



for the Gardener

Choosing and Using Cover Crops in the Home Garden and Orchard

Cover crops (often used as “green manures”; see below) and their positive, restorative effects on the soil come down to us through agricultural antiquity. Additionally, their ability to stimulate the growth of subsequent or “follow” crops is well documented via Chinese manuscripts from 3,000 years ago. Greek and Roman cultures also featured liberal reference to cover crops in both technical treatises as well as poetry. The Roman poet Virgil’s classic *Georgics* (Earth Works) is an epic poem of agriculture and culture laced with frequent and quite specific reference to the use of cover crops/green manures and compost.

Cover crops, compost, and cultivation techniques (plowing and digging) are the three fundamental drivers of any sustainable/organic growing system, from a postage stamp-sized backyard to sections² of wheat in Kansas.

¹ *Lupines are a nitrogen-fixing legume (member of the pea/bean family) used extensively throughout antiquity as well as presently in Europe. This is akin to our modern use of bell beans and vetches.* ² *A section = 640 acres*

So first, to define terms:

Cover Crop ▶ Any plant cover used to protect, and of course, cover, the surface of the soil and to prevent erosion. This includes the effects of foliage to shield the soil from the “explosive” impact of rain hitting an exposed soil, as well as the binding and holding power of roots to prevent erosion. While there are many domesticated cover crops (principally, but not exclusively, legumes and annual grasses), weeds are also an effective cover crop. Bare soil is anathema (Greek for “an accursed thing”) to good soil stewardship, and not often found in natural systems.

Green Manure ▶ A cover crop that is chopped up and turned into the soil. Chopping the cover crop into small pieces increases the surface area of the incorporated biomass, which translates to faster decomposition by soil microbes. Green manuring has two main benefits:

1. When incorporated at the succulent stage (pre flowering) the crop decomposes quickly and acts primarily as a fertilizer for the “follow crop,” usually spring and summer vegetables.³
2. When incorporated at a more mature stage (half to full bloom) with a higher carbon content, it adds to the organic matter content of the soil. In this instance nutrients are stored in the reservoir of humus and released slowly over a number of years.

While this is not a strictly delineated process, both approaches provide a food source for soil organisms, a fertilizer, and a way to build organic matter in the soil. You tend to use the first approach on established soils to fertilize crops, and the second on developing soils to build organic matter and improve structure, i.e., to build the “body” of the soil.

³ *The field operation of 5.8 acres of vegetable crops at the UC Santa Cruz Farm has used fall-sown, spring ploughed-down cover crops as its sole fertilizer for the better part of the last decade. Note, this is after establishing a foothold of fertility for 35 years with both cover crops and compost—my joke about fertility systems being: Fertility systems are a lot like political systems (democracy being the preferred system), that is, the broader the constituency, the greater the end product.*

Trap or Catch Crop ▶ Cover crops can effectively trap or catch nutrients and prevent them from leaching downward in the soil profile. For example: Broadleaf mustards and canola tend to take up nitrogen, calcium, and phosphorous, and concentrate them in their leaves, thus preventing leaching during the rainy season. Legumes are effective in this regard as well.

“Where no kind of manure is to be had, I think cultivation of lupines¹ will be found the readiest and best substitute. If they are sown around the middle of September in poor soil, and then ploughed in, the following spring, they will answer as well as the best manure.”

—Columella, 1st century Rome

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Thus, cover crops/green manures offer numerous benefits; they can—

- Improve the physical properties of a soil, particularly the enhancement of aggregation and development of a “crumb-like” structure.
- Increase soil’s organic matter content, which feeds soil microbes and stores nutrients in a non-leachable form and releases them slowly over time.
- Protect the soil surface and prevent erosion.
- Improve water infiltration and retention as well as drainage.
- Provide a “feedstock” for soil organisms.
- Break up hard pans and reduce compaction via the “bio-drill” effect of the deep tap roots of legumes, mustard, chicory, daikon radish, etc., and—in the top foot of soil—via the fibrous roots of annual grasses.
- Cycle nutrients.
- Provide habitat and food (in the form of pollen and nectar) for beneficial insects, i.e., provision the “3 P’s”: pollinators, predators, and parasitoids
- Offer a rest or “fallow” period for soil, with little or no disturbance for 5-7 months (fall through spring). This allows for an increase in earthworm populations, among other benefits.
- Reduce or eliminate the need for purchased fertilizer.
- Increase nitrogen levels in the soil. Through the use of legume species (vetches, bell beans, clovers, etc.) atmospheric nitrogen can be “fixed” and left in the soil to fertilize subsequent crops (see sidebar).

A simple method to calculate the nitrogen contribution of a legume cover crop is alternately referred to as the Rule of 4 or Rule of 16:

- Cut and weigh (wet weight) the fresh cover crop from 16 square feet (4 feet x 4 feet)
- Multiply the weight in pounds by the appropriate factor to estimate the pounds of nitrogen per acre contributed by the cover crop –

Factors: Vetch = 16
Bell beans = 10
Clovers = 13

So if the wet weight = 10 pounds and the cover crop legume is bell beans, multiply $10 \times 10 = 100$ lbs./acre of nitrogen. Most vegetable crops require between 100-200 pounds of nitrogen/acre (an acre = 43,560 square feet).

NITROGEN FIXATION

Through a biological and chemical process now called facultative-parasitic, but formerly referred to by the more poetic term *symbiosis*, soil bacteria in the genus *Rhizobium* (root zone) associate with the roots of legumes and “fix” atmospheric nitrogen that can be retained in the soil after the cover crop is plowed in. This is in addition to the contribution of nitrogen from the foliage of the legume.

The rhizobial bacteria are attracted to the legume roots by chemical secretions and gain entry into the roots via an infection thread, a tunnel-like ingrowth of the root hair. The infection thread keeps migrating farther inward into the root hair and is filled with multiplying bacteria. Eventually it enters the main part of the root, ruptures, and spews bacteria into root cells. These cells enlarge and form a visible, pink-colored nodule where the rhizobial bacteria “fix” or “grab” nitrogen from air in the soil and convert it into a form (ammonium) that plants can use. In return, the legume provides the bacteria with carbohydrates, protein, and oxygen. When the cover crop is killed the nodules remain in the soil and release their nitrogen, which is then available for uptake by crops (or weeds—a cautionary note).

TIMING

On the Central Coast, cover crops are best seeded in late September to mid-November and plowed into the soil late February to early April. Note that on a garden scale, incorporating cover crops into the soil is often slow and laborious, and it may take 3-5 weeks for the cover crop to break down to the degree that crops can be seeded or transplanted.

An alternative method is to skim off the cover crops at the base of the plants and combine them with a carbon source (straw, and/or leaves and manure) to make compost, and to subsequently reapply the compost to the soil. In the interim, a previously made compost can be applied to the skimmed area where the cover crops were removed at a rate of $\frac{1}{2}$ -1 pound of compost per square foot to fertilize crops.

It is important to retain the roots and nitrogen-filled nodules in the soil. Take only the vegetative portion of the cover crop for compost construction. When agitated by the skimming action of the spade or machete, the nodules will slough off into the soil in 3-7 days and then as you dig the soil the roots can be picked out. This is a gardener's dividend from the co-evolution of grazing animals and perennial legumes. The animal chews at and agitates the perennial legume, nodules slough off, and nitrogen is released into the soil to regrow the legume.

MATERIALS AND METHODS

Typically, annual cereals (grasses such as oats, barley, or annual rye) and legumes (vetches, bell, or fava beans) are used in tandem.

The grasses are referred to as "nurse crops." That is, they germinate quickly (within 3-5 days) and provide leaf cover for the soil surface and soil-holding action via the roots until the slower-emerging legumes get established (7-10 days). The grasses have a fibrous, shallow root system that "works" the surface soil (to approximately one foot deep) and is amazing in terms of its ameliorating effect on soil structure. Grasses are constantly sloughing off dying roots (on an almost daily basis) and growing new roots, thus increasing the organic matter content of the soil even as they grow. Some of the richest soils of the world, the soil order Mollisols (the root of the word, mollify, is to soften) are the soft, black soils of the U.S. upper Midwest and the steppes of Russia—the "breadbaskets" of the world.

The legumes feature a deep taproot (bio-drill) that breaks up compaction at depth as well as shallower, fibrous root systems. Some of the legumes, notably



Bell beans grown around the base of the tree in the fall, then chopped and used as a mulch in the spring, provide nutrients and build the soil's organic matter content.



Photo by Abigail Huetter

Students observe the roots of bell beans and the root hairs that aid in the uptake of beneficial bacteria into the plant.

vetches and bell beans, are amazing biomass producer (6-8 feet of top growth). Legumes also fix nitrogen, as noted above. Nitrogen is the most expensive, mobile, motile, and thus precious of all nutrients. It is needed in greater amounts than any other nutrient.

At plow-down time, the combination of the grass and legume contributes to a balance of carbonaceous material (grasses) and nitrogenous material (legumes), which results in an optimal formula for both organic matter increase and immediate fertilizer effect.

The ideal time to incorporate a cover crop as a green manure is prior to the grasses flowering and when the legume is 25-50% in bloom. Note that legumes make 70-80% of their growth in the last 20-30% of their growth cycle.

The best legumes to use in our area are bell beans and vetches (genus *Vicia*), combined with grasses, including oats, barley, or annual rye. Although fava beans were formerly used, the law of supply and demand, and thus price, make bell beans a better bet: you get five times the number of bell beans to the pound (vs. favas) and bell beans cost five times less than favas (59 cents vs. 2.99/lb.).

SOIL PREPARATION AND SEEDING

Soil preparation can be as simple and easy as skimming the soil surface, irrigating, waiting 3-5 days for dry down, broadcasting or scattering the seeds on the soil surface, and raking them in with quick, short strokes using a bow rake (not a leaf rake), moving in one direction—either to or fro, but not both—to cover the seed. Mulch with straw or leaves, then water. Stand back, go write the Great American Novel, reappear periodically, and plow down in late February-early April.



Cover crops grown in greenhouse for study.

On a garden scale, seeding so as to have 8-10 plants/square foot is an adequate cover crop. This is actually a light scattering of seeds. An admixture (by weight, not volume) of anywhere between 60-90% legume and 10-40% grass should suffice.

When planting cover crops around fruit trees, I prefer to use only bell beans at about 20-30 seeds per square foot. The reason being that vetch is an 8-foot vine and recognizes the tree as a trellis and wreaks all kinds of mayhem as it intertwines and shades flowers and leaves in the spring. The grasses are also often hard to eradicate in handworked systems.

I have used the bell beans as a green manure under trees and simply chopped them on the surface in the spring and mulched them over with 3-4 inches of wood-chips as the sole source of fertilizer input for our established (2 to 3-year-old) trees for 25 years, to great benefit. In the first two years after planting I also apply 2-3 shovels of compost and one-third to 1 pound of an organic granular fertilizer in addition to the green manure crop. Local organic apple grower extraordinaire Jim Rider uses a similar system on 80 acres.

—Orin Martin

SEED SOURCES

General Feed and Seed

1900 Commercial Way, Santa Cruz
476-5344, www.generalfeedandseed.com

San Lorenzo Garden Center

235 River Street, Santa Cruz 423-0223,
sanlorenzolumber.com

Mountain Feed and Farm Supply

9550 Highway 9, Ben Lomond
336-8876, www.mountainfeed.com

Peaceful Valley Farm Supply (shipping)

530.272-4769, www.groworganic.com

REFERENCES

Building Soils for Better Crops (3rd edition), by Fred Magdoff and Harold Van Es. Published by SARE/USDA. Available by mail (\$20.95) or free online: www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Managing Cover Crops Profitably (3rd edition), Sustainable Agriculture Network, Handbook Series #3. Available by mail (\$19.95) or free online: www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition

The Soul of Soil: A Soil-Building Guide for Master Gardeners and Farmers (4th edition), by Grace Gershuny and Joe Smilie. Chelsea Green Publishing, 1999

Unit 1.6: "Selecting and Growing Cover Crops". In *Teaching Organic Farming and Gardening: Resources for Instructors*, edited by A. Miles and M. Brown. Available free online: <http://casfs.ucsc.edu/education/instructional-resources/downloadable-pdf-files>

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