



Organic Farming: Green Manures for Vegetable Cropping

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Introduction

Green manure crops play a very valuable role in agriculture because of the many benefits they provide to the soil and cropping system.

Green manures are crops grown specifically to improve soil condition and nutrition. Suppression of weeds and soil-borne diseases are additional benefits of particular green manures. Clever use of the characteristics of green manure crops is an essential tool in organic farming where chemical fertilisers, herbicides and soil sterilants are not permitted.



Figure 1. A green manure of ryecorn and vetch helps improve the soil on an organic vegetable block.

Instead of being harvested, green manure crops are incorporated into the soil, usually while they are still lush and green. At this stage of growth the plants have a relatively high nitrogen and moisture content, and provide an ideal food source for soil microbes and other organisms like earthworms. Under favourable conditions these organisms decompose the green manure reasonably quickly. During this process, organic matter and nutrients are released into the soil where they become available for use by other organisms including crop plants.

Some benefits of green manures

Organic matter source:

This critical component of soils is added through root growth, mechanical incorporation or mulching of the green manure crop. Soil organisms then decompose this organic matter into humus and other organic compounds. The organic component of soils, particularly humus, is a major determinant of soil properties including structure and biological activity. The latter includes the vital role that predatory nematodes and mites, parasitic fungi and other beneficial microbes play in suppressing crop pests and diseases. Maintaining or improving the organic matter level and biological activity of soil is one of the fundamental objectives of organic agriculture, and green manure cropping helps growers achieve this.

Nutrient recycling:

Residual nutrients which might otherwise be leached from the soil are absorbed by the green manure crop as it grows, then released when that crop decomposes. The nutrients largely become available to the following cash crop. This helps growers make more efficient use of applied nutrients and reduces the risk of nutrients being leached out of the crop root zone and into ground water or water ways. In this way, green manuring helps organic growers address the issue of water pollution along with the conservation and recycling of nutrients.

'Free' nitrogen:

Soil nitrogen levels are increased by leguminous green manures through their association with nitrogen-fixing *Rhizobium* bacteria. These bacteria 'infect' plant roots and fix atmospheric nitrogen into a form that plants can use. When leguminous plants decompose, the nitrogen is released for use by other crops. By using this 'free' service, organic growers can improve their soils while reducing their reliance on off-farm nutrient inputs.

Weed control:

Weeds are suppressed by the competition that dense, green manure crops exert for water, light and nutrients. Short-term green manures therefore provide organic growers with a productive, chemical-free and reduced-cultivation

option for weed management during non-crop phases of their vegetable crop rotation.

Pest and disease management:

Pest and disease cycles can be disrupted by the use of non-vegetable green manure crops in the crop rotation program. Some green manure plants, including cowpea, have extra-floral nectaries that attract beneficial insects like parasitic wasps to the cropping area. Others, like mustards, release natural chemicals into the soil and provide some bio-fumigant action against soil-borne diseases and nematodes. Thoughtful use of such green manures can benefit the overall cropping system whilst contributing to soil improvement.

Some disadvantages of green manures

No cash income:

While green manures do require management inputs, they do not provide a cash return to the grower. Their benefits need to be weighed against the income that a cash crop would generate.

Good timing needed:

If green manures are incorporated into the soil too late, when the plants are tougher, drier and relatively low in nitrogen, soil nitrogen levels may drop as the soil microbes use the available nitrogen to decompose the crop. This nitrogen depletion may affect the following crop.

Short window of opportunity:

Some green manures may not fit into the crop rotation easily because they take too long to develop and also too long for their residues to decompose sufficiently to allow seeding of the next cash crop.

Choice of green manures

The choice and management of green manure crops depends largely upon the farmer's objectives. For example, the structure of fertile soils may be improved with cereal and other non-legume crops, but legumes or mixtures including legumes would be chosen to improve the nitrogen status of poorer soils.

Following are some of the points to be considered when selecting green manures for particular situations and purposes:

- major objective (nitrogen source, bulk organic matter, weed competition, bio-fumigation);
- adaptation to seasonal climatic conditions (heat or cold tolerance);
- adaptation to local soils (heavy or light, pH, salinity);
- availability of water (rainfall or irrigation);
- availability and cost of seed and microbial inoculants if required;
- length of time from sowing to flowering (short enough to fit the 'window' between cash crops).

Some common green manures used in vegetable production in Victoria are listed below.

Table 1. Some crops commonly used in Victoria as green manures and their planting season (adapted from Sutherland and Piggott 1980).

	Summer	Autumn	Winter	Spring
legumes				
cow pea (slow)				
cow pea				
faba bean				
field pea				
lupin				
lupin (fast)				
vetch				
non-legumes				
barley				
canola				
Italian ryegrass				
Japanese millet				
mustard (slow)				
mustard				
oat (slow)				
oat				
oat (fast)				
rye corn				
sorghum (slow)				
sorghum				

(fast)/(slow) = faster or slower maturing varieties

Because crop performance is influenced by local conditions, local experience and expertise should be sought before choosing a green manure crop.

Cowpea and millet

Cowpea (*Vigna unguiculata*) and Japanese millet (*Echinochloa frumentacea*) are two summer annuals suited to use as green manures in warm areas. Both crops are frost sensitive so should be restricted to frost-free districts or sown after the frost risk period has passed. Cowpea and millet tolerate a range of soil types and can be grown together for the joint benefit of bulk organic matter and nitrogen fixation.



Figure 2. A dense stand of cowpea and Japanese millet ready to be incorporated into the soil.

Because of their rapid growth, cowpea and millet can produce useful amounts of organic matter during relatively short periods between vegetable crops. Table 2 lists the yields of dry matter in the above-ground portion of cowpea and millet green manures three months after sowing.

Table 2. Organic matter production by pure and mixed stands of cowpea and Japanese millet under irrigation at Mildura (February 2002).

Green manure mixture	Above-ground dry matter tonnes/ha
Cowpea (25kg/ha)	4.0
Cowpea (50kg/ha)	3.9
Millet (25 kg/ha)	7.3
Millet (50 kg/ha)	6.7
Cowpea + Millet (both 25 kg/ha)	6.3
Cowpea + Millet (both 40 kg/ha)	6.0

These yields are substantial, especially considering that they do not include the plant root system or the material removed by slashing the crop to a height of 20cm one month earlier.

Because of the importance of soil organic matter to long-term soil stability and productivity, the use of green manures to add these amounts of organic matter to the soil should be a regular aspect of most organic crop rotation systems. This is especially critical in frequently cultivated vegetable production, where soil organic matter is broken down rapidly.

Establishment and management

Like any crop, green manures require good management for successful establishment and growth. Good seedbed preparation, correct sowing rate and depth are all important.



Figure 3. A green manure of cowpea and Japanese millet three weeks after sowing.

Other keys to success include:

Weed management:

Although densely planted green manures can effectively smother weeds, early weed management is important to ensure good crop establishment and prevent the early establishment of weeds. Correct timing of sowing, sowing into a weed-free seedbed and well-timed mechanical weeding will all help get the crop off to a good start.



Figure 4. Weeding a young green manure of Japanese millet and cowpea with a striegel (a flexible-tined implement).

Nutrition & irrigation:

In vegetable cropping, green manures require irrigation for optimal production of organic matter. The need for nutrient and water inputs depends on the crop chosen as well as local climate and soil conditions. Some fertiliser application is likely to be needed to optimise establishment and growth of the crops. Nitrogen is generally not required for leguminous green manure crops but a small amount will aid establishment of the plants during the pre-nodulation stage. Non-legumes such as millet require adequate levels of nitrogen for good production. Fifty kg of nitrogen/Ha is recommended for irrigated Japanese millet in Victoria (Pritchard 1995). A range of nitrogenous fertilisers approved for use by certified organic growers

are available commercially. These are generally based on pelletised, composted poultry or cow manure.

Inoculation:

Leguminous crops such as cowpea, bean, clover and vetch should be inoculated with the appropriate strain of Rhizobium bacteria before sowing. This helps the crop establish good levels of root nodulation and nitrogen fixation.

Slashing:

Green manure crops are slashed, or better mulched, shortly before cultivation, to improve the mixing of organic matter into the soil and speed the release of nutrients. Earlier slashing is also used to improve the vigour of certain green manure crops.



Figure 5. A cowpea/Japanese millet crop being slashed prior to cultivation.

Incorporation:

As the majority of biological activity in soils is typically concentrated in the top 15cm of the soil, the incorporation of organic matter should be limited to this depth. The objective should be to mix the plant material thoroughly with the soil and bury it lightly below the soil surface. The plant/soil mixture should remain moist and aerobic for optimal microbial decomposition of the organic matter.

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Contacts

Australian Quarantine and Inspection Service (AQIS)
Organic Program

For information on certification organisations, the 'National Standard for Organic and Biodynamic Produce' and export requirements for organic produce.

Tel: (02) 6272 3928

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Organic Federation of Australia (OFA)

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