except one in which the brassica plants were about three times as high as the clover background) 39-100% fewer of the competing insects (of all eight species) were found on the host plants presented in clover than those presented on bare soil. The differences were not accounted for by an increase in natural predators and therefore, lower colonisation accounted for fewer pest species.

However, undersowing with clover only reduced the small white butterfly oviposition (laying of eggs) by 40-60%, which may be insufficient to reduce the damage to acceptable levels. In these circumstances fleecing in early spring and netting in the height of summer need to be considered. Ensure the netting does not rest on the plants and also has a narrow mesh or the cabbage white butterflies will push their way through. The long-term solution includes encouraging natural predators like parasitic wasps by planting attractant flowers.

---

[1] TOLHURST I (2002) reprinted in *Growing Green International.* No 9 page 22.

[2] COLEMAN, E (1995) *New Organic Grower. A Master's Manual of Tools and Techniques for the Home and Market Gardener.* Chelsea Green publishing.

[3] COLEMAN E (1995) *New Organic Grower. A Master's Manual of Tools and Techniques for the Home and Market Gardener.* Chelsea Green Publishing.

[4] TOLHURST I (2002) *Undersowing Green Manures in Vegetable Crops.* In *Growing Green International* no.9 page 23 reprinted with kind permission of the Soil Association.

[5] FINCH S & EDMONDS GH (1994) *Undersowing Cabbage Crops with Clover – Effects on Pest Insects, Ground Beetles and Crop Yields.* IOBC / WPRS Bulletin 17(8) 159 - 167.

The Vegan-Organic Network

The Vegan Organic Network is a registered charity (registered charity number 1080847), providing education and research in vegan-organic principles and has an international network of supporters. VON supporters enjoy a wide variety of contacts and can obtain advice on cultivation techniques. The magazine *Growing Green International* is sent to supporters twice a year. For more information and details of how to join, please contact:

VON, 58 High Lane, Chorlton, Manchester M21 9DZ
Email: info@veganorganic.net

General enquiries and advice on growing:
Phone: 0845 223 5232
Email: advice@veganorganic.net
Website: www.veganorganic.net

Vegan-Organic information sheets

This is one of several sheets produced on various topics by the Vegan-Organic Network. These are aimed mainly at those with allotments, kitchen gardens or other small growing areas, although many of the techniques will also apply to larger-scale situations. We welcome feedback on this information sheet and any other related topics. The information sheets currently available are: #1 Propagation and Fertilisers; #2 Growing Beans for Drying; #3 Growing on Clay Soils; #4 Vegan-Organic Growing - The Basics; #5 Fungi - FAQ: #6 Gardening for Wildlife; #7 Growers' Guide to Beetles; #8 Green Manures; #9 Chipped Branch-Wood; #10 Composting.

These are available on request. Please send £5.00 per set, or 60p each (£6 and 75p respectively if outside the UK). The sheets are also available free on our website.

Issued March 2005. This advice is given as guidance only, with no responsibility for any results, due to the nature of the processes involved!