Turnip green *(Brassica rapa var. rapa)*

CHAPTER TWELVE

Eating Cover Crops

Cover crop is a broad term for a crop whose primary purpose is improving soil. Cover crops are sometimes called green manure crops, but cover crop may be a more appealing term when we are advocating eating a portion of them. Of all of the various techniques proposed to further sustainable agriculture, few have greater potential than eating a portion of cover crops.

Cover crops have been used to improve agricultural soil for at least 3,000 years in China and for over 2,000 years in southern Europe. Agriculturalists have long observed that yields are enhanced in fields that have been previously occupied by certain plants, especially plants of the legume or pea family. Over thousands of growing seasons they developed numerous systems for using plants to improve the vigor of their soil and produce more bountiful harvests.

Cover crops are the most ecologically realistic way to protect and improve essential food-producing soils. They can maintain the structure and fertility of good land and make marginal land more useful. All cover crops are essentially leaf crops, in that they are normally killed and incorporated into the soil before they can flower and reproduce. Cover crops can all take carbon dioxide from the air, where it is driving climate change, and put it into the soil as beneficial organic matter. Cover crops in the legume family have the enormous advantage of also taking nitrogen from the air and turning it into forms that plants can utilize.

Cover crops can serve several other functions. Their vast networks of roots open channels in compacted soil, improving drainage, aeration, and water-holding capacity. Cover crops create favorable conditions for earthworms and feed beneficial soil microorganisms, who in turn also improve soil aeration and nutrient availability.

The cover and roots of green manure crops protect soils from wind and rain erosion, especially on sloping land. Deep rooted cover crops can bring plant nutrients up from deep in the subsoil and dynamic accumulators can concentrate scarce minerals into useful quantities for later crops. Cover crops can reduce aluminum toxicity and interrupt the buildup of disease and pest organisms in crop land. Some cover crops can form a dense enough cover to smother out persistent weeds.

THE ECONOMICS OF EDIBLE COVER CROPS

The use of cover crops is a highly adaptable agricultural craft. There are cover crops that can be grown in all of the different seasons in most of the world. They can be grown as intercrops between rows of other crops. They can be planted around taller, faster growing plants. This is called undersowing. They can be grown on a separate field and harvested for use as mulch or to make compost. All of these methods use plants to improve the soil.

Cover crops are usually the cheapest and most ecologically sound means available for farmers and gardeners to improve and maintain the fertility of their soil. Purchasing seed for cover crops costs a small fraction of what farmers would pay for synthetic fertilizers. Animal manure is a useful fertilizer, but it must be gathered and brought to the land and it is most often in very short supply relative to the fertility demands of the farmer. Compost is certainly a useful practice for soil building. However, compost simply decomposes the organic matter and nitrogen that you already have on hand, whereas cover crops can actually create up to 36 metric tons of organic matter and 225 kg of nitrogen per hectare (16 tons of organic matter and up to 200 lb of nitrogen per acre).[1] What's more, a cover crop doesn't need to be hauled to a compost heap or hauled back to the fields because it can be grown exactly where the fertility is needed.

With these many advantages you might assume that cover crops are universally employed by people growing food. This is hardly the case. Throughout the world the use of cover crops is the exception rather than the rule. Farmers who can afford commercial fertilizer prefer it because it requires the least labor. Growers who can't afford commercial fertilizers often are unaware of the practice, and even when they are aware of it they often believe that they can't afford to grow a crop just to improve the soil. Subsistence farmers usually try to keep every scrap of land busy growing food for the family or growing something that can be sold.

There is evidence that many more farmers would adopt green manuring if there were any secondary benefits to them. This is evident in Honduras where the farmers most likely to use velvet beans *(Mucuna pruriens)* as a cover crop are the ones who appreciated the roasted beans as an inexpensive coffee substitute. In Ghana both velvet beans and jackbeans *(Canavalia ensiformis)* are grown as much for the marginally edible beans[2] as for the cover crop benefit.

An economist would likely explain this by saying that farmers were not convinced that the benefit of the cover crop would offset the "opportunity costs" of the loss of income which could have been earned had that land and labor been used for another crop or activity. There are many cover crops that produce edible seeds, including rye, soybeans, and pigeon peas. Theoretically these seeds could add a secondary value to the cover crop, and make the practice more economically enticing. The difficulty with this plan is that cover crops are most effective at improving soil when they are cut down before they flower, which is necessarily before they can form seeds. Again, cover crops are essentially leaf crops.

Not all cover crops have edible leaves, but a surprising number do. Not only that, but there are edible leaf plants in every category of cover crop. Within the nitrogen fixing legume family, cowpeas, Austrian winter peas, common beans, hyacinth beans, fenugreek, winged beans, alfalfa, and many others are good cover crops, as well as having edible and highly nutritious leaves. Barley and wheat are two excellent cover crops from the grass family that can add huge amounts of organic matter to the soil. Both are also highly nutritious leaf crops when young. Health food stores often feature expensive elixirs made from the young leaves of these two cover crops. Turnips, rape, and sugar beets have powerful tap roots that drill deep into the

1 Where does all this matter that is "created" come from? About 96% of the dry weight of plants is comprised of hydrogen, oxygen, and carbon. The hydrogen and most of the oxygen come from water, while the carbon comes from the carbon dioxide in the air. The cover crop uses solar energy to combine these three elements into carbohydrates

2 Velvet beans contain levadopa, a compound used in the treatment of Parkinson's disease that can sometimes cause vomiting and confusion in people who consume it. There have been several reported incidents of toxicity from velvet beans, though most involve inadequate cooking or over-consumption. In Ghana the seed coat is removed and the seeds are boiled for at least 40 minutes, then the water discarded. Typically they only eat about 10 seeds each per meal. ILEIA Newsletter Vol. 12 No. 2 p. 30, Edible cover crops, P Osei_ Bonsu, D Buckles, FR Soza and JY Asibuo, References, _ Buckles, D. 1995. Velvetbean: a "new" plant with a history. In: Economic Botany 49:(1).

subsoil, opening the way for earthworms, water, and air. All three have nutrient rich greens that can be prepared as you would cook spinach or kale. Mustard plants are dynamic accumulators of sulfur, zinc, and phosphorus, bringing these essential plant nutrients up from the subsoil and concentrating them for use by other crops. Alfalfa does the same with iron. Both of these plants have leaves that can provide superior nutrition and that have been used as food for centuries by various cultures.

The most realistic secondary economic benefit of a cover crop may well be the use of part of the crop as leafy vegetables. For this to work we will need to slightly alter our conception of cover crops and radically redefine leafy vegetables. As discussed earlier, our limited interest in leafy vegetables tends to focus on a very small group of fast growing, mild-flavored plants. The market demands that they be cosmetically perfect, even at the cost of having significant pesticide residues. The very small impact they have on our diet is mainly as fresh salads, garnishes, and as additions to soups or stews. Leaf vegetables are poorly suited for incorporation into the industrialized diet; and the more highly processed a meal is the less likely it is to include leafy vegetables.

On the agricultural front the first task is to develop a complete list of edible-leaf cover crops. These should then be ranked for palatability, or flavor. The plants with the most acceptable flavors then need to be assessed for optimal harvest time, both for use as soil improvers and as leaf vegetables. We then need an economic analysis of the soil-improving value of these edible leaf crops, compared to the most profitable cover crops currently in use in a given agricultural situation. Next we need to begin experimenting with different schedules and intensities of partial leaf harvesting. For instance several stands of Austrian winter peas would have 10%, 20%, and 30% of the leaf harvested. These partial harvests could be timed at flowering and at two weeks before flowering to get a sense of best times for intensities of leaf harvest. This is the sort of work that could be done by college agriculture students or civic gardening associations over the course of a few years. Most of the work could be done on a relatively small scale to develop a proof of concept.

The food processing challenges could be addressed by making leaf concentrate as well as solar leaf dehydration. The idea is to create a means of taking a relatively large amount of nutritious fresh leaf from a cover crop and converting it into a stable food ingredient quickly and at low cost. Both of these leaf processing techniques might qualify. No doubt leaf concentrate would be better suited to larger scale operations, and solar leaf drying could be more easily put into practice on the garden and micro-farm scale. The success of either would depend on making economical use of the leaf concentrate or the dried leaf meal, as well as by-products. That in turn would depend on assuring people that the nutritional potency of these products would benefit their families' state of health. Obviously, a great deal of work needs to be done in several areas to make this strategy viable. What is equally obvious is that new food systems need to be developed in the very near future that can protect and improve the soil, while providing some income for the grower, and nutritious food for consumers. Edible cover crops certainly deserve a closer look.

SMALL SCALE EDIBLE COVER CROPS IN PRACTICE

How might the system work in practice? Let's consider this at two different scales of operation: a home vegetable garden and a micro-farm. Before trying to calculate advantages and drawbacks to these two different agricultural situations, it is important to point out just how inexact existing data on cover crops is. Because they are never sold, cover crops are not weighed or measured except in institutional settings. Also, differences in climate, soil type, planting dates, plant varieties, and the point in the plant's lifecycle at which it is turned under, all combine to account for large differences, sometimes factors of three or more, in reported cover crop yields. For example fresh green crop yields for barley are reported from 20 to over 110 tons per hectare (18,000 to over 100,000 pounds per acre).

There are a few points to keep in mind. Generally, cover crops, like any other crops, will produce much more vegetation on good soil with adequate moisture. When they are used to repair seriously depleted land the yields will be low until the soil is in better condition. Growers may become disillusioned with cover crops if they expect them to produce huge yields on very poor soil. Legumes will fix less nitrogen from the air if there is plentiful nitrogen already available in the soil. The plants will use what is in the soil before expending the energy required to fix atmospheric nitrogen. Legumes will also perform much better if there are adequate levels of soil phosphorus available.

At the time of flowering, the weight of most cover crop plants will be made up of about 15–20% roots, with the remainder being roughly half leaves and half stems. For the sake of simplicity I've assigned a somewhat arbitrary, but not entirely unrealistic, average yield of 27 tons per hectare (24,000 lb/acre) of above-ground green matter for each crop. This means about 13.5 tons per hectare (12,000 lb/acre) of edible green leaf.

The exercise below is intended to give some idea how the concept of edible cover crops might play out in the field. The actual numbers will need to be determined from years of experience by a wide range of growers. These examples are from temperate climates. Tropical cover crop systems share most of the attributes of temperate systems though they have many more legumes available for use and they tend to be more affected by a wet season and a dry season than by a warm season and a cold season. Developing effective systems of mixed vegetable and edible cover cropping will require both experimentation and site-specific analysis of soil, climate, and market conditions.

A) Home vegetable garden:
15 x 15 m (225 sq m; 1/44 hectare)
or 40 x 60 ft (2,400 sq ft; 1/18 acre)

In the autumn, after most of the summer vegetables were done growing, most of the garden would be planted in Austrian winter peas, barley, and mixed members of the brassica or cabbage family (kale, rape, mustard, turnips, radish, etc.). Let's say 75 sq m (800 sq ft) each in winter peas and barley, and 38 sq m (400 sq ft) of brassica plants. These would be mowed down in the early spring and 38 sq m (400 sq ft) of bell bean cover crop could be planted before space was needed for warm season crops like sweet potatoes and tomatoes. In the remaining 75 sq m (800 sq ft) of garden, potatoes, cabbage, beets, carrots, and other spring and early summer crops would be planted. When they were harvested they would be replaced with cover crop cowpeas. Because the cowpeas grow fast in the summer heat, 75 sq m (800 sq ft) of them could be grown by sticking them in wherever space opened up. When the cowpeas came out it would be nearly time for winter cover crops to go in.

By growing cover crops year round this gardener would produce about 900 kg (2,400 lb) of above-ground cover crop each year. Assuming half that total was stem, about 450 kg (1,200 lb) of edible leaf crop would be available. If the gardener took 150 kg (400 lb) of this as food for the family, 750 kg (2,000 lb) could still be returned to the soil as mulch or compost, or turned under as green manure. The 150 kg (400 lb) of fresh greens could provide each member of a family of five with nearly an extra serving of highly nutritious green leafy vegetables per day for the entire year. That extra serving of greens could move people much closer to the Word Health Organization's recommendation of eating at least 400 grams of fruits and vegetables every day. Or even better, it could get them closer to the daily level of 600 grams of fruits and vegetables that is considered to minimize the risk of cancers, heart disease and diabetes. This nutritional bonus could be added to the family's pantry without the need to add any additional growing space and while significantly improving the garden's productive capacity.

B) Micro farm:
1.2 hectare (3 acres)

In the autumn, after the summer vegetables were done growing, most of the gardens would be planted in Austrian winter peas, barley, and mixed members of the brassica or cabbage family (kale, rape, mustard,

turnips, radish, etc.). Let's say four-tenths of a hectare (one acre) is planted in winter peas and two-tenths of a hectare (half an acre) each of barley and of mustard cover crops. This still leaves four-tenths of a hectare (one acre) to be planted in late fall vegetable crops for sale. The winter peas, barley, and mustard would be mowed before they flowered in the spring. They would be turned under or left on top of the soil to serve as mulch for a mix of tomatoes, peppers, squash, sweet potatoes, okra, and other heat loving vegetables.

Cool weather vegetable crops, such as broccoli, cabbage, lettuce, greens, radishes, potatoes, and beets, can be planted in early spring (where the late fall crops were) and followed by a summer cover crops like cowpeas. In late summer or early fall the cowpeas can be cut to make way for another planting of cool weather vegetables.

This would mean that a cool weather cover crop and a hot weather cover crop would be grown every year on eight-tenths of a hectare (2 acres), while four-tenths of a hectare (1 acre) produces vegetables nearly all year. These would be rotated every year to keep the soil in top condition and to prevent the buildup of pests.

The actual yields of cover crops are highly variable, but these numbers will give an example of how this system could work. The eight-tenths of a hectare (2 acres) planted in both summer and winter cover crops should yield about 8,000 kg (18,000 lb) of fresh green leaves, and an equal weight of stems. If 30% of the leaf is harvested for edible greens, 78 people could get one serving a day of leafy vegetables all year round. This could be used in the form of fresh greens, solar-dried greens or leaf concentrate. To improve soil structure and fertility, 13,600 kg (30,000 lb) of leaf and stem would still be returned to the soil.

A similar plan could be carried out on larger farms as well, though large farm systems are outside of the scope of this book. There is obviously a lot of field testing to be done in order to work out the best systems and planting schedules, but the concept of using part of a cover crop as leafy green vegetables is an important one. It could help us improve our health while rebuilding the health of our food-producing land. Combining a nutritious leaf crop with a soil-improving crop is a dynamic opportunity for innovative growers.

SELECTING EDIBLE COVER CROPS

The vast majority of all cover crops, and especially of edible-leaf cover crops, are members of one of three plant families; the legume family, the grass family or the mustard family.

The Legume Family

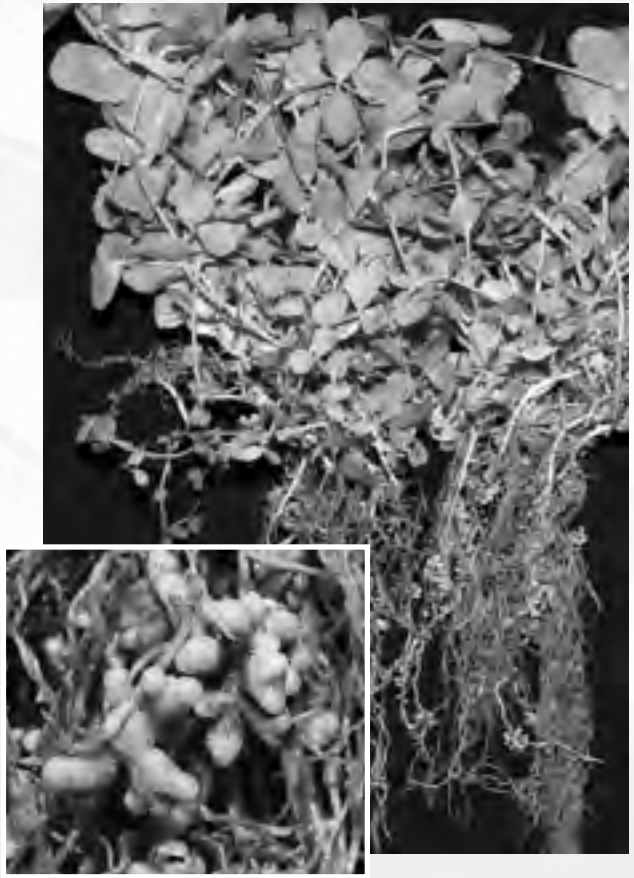
The legume family is the third largest plant family behind the orchid and the aster families. It is a sprawling clan with over 19,400 species, including familiar beans, peas, and clovers. About 185 legume species have leaves that have been eaten by humans. Many of these edible leaf legumes make good cover crops.

Most legumes have evolved symbiotic relationships with the rhizobia family of bacteria. These bacteria use an enzyme called nitrogenase to reassemble the nitrogen in the air, along with hydrogen from water, into ammonia molecules. We need to increase our understanding and use of legume based biological nitrogen fixation in order to radically trim the energy requirements of producing our food. Legume cover crops with edible leaves could become a key component of emerging sustainable food systems. Some of the most promising of these crops are described below.

Alfalfa - *Medicago sativa*

Alfalfa, or lucerne, is a perennial forage plant first cultivated in Mesopotamia before the advent of recorded history. Alfalfa is now grown throughout the world under extremely varied climatic and soil conditions. It has been an animal feed longer than any other forage crop, and today is considered to be the most important fodder crop in the world.

Alfalfa's extremely deep roots (up to 9 m, or 30 ft) enable it to access otherwise inaccessible nutrients from the subsoil, and to reach water during droughts. They also create channels for air and water to penetrate the subsoil, creating improved drainage for future crops. It usually



Austrian winter pea *(Pisum sativa)*, showing rhizobia nodules

requires replanting only once every 6–8 years, which greatly reduces the energy and labor costs of land preparation, and more importantly, makes alfalfa the best of all commercial crops at preventing soil erosion.

Alfalfa seeds are very hard and should be soaked in hot water for an hour or two before planting. Planting in ridges or rows 50–75 cm (1.5–2 ft) apart makes weeding much easier until cover is established. Leaf production is much greater if the soil has an adequate supply of phosphorus.

Alfalfa can produce yields of 75–220 metric tons of forage per hectare if it gets enough water. It is an excellent nitrogen fixer. It can be harvested up to twelve times a year in frost-free locations; and it recovers quickly from cutting. Alfalfa grows well up to 4,000 meters of elevation, where few other crops thrive. It has a dense and erect growth habit ideal for easy harvest with scythe or sickle bar mower. While it is quite cold hardy, alfalfa is susceptible to viral diseases in hot humid climates, and doesn't do well on acid soils.

Alfalfa sprouts are widely eaten and very young shoots have been eaten as potherbs in various cultures. However, the plant's potential as a direct human food has barely been touched. Of all the crops whose leaves can be eaten by humans, alfalfa is easily the most prolific. Alfalfa production in the United States is about 680 g (1–1/2 lb) per day per person. Unfortunately it is too tough and stringy and sometimes too bitter to eat in the way we eat spinach or lettuce. Alfalfa can be made much more useful for direct human consumption by drying and grinding the leaves or especially by converting the leaves to leaf concentrate.

Cowpea - *Vigna unguiculata*
Cowpea is an annual legume that was domesticated in West Africa. The best known type of cowpea is probably the black-eyed pea. In much of Africa and parts of Asia the cowpea is an important seed legume and is also an important leaf vegetable. Cowpea leaves are produced as a vegetable on a commercial scale in eighteen African countries and seven Asian countries. Often cowpeas are grown for their leaves in high rainfall areas, and for seeds in lower rainfall areas. According to James Duke in his Handbook of Legumes of World Economic Importance, growing cowpeas for leaves can produce, per day, 9 times more calories, 15 times more protein, 90 times more calcium, and thousands of times more vitamin C and beta-carotene, than growing the same crop for seed.

Cowpeas are an excellent intercrop plant to use between rows of corn, cassava, bananas, or other crops. Two hectares of corn and cowpeas intercropped will typically produce about 30% more total food than one hectare of corn and one hectare of cowpeas. Both beans and edible greens can be economically produced from the same parcel by planting cowpeas in rows 40 cm

(16 in) apart and letting them grow till the leaves begin to touch. Then every other row is harvested for greens without lowering bean yield. Rather than just killing weeds between the rows, this technique captures free nitrogen from the air and offers a mild-flavored and nutritious leaf vegetable for harvest.

Green matter yields of up to 9 metric tons per hectare (4 tons/acre) in 60 days are realistic if adequate soil moisture is provided. Of this, about 45% is stem, and 5 metric tons (2 1/4 tons/acre) is actual leaf. This will yield about 320 kg (700 lb) of dried cowpea leaf and it is usually possible to get in at least two crops per year without reliance on irrigation. Intercropping cowpeas with corn has roughly the effect of applying 156 kg per hectare (71 lb/acre) of nitrogen fertilizer.

Although the losses during drying are significant and the figures below may not adequately compensate for the low bioavailability of some nutrients, dried cowpea leaves can be a very inexpensive and nutritionally potent addition to the diet. 100 grams (3 1/2 oz) of fresh cowpea leaf will yield about 15 grams (1/2 oz) of dried leaf. This can provide a 4–8 year old child with about 20% of his protein needs; 29% of calcium needs; 44% of iron requirement; 100% of vitamin A; and 50% of the vitamin C requirement.[3]

3 Derived from averages from UN FAO 1968, and Imungi, J. and Potter, N., Nutrient Contents of Raw and Cooked Cowpea Leaves, Journal of Food Science, Volume 48, Issue 4, pages 1252-1254, July 1983

Cowpeas for leaf production should be sown at least twice as densely as for bean production. Cowpeas cut at 20 cm (8 in) above the ground will regrow for a second cutting but those cut at 5 cm (2 in) will regrow slowly if at all. Cowpea seed should be soaked overnight and then inoculated with EL type rhizobia if cowpeas haven't been grown on the land in the past three years. Actually evidence suggests that better nitrogen fixation takes place with inoculation even on land where cowpeas have been recently grown. Adding a bit of sugar to the soaked cowpeas aids inoculation by helping the rhizobia stick to the seeds until they sprout.

Cowpea plants turned under at the start of flowering will add nitrogen and organic matter and improves soil structure. Up to 168 kg per hectare of nitrogen (150 lbs/acre) can be fixed. Incorporating a cowpea cover crop has the side benefit of lowering aluminum toxicity, which is a serious problem in many tropical soils.

Austrian Winter Pea - *Pisum sativa*

Peas were one of the first plants to be cultivated by humans and are commonly grown throughout the world's temperate and subtropical zones. Austrian winter peas are a variety used as a cold weather cover crop to add nitrogen and organic matter to the soil. They are annual plants that grow about 60 cm (24 in) high and usually have beautiful two-tone purple flowers. They don't easily tolerate acid soil, salinity, waterlogging, drought, or heat, but they are quite hardy to cold weather and will usually survive several freezes. Winter peas are sometimes killed by periods of rapidly fluctuating winter temperatures. They will produce the most biomass, soil nitrogen and edible leaves if planted relatively early in the fall so that they can utilize some warmer weather and more intense sunlight. Winter peas produce nearly as well when planted in the early spring. However, spring garden planting then has to be delayed to allow them the time they need for generating the maximum nitrogen and biomass.

Before planting, pea seeds should be treated with pea inoculant or with an all-purpose garden inoculant. Broadcast about 30–85 g (1–3 oz) of seeds per 9 sq m (100 sq ft), or sow every 12 cm (5 in) in rows 60 cm (2 ft) apart. There are several advantages of using close rows rather than broadcasting cover crops. Planting in rows allows you to hoe between them to reduce weed competition. It is also far easier to harvest edible leaves from rows and avoid accidentally including weeds that may not be palatable or may even be toxic. In addition, rows allow the gardener to accelerate the soil building process by combining the cover crop with organic mulch between the rows.

The tender young shoots of the pea plant have a pleasant nut-like flavor and make a good salad green or potherb. Dried

winter pea leaf has one of the best flavors of any dried leaf powder or leaf concentrate. A cover crop medley that provides your soil with nitrogen, organic matter and cover from erosion can be established with the triple mix of Austrian winter peas, barley, and white mustard. All three of these plants have highly nutritious edible leaves as long as they are picked when fairly young.

Lablab Bean - *Lablab purpureus*
Lablab, or hyacinth, bean is a short-lived perennial climber native to Africa and India. It is used as a forage or cover crop as well as for its edible beans. It is a strong nitrogen fixer. Lablab thrives in a range of soil types. It is relatively drought tolerant once established but doesn't grow well in cold weather, saline conditions or in waterlogged soil. Lablabs are grown much like cowpeas but are generally more disease resistant.

Rows are typically 80–130 cm (32–50 in) apart with plants every 30–50 cm (12–20 in) along the row. It can produce up to 220 metric tons per hectare (100 tons/acre) of green matter and fix 180 kg of nitrogen per hectare (160 lb/acre) under ideal circumstances. Late flowering types like Rongai produce far more biomass than seed types such as Highworth or purple hyacinth beans. Lablab is shade tolerant enough to be useful when planted under orchards. Perennial varieties are being developed in Australia, though they would only be perennial in frost-free areas. Lablab is often sold for creating wildlife forage and attracting deer. Seed sold for this purpose is usually many times cheaper than the seed sold for home gardens.

The purple hyacinth varieties are vigorous climbers and their beautiful purple flowers and pods make them attractive plants for garden fences and trellises. This is a good plant for attracting hummingbirds and butterflies to a garden. Along with the beans (which must be very well cooked, with two changes of water), lablabs have edible leaves, flowers, and even edible root tubers. Like pigeon peas and pinto beans, it is rarely used for its edible leaves but could become a more important leaf vegetable. Very young leaves are occasionally eaten raw in salads. However, lablab leaves are generally treated as potherbs and cooked at least briefly before eating.

Bell Bean - *Vicia faba*
Bell Bean is a small seeded variety of the fava, Windsor, or horse bean. It is a cool weather annual native to the Mediterranean area. Bell beans are normally planted in the fall or in the very early spring and can withstand temperatures as low as –9° C (15° F). In colder areas, such as much of Canada, they are grown as a summer crop. They will usually flower within 60 days and won't regrow well after close mowing; nor will they reseed themselves.

Bell beans are not too choosy about soil type or pH, but are not very drought tolerant. They are shade tolerant enough to make a good cover crop in orchards. They are normally planted every 15 cm (6 in) along rows that are 74 cm (30 in) apart. Bell bean seed needs to be treated with pea/vetch /lentil inoculant or with garden combination type inoculant. They can add 22,000–44,000 kg per hectare (20,000–40,000 lb/acre) of green biomass to the soil and fix up to 44 kg (100 lb) of nitrogen in 45 days.

Young tender bell bean leaves can be eaten as a potherb or dried. They are usually too tough and strong flavored to be eaten raw.

Common Bean - *Phaseolus vulgaris*
The common bean was domesticated in southern Mexico and in the Andes Mountains of South America over 6,000 years ago. It has a thousand names and ten thousand varieties, including kidney bean, pinto bean, navy bean, cranberry bean, wax bean, green bean, black bean and turtle bean. It has become a popular food throughout the world and is sometimes referred to as "The Poor Man's Meat" because of its high protein content.

Bean cultivars are either climbing pole types, or dwarf bush type. The pole beans grow up to 3 m (10 ft) and require some sort of support or trellis. The bush varieties are less than a meter high and produce flowers and seeds much sooner. Pole beans generally yield about twice as many beans as bush beans but take nearly twice as long

to do so. Bush beans usually have lower labor costs and are often harvested all at one time for processing. Despite higher labor requirements, pole beans are often preferred for family gardens because they will yield enough beans for a meal over a much longer time.

The soil should be at least 12° C (54° F) before planting beans, and the ideal growing temperature is between 22–26° C (72–78° F). The common bean is sensitive to frost, waterlogging, soil acidity, salinity, and aluminum toxicity. Seeds are usually planted every 5 cm (2 in) in rows 60–80 cm (24–32 in) apart. Pole beans are often planted in groups of 3 or 4 at the base of whatever support they will be climbing. Before planting, seeds should be treated with an inoculant designated for beans. There are several general purpose garden inoculants that will treat bean seed as well as many other legumes.

Beans are rarely grown solely as a cover crop because other plants that are less susceptible to insect and disease problems can fix more nitrogen. They are still frequently used as an intercrop with corn, sorghum, millet, and cassava, and significantly reduce the fertilizer demand of those crops.

Outside of Africa and Indonesia, few people realize that beans also produce highly nutritious and tasty leaves for potherbs. Bean leaves are grown in two different ways. When grown as a separate crop for leaves, they are planted more densely than when grown for beans, and the plants are usually uprooted at 3–5 weeks. It can also be cut when about 8 inches tall, like cowpeas, and allowed to regrow for a second cutting, though beans in general don't make strong regrowth.

Some varieties of beans have leaves that are too fibrous to make a good leaf crop, especially if grown in hot and dry conditions. Sometimes small farmers and gardeners try to combine a harvest of leaves and beans. This is best done by harvesting leaves from the lower third of the plant just before flowering begins. Bean leaves are very rich in beta-carotene, vitamin C, iron, calcium, and protein.

Winged Bean - *Psophocarpus tetragonolobus*
The winged bean is a vigorous twining perennial legume with beautiful pale blue flowers. The plant is thought to have originated along the east coast of Africa and is especially popular in Papua New Guinea. Used for leafy green potherbs, fresh pods, dried beans, edible tubers, animal forage and cover crop, winged beans are the ultimate multi-purpose crop.

During the 1970s some development groups went overboard promoting winged beans as a miracle crop and many people were disappointed that yields were not up to the promises. Unfortunately, maximizing the yield of one of the winged beans' outputs tends to be at the expense

Wheat *(Triticum aestivum)*

Cowpea *(Vigna unguiculata)*

of its other outputs. This means that you can't get a maximum yield of fresh leaves, mature seeds and edible tubers from the same plant. Winged beans also are limited by some specific day-length requirements for blooming, though a day-neutral variety is now available.[4] Of course, when growing winged beans for potherbs or cover crops, delayed blooming is advantageous.

Winged beans won't live in waterlogged soil but thrive with high rainfall up to 250 cm (100 in) a year if there is good drainage. They are very sensitive to frost but can be grown as an annual in warmer temperate climates. They are tolerant of high temperatures and acid soil. Like cowpeas, winged beans use EL type inoculant. Seeds are hard to germinate, and benefit from being scratched or soaked in hot water before planting. Although they are strong nitrogen fixers, most of the nitrogen is not available until the following season, so it is helpful to have some other source of nitrogen for first-year growth. They are normally planted every 10 cm (4 in) in rows 80 cm (32 in) apart, though they will produce more beans grown with a wider spacing on trellises.

They can produce 8,000 kg per hectare (7,000 lb/acre) of fresh leaves per acre in just 60 days. Winged beans are a beautiful and interesting home garden plant with brilliant blue flowers and unique light green beans with four fins or wings on each.

The tasty, mild flavored greens are 5–7% protein, which is exceptionally good, and the quality of that protein is superior to that found in most other leaves. They are also an excellent dietary source of iron, calcium, beta-carotene and vitamin C.

Fenugreek - *Trigonella foenum-graecum*
Fenugreek (translated, "Greek hay") is one of the oldest cultivated food plants. Its seeds were found in the tomb of Tutankhamen. It is a popular potherb in India called mehti, and is an important source of iron in that largely vegetarian country. The leaf, dried seeds and sprouted seeds of fenugreek are all eaten. The seeds are commonly used in curry powders and have a complex and interesting flavor sometimes compared to a cross between maple and celery.

Fenugreek is an annual plant rarely exceeding 50 cm (20 in) in height. It is rather drought resistant but doesn't grow well in acid soils. Fenugreek is best planted in the spring as soon as the soil has begun to warm up. In frost-free areas it can be grown through the winter. The seedlings should be thinned to about 10 cm (4 in) apart. They will do best in well drained soil and full sunlight. They don't transplant well, so should be direct seeded. A mixed garden legume inoculant will increase nitrogen fixation. It grows quickly and is best eaten just before flowering. Fenugreek is an excellent potherb to grow in containers.

4 From ECHO http://www.echonet.org

Fenugreek seeds are often easier to get as a flavoring from Asian grocery stores than as garden seed. They are also sometimes sold for sprouting at health food stores. Caution and good hygiene are important when growing your own sprouts, regardless of what type of seed is used. Sprouts are usually eaten raw and have been tied to outbreaks of *E. coli* bacterial infections, so it is a reasonable precaution to treat the seeds before sprouting. Soak the seed for 15 minutes in a disinfectant solution of 1 teaspoon of household bleach to 1 cup hot tap water. Rinse the seeds thoroughly afterwards to remove any trace of the bleach.

Rice Bean - *Vigna umbellata*
Rice beans probably originated in the foothills of the Himalayas and are now grown throughout much of southern Asia. They thrive in the hot humid tropics where many legume crops suffer from disease. They prefer 100–150 cm (40–60 in) of rain per year and soil that is neutral to slightly alkaline. Once established, rice beans have some resistance to drought but are sensitive to frost or waterlogging.

For a cover crop or forage, the seed is normally broadcast at a rate of about 60 g per 10 sq m (2 oz/100 sq ft), or about 67 kg per hectare (60 lb/acre). It can also be planted in narrow rows, one to two feet apart, or in groups of three seeds clustered around bamboo pyramids or other such trellising. The plant is used as fodder, made into hay and silage, or grown as a cover crop. It grows very quickly for a legume and can sometimes be used as a cover crop just 30 days after planting. Just before flowering the plants can be mowed and either incorporated into the soil or left on top as mulch. It can supply up to 66 metric tons per hectare (30 tons/acre) of fresh green crop to enrich the soil. Rice beans are also sometimes grown as an intercrop with maize in south Asia.

Some varieties grow as small erect bushes but most are vigorous vining plants. The vining forms make great garden trellis plants with pretty yellow flowers. The small mature beans are cooked in many rice dishes, while the immature pods and young leaves are eaten as cooked vegetables.

There are many other legumes that could be used as edible-leaf cover crops. These include butterfly pea *(Clitoria ternatea)*, berseem clover *(Trifolium alexandrinum)*, pigeon pea *(Cajanus cajan)* and scarlet runner bean *(Phaseolus coccineus)*.

The Grass Family
After legumes the next most important family of cover crops is the grass family, or Poaceae. Annual grasses are commonly grown to capture carbon dioxide from the air and build soil organic matter. Sometimes they are grown alone, but more often with a legume. The grass family is the fourth largest of all plant families, with 10,025 known species, and it is perhaps the most important plant family to humans.

Roughly 30% of the Earth's land surface is dominated by grasslands or prairie. Grazing (the word derives from the Old English word for grass) ruminant animals are able to convert the tough prairie grasses into highly valued meat and milk. Grasses grown for their edible seeds are called cereals. More than half of all the calories consumed by humans come from the seeds of just three of these grasses: maize, wheat, and rice.

A small handful of the grasses have become multi-purpose agricultural stars, providing animal feed, edible seeds and cover crops. These include wheat, barley, oats, and rye, four of the most useful plant species on Earth. In the temperate zones these are often planted as cover crops in the fall after other crops are harvested. They are normally mowed and turned under in the spring before new crops are sown. Part of their great value as cover crops comes from the fact that they can be grown when most other economic crops cannot.

It is widely presumed that humans can eat only the dried seed of the cereal grasses directly, and that the leaves of the cereal plants need to be digested by ruminant animals before becoming food for us. It is true that the relatively high fiber content of grasses prevents us from using them directly as a major source of calories. However, since the 1930s, a modest amount of cereal grass leaves have been eaten by

people as vegetables, adding yet another potentially valuable use for these plants.

In 1934, an American agricultural chemist named Charles Schnabel applied for a patent for processing tender young wheat, barley, and rye grass shoots, for the production of an animal and human food supplement that provided unique health benefits. He believed the key beneficial ingredient in the grasses was chlorophyll, perhaps because of its molecular similarity to hemoglobin. Since that time considerable research has been done, primarily in the United States and Japan, on the benefits of direct consumption of cereal grasses.

The nutrient profile of young cereal grasses is quite similar to that of most nutritious dark green leafy vegetables, all of which are rich in chlorophyll, high in fiber, and best eaten before the plant begins to flower. While fiber is indigestible by humans, the relatively high fiber content of these green leafy foods is actually beneficial for people eating a modern industrial diet. For example, Americans typically consume less than half the recommended plant fiber. Many other cultures, especially in urban areas, have been rapidly adopting similar low-fiber diets. For these diets, doubling the average intake of dietary fiber would lower rates of digestive disorders, obesity, some cancers, diabetes, and heart disease. More information on dietary fiber can be found in Chapter 5.

Cereal grasses, especially wheat and barley, have been marketed almost entirely through health food outlets, more as supplements than as foods. Exaggerated claims about their mysterious healing powers and even more exaggerated prices have limited their appeal to a small but growing segment of the populace that is extremely concerned with nutrition. If broader markets are developed for dried cereal grasses the prices should tumble.

Meanwhile, gardeners could easily incorporate them into their local food systems. They are very productive and easily grown crops that can provide substantial amounts of beta-carotene, vitamin K, folic acid, calcium, iron, protein, fiber, vitamin C, and many of the B vitamins at a very low cost. Seed for wheat and barley greens is very cheap compared to most other dark green leafy vegetables; they have relatively few problems with insect pests; and they can be grown when the garden is not needed for other crops.

This concept evolves from a good idea into a truly great one when growing the young cereal grasses for vegetables is combined with growing them as a soil-improving cover crop. With a little planning and a little work it is possible to simultaneously improve your diet and the fertility of your garden soil by growing cereal grasses over the temperate zone winter. The composition of all cereal grasses is very similar when they are young plants, but much more research, development, and marketing work has been done with wheat and barley grasses than with rye and oats. For that reason I will focus on wheat and barley, though the other cereal grasses certainly deserve further research.

Wheat - *Triticum aestivum and Triticum durum*
Barley - *Hordeum vulgare*
Wheat and barley originated in western Asia. Their domestication roughly 10–12,000 years ago in the valleys of the Tigris and Euphrates Rivers was a cornerstone in the development of agriculture. The cultivation of these two cereals has spread from the fertile crescent to most of the world's temperate regions and sub-tropical zones. Wheat now ranks just behind maize and just ahead of rice among the most produced food crops.

These cereal grasses are impressive multi-use plants. Their fibrous mats of roots loosen up tough soils and feed earthworms and soil bacteria, while their copious production of biomass fixes carbon from the air as beneficial soil organic matter. They produce huge yields of nutritious greens with almost no waste. Cereal grasses make excellent fodder for animals either fresh or dried as hay. If some of the crop is allowed to mature it will yield nutritious whole grains. And when the grain is separated from the stalks, the leftover straw

makes excellent mulch or animal bedding, and can even be used to build a house.

Both wheat and barley are tolerant of most soil types and a fairly wide range of pH, but wheat is more sensitive to saline soil. Annual rainfall between 30 cm (12 in) and 100 cm (40 in) is needed for good growth. While wheat and barley are both temperate zone crops, varieties have also been adapted for the higher elevations and to endure the coolest part of the year in the tropics as well.

For use as edible cover crops, both wheat and barley should be planted in very late summer through mid-autumn at a rate of about 180 g per 10 sq m (6 oz/100 sq ft). It can be broadcast or sown in narrow rows. The rows tend to be easier to harvest but won't generate as much biomass to add to the soil. Ordinarily both make some growth before cold weather sets in, and then go dormant until temperatures begin to warm up in the spring, when rapid growth can resume. Barley can be planted a week or two after wheat and will typically produce more organic matter.

For a cover crop or for leafy vegetables, wheat should be harvested just before the reproductive cycle or, the jointing process, begins. It can be mowed with a heavy duty lawn mower, a string weed cutter, a scythe or machete. Like most cover crops, the cut wheat plants can be incorporated into the top few inches of the soil with a tiller or hoe, hauled off to use as mulch or compost

Winged bean *(Psophocarpus tetragonolobus)*

Rice bean *(Vigna umbellata)*

elsewhere, or simply allowed to rot in place. The rot-in-place option is becoming popular because it gives the best soil protection and takes the least work. It works better when transplants such as tomatoes, peppers, sweet potatoes or large seeded crop are planted after it than when followed by small seeded crops.

The ability of the cover crop to improve the soil will be somewhat diminished when a portion of the crop is used directly as food rather than left in the field. However, the loss of soil building can be minimal because only 20% or so of the aboveground crop is used as food. Furthermore, much of the benefit of the cereal cover crops comes from the roots improving soil structure. The yields of cover crops can vary considerably depending on soil and weather conditions, timing, and density of planting. A typical cover crop of winter wheat might produce 4,400 kg of dried wheat grass per hectare (4,000 lb/acre). This comes out to half a kilogram per square meter of garden bed. If 20% is removed as leaf and the remaining 80% allowed to enrich the soil, nearly 1 kilogram of dried wheat grass may be reaped from an average sized garden bed.

Fresh or cooked wheat grass tends to make a stringy vegetable, but dried and powdered wheat grass is a mild flavored and super-nutritious addition to many dishes. When you consider that it is often sold for over $40/kg ($20/lb) by health food retailers, this becomes an economical proposition.

The Mustard (Cabbage) Family

The scientific name for the mustard, or cabbage, family is Brassicaceae, or sometimes the older name Cruciferae, meaning "cross-bearing," because their flowers have four petals arranged like a cross. Most of the cabbage family is native to the Mediterranean region. There are about 3,700 species of brassicas and some are widely grown throughout the temperate zones and the cooler parts of the tropics. Many members of this family, including broccoli, cauliflower, Brussels sprouts, kale, kohlrabi, mustard, turnips, radishes, rape, watercress, and the familiar head cabbage, are extremely valuable foods. They are rich in beta-carotene, vitamin C, potassium, calcium, and boron (an important mineral for strong bones). Cabbage juice contains the compound gefarnate, which helps protect the stomach lining from acid and eases the pain of ulcers. Brassicas also promote the body's production of glutathione and are the best food sources of sulphoraphane and indoles. All three of these compounds are very effective antioxidant cancer fighters.

Varieties of turnip, mustard, radish, and rape are frequently used as cover crops. None of these fix nitrogen, as legumes do, but all four have deep roots that help break up compacted soil and all four add a significant amount of organic matter to the soil. A further advantage of mustard family cover crops is that they can reduce pest problems

for the crops that follow them. The same sulfur compounds that provide the snappy flavor and the nutritional protection against cancer also inhibit the growth of many crop diseases and nematodes, as they break down in the soil.

Turnips, mustards, radishes, or rape can be used alone as cover crops or they can be combined with legumes and/or grasses for a more complete green manure. The Germans have a favored agricultural system called Landsberger Gemenge that is used to provide late grazing for cattle and sheep, and green manure for maintaining soil fertility. It involves planting two legume species, a grass and a mustard family crop together. These can be planted in adjacent strips but more often the seed is mixed and just broadcast together. The four together produce a crop mixture that is very nutritious and well-balanced for feeding both the livestock and the soil. Furthermore, it is entirely possible to devise a Landsberger Gemenge that includes only plants that have leaves that are edible and nutritious to humans. Creating a crop that can simultaneously provide food and animal feed as well as rebuild the soil, adds another whole dimension of stability and productivity to the food system.

Common mustard family cover crops are:

Turnips - *Brassica rapa var. rapa*
Rape or Canola - *Brassica napus*
Mustard
White mustard - *Brassica hirta*
Field mustard - *Brassica campestris*
Brown mustard - *Brassica juncea*
Black mustard - *Brassica nigra*
Fodder Radish - *Raphanus sativus*

All of the mustard family cover crops are cool weather plants that can be sown in early spring or in late summer for a fall crop. All germinate quickly, have strong tap roots, and reduce the populations of soil-borne pathogens in the soil when they are turned under. Seed for turnip and mustard can be broadcast at about half a kilogram per 100 square meters (1 lb/1,000 sq ft), or planted in rows 45 cm (18 in) apart and thinned to every 8 cm (3 in). Fodder radish requires about twice as much seed, but rape requires only about one-third as much. Dragging the back end of a rake lightly over the seed covers in and assures good soil contact.

Turnips and fodder radishes have especially strong and deep tap roots, sometimes drilling 2–3 meters (6–9 ft) into the soil. This can be very useful in breaking up plow pans, improving drainage, and bringing up subsoil nutrients such as calcium and boron to where shallower-rooted plants can reach them.

Canola oil is made from rape seed. It has been bred to produce healthy cooking oil. Most rape is now genetically modified, though the extra price of the seed is not worthwhile for use as a cover crop. Essex dwarf is a cheap non-GMO variety of rape that makes an excellent cover crop with tasty greens.

Some mustard varieties can produce up to 26 metric tons per hectare (12,000 lb/acre) of biomass to turn under in just 5 weeks. A cover crop of mustard is considered to be especially beneficial when turned in before a crop of potatoes because it reduces many of the diseases affecting potatoes.

Thinnings from any of these mustard family cover crops make good greens. Turnip greens are a traditional dish in the southeastern US. The tiny hairs, technically trichomes, on the leaves disappear with cooking. Newer tender leaves can still be harvested from the center as the plants begin to mature, but once flowering begins all the leaves become quite tough and bitter. Only the very youngest leaves are eaten raw. Of course, harvesting leaves will somewhat reduce the amount of biomass returned to the soil. Optimal proportions of leaf harvest, root harvest, green manure and even seed harvest will need to be determined based on the specifics of each crop and each agricultural situation.