Building Healthy Soils in Vegetable Gardens: Cover Crops Have Got It Covered

Part III: Selecting Cover Crops for Vegetable Gardens

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This article is part of a four-part series about cover cropping in vegetable gardens. To learn more, see:

- *Part I: Introduction to Cover Cropping*
- *Part II: Types of Cover Crops -- Non-Legumes, Legumes, and Mixtures (oh, my!)*
- *Part IV: Planting and Managing Cover Crops in Vegetable Gardens.*

As I outlined in Part I and II of this series, cover crops can serve many purposes in small-scale vegetable gardens, including soil quality improvement, nitrogen (**N**) fixation, weed suppression, and habitat for beneficial insects. To achieve maximum benefits from cover crops, it's important to select appropriate species (or species mixtures) for each garden bed. In this article I'll highlight promising annual cover crop species for different seasonal niches, management goals, and environmental conditions. Much of this information is based on *preliminary* results from two seasons of cover crop research in Brooklyn, NY community gardens.[1]

Note: The cover crop seasonal niches and planting dates in this article are for USDA Plant Hardiness Zone 7 (average minimum winter temperature of 0-10°F). **To adapt this information for your local climate:**

1. Find your USDA Plant Hardiness Zone at: http://planthardiness.ars.usda.gov.
2. Consult your local Cooperative Extension and the book Managing Cover Crops Profitably to find ideal cover crop species and planting dates for your area. (Cover crop species profiles in this book all have maps indicating the most appropriate seasonal niche.)
3. A tip on adjusting planting dates: For **winter-kill and over-wintering cover crops** -- If you live in a *warmer climate* (Zone 8 and up), planting dates can be pushed *later* than those given in this article. If you live in a *colder climate* (Zones 6 and below), planting dates must be *earlier*. For **spring- and summer-planted cover crops**, the opposite is true.

Considerations when selecting cover crops

When choosing cover crops for a particular garden bed, there are three main considerations:[2]

- *Rotation planning:* What seasonal niche will the cover crop occupy? What vegetable crops will precede and follow the cover crop?
- *Management goals:* What do you want the cover crop to do? What cover crop function is most important -- adding organic matter to improve soil quality, contributing fixed N to the soil for food crops, suppressing weeds, providing habitat for beneficial insects, or suppressing a soil-borne disease?
- *Environmental conditions:* What species will grow well given your climate, soil, and light availability?

Seasonal niches

There are a number of seasonal niches when gardeners can fit cover crops into a vegetable rotation. **Winter-kill** and **over-wintering** cover crops are planted near the end of the growing season, and allow gardeners to take advantage of the warm summer months for vegetable production. **Summer** cover crops can be planted in the window after early spring crops (like lettuce) and before crops for a fall harvest (like broccoli or kale).

Winter-kill cover crops: Plant in late August, killed by frost

Winter-kill cover crops are planted in late August through early September, grow through the late summer and fall, and die with the first hard frosts (Fig. 1). It's best to plant winter-kill cover crops following a short-season vegetable (such as beans or beets) which can be harvested by mid- to late-August.

Plant a winter-kill cover crop in beds where you want to plant early spring crops in March and April (e.g., peas, spinach, broccoli).

Since these cover crops are killed by frost, they are **easy to manage**. The next season, you can plant cool-season crops (like peas, spinach, and broccoli) into the dead cover crop mulch as soon as the soil can be worked.

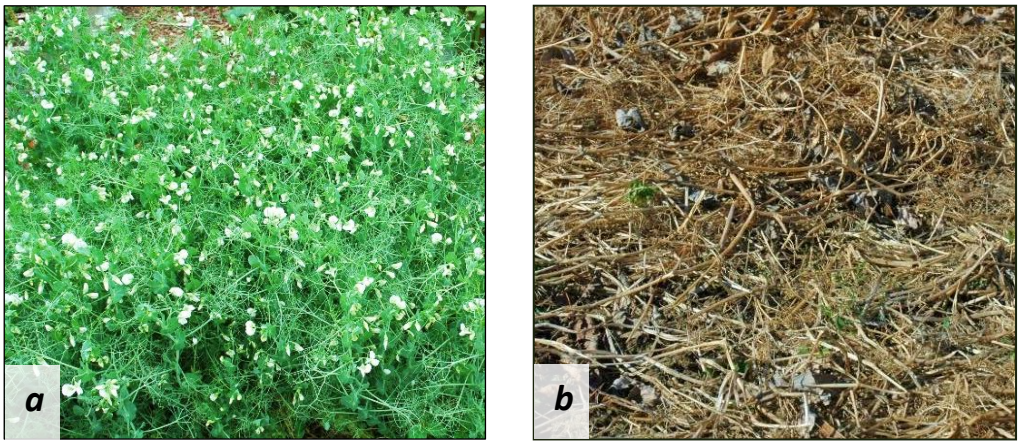

Figure 1. Field pea cover crop: a) growing in late fall and b) winter-killed mulch in early spring. Vegetable crops can be transplanted through the dead mulch as soon as the soil can be worked, in March or April. Photo credits: M. Gregory.

Due to their short growth period, however, winter-kill cover crops **produce much less biomass (plant material) and fix less N** to enrich the soil, compared to over-wintering cover crops (see below).[1] Since winter-kill cover crops decompose over the winter, they also **don't provide much spring weed suppression**.

In USDA Zone 7, winter-kill cover crops include **non-legumes** oats and brassicas and mustards, and a **legume**, field peas. (In Zones 5-6 and colder, crimson clover will also winter-kill.)

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Over-wintering cover crops: Plant in September – October, Cut down at flowering in early May

Over-wintering cover crops are planted in September and October, survive the winter, and resume growth the following spring. These cover crops are a good choice where you have longer-season vegetable crops that produce into the fall, as the cover crop can be seeded beneath food crops finishing up for the season (Fig. 2a). The following spring, the cover crops should be cut down at flowering, usually in early May (Fig. 2b).

Plant an over-wintering cover crop to get the most benefit for soil quality, legume N fixation, and spring weed suppression.

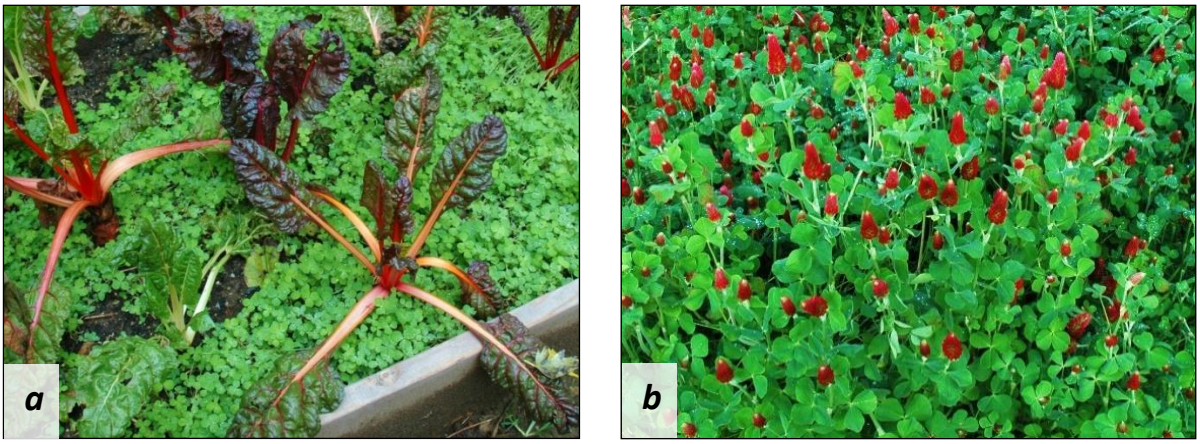

Figure 2. Crimson clover cover crop: a) under-seeded to Swiss chard in fall, and b) flowering the following spring. Photo credits: M. Gregory.

When allowed to reach maturity (flowering), over-wintering cover crops **produce large amounts of biomass and fixed N**.[1] Since over-wintering cover crops are well-established in early spring, they also **provide excellent spring weed suppression**. In Brooklyn gardens, four over-wintering cover crop combinations reduced spring weed growth by 93-100%.[1]

The main disadvantage of winter-kill cover crops is that **gardeners must wait to plant vegetables until late May or early June the following spring**. To obtain the most biomass and legume N fixation (and to ensure that the cover crops do not re-sprout!), gardeners *must wait* until over-wintering cover crops flower before cutting them down. Since this occurs in May, it's *not* possible to plant early spring crops following an over-wintering cover crop. Instead, gardeners should choose warm-season, transplanted vegetables (e.g., tomatoes, peppers, eggplants, and Cucurbits), or short-season vegetables (e.g., beans) for planting after an over-wintering cover crop.

In USDA Zone 7, over-wintering cover crops include the **non-legumes** winter rye and winter wheat, and the **legumes** crimson clover and hairy vetch.

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Summer cover crops: Plant in June or July

Summer cover crops can suppress weeds and add organic matter to the soil in the few months between early spring crops and late-season plantings for a fall harvest (June – mid-August). Some warm-season annuals can also be planted after a short-season vegetable in late July and allowed to grow into the fall for additional benefits to soil quality, weed suppression, and legume nitrogen fixation.

Plant a summer cover crop to suppress weeds and add organic matter to your soil between early spring crops and crops transplanted for a fall harvest.

Summer non-legumes like buckwheat and Japanese millet are fast-growing and may provide excellent weed suppression. Be sure to cut down these cover crops about one week after they begin flowering in order to prevent seed set. For buckwheat, this will be just 35-40 days after sowing.[3] Japanese millet will take at least 45 days to mature.[4]

In USDA Zone 7, legumes that can be planted in the summer include cowpeas and crimson clover. To obtain the weed suppression benefits of non-legumes *and* the nitrogen fixation benefits of legumes, try planting a

mixture. Finding an ideal combination – in which the non-legume does not suppress the legume – can be tricky, but there are a couple promising summer cover crop mixtures:

- **Japanese millet and cowpea:** The millet improves weed suppression over a cowpea monoculture, and also stimulates greater biomass production and nitrogen fixation by the cowpea.[5, 6]
- **Buckwheat and crimson clover:** Buckwheat's quick growth gets a jump start shading out weeds, but also suppresses the clover. To get the most out of this mixture, mow or clip the buckwheat when it begins flowering. This will allow light to reach the crimson clover, which can then grow and fix nitrogen into the fall.[7]

Management Goals

Most cover crops serve multiple purposes, but some will be better than others for different functions. Here are some tips on cover crop selection for common management goals.

Figure 3. Rye and hairy vetch is an excellent over-wintering cover crop combination that provides high biomass, N fixation by vetch, and weed suppression. (Photo credit: M. Gregory).

Increasing soil organic matter, Suppressing weeds → Over-wintering grass/legume mixtures

If your main goal is to build soil organic matter or suppress weeds, an **over-wintering grass-legume mixture** may be your best bet. Over-wintering mixtures produce high biomass (and therefore add lots of organic matter to the soil)[8, 9] and are well-established in spring to shade out weeds.

- In Brooklyn gardens, mixtures of **rye and hairy vetch** (Fig. 3) produced the most biomass of any cover crop combination and nearly eliminated spring weeds.[1]
- If a legume alone is desired (for example, to minimize the risk of N tie-up), **crimson clover** (Fig. 2) produced the highest biomass of all legumes in Brooklyn gardens. However, it had slightly lower weed suppression than other over-wintering cover crops, particularly in very fertile soils.[1]

Nitrogen fixation → Legumes:

To add 'new' nitrogen to the soil for food crops, **legumes** must be planted – either by themselves, or in mixture with a non-legume. In our research with community gardeners, we studied N fixation by three legume species:[1]

- **Over-wintering hairy vetch fixed the most N** – on average, enough to completely supply the N needs of a heavy-feeding vegetable, like tomatoes or squash.
- **Over-wintering crimson clover also fixed appreciable N** -- on average, enough to supply the N needs of a medium-feeding vegetable, like carrots.
- **Winter-kill field peas fixed much less N** than the two over-wintering cover crops. Even light-feeding vegetables (like radishes) would require additional N inputs from compost or manure following a field pea cover crop.

Research on farms has shown that **summer annual legumes** like **cowpeas** (planted in mixture with Japanese millet)[5] and **crimson clover** planted during the summer niche[7] fix intermediate amounts of nitrogen – on average, enough to supply the N needs of light-feeding vegetables.

Mixtures with non-legumes can increase the percentage of N that legumes get from N fixation, and therefore the amount of 'new' N introduced to the garden (see Part II of this series). However, gardeners should experiment with mixtures to make sure the non-legume does not suppress legume growth. If the non-legume grows so vigorously that the legume doesn't have much space or light, the legume will grow very little and not fix much N. **Rye and hairy vetch** (Fig. 3) are usually a good mixture, since the hairy vetch is viny and can climb the rye.[5] That way, the hairy vetch can access more light and produce substantial biomass. In Brooklyn gardens, hairy vetch actually had equal biomass by itself and in mixture with rye -- even though the vetch was seeded at just half the rate in the mixture![1] In other cases, it may be necessary to seed the legume at a higher rate than the grass to get good N fixation. In the cases of oats and field peas, or rye and crimson clover, the grass may suppress the legume and reduce N fixation.[1]

A few caveats: The comparisons of N fixed by various legumes with the needs of different vegetable crops provided above are rough 'ballpark' figures. However, the amount of N fixed by a legume varies tremendously between gardens due to differences in climate, light availability, soil, planting dates, and whether or not the legume was grown in mixture with a non-legume. Also, not all the N fixed by a legume cover crop becomes available during the first year after growing it. As the legume plant decomposes, some of its N will become part of soil organic matter, and can be released by microbes in future years for crops to use. Therefore, gardeners may need to grow legumes for several years -- to build up N reserves in soil organic matter -- before relying mostly on legumes to supply crop N needs.

Nutrient retention → Over-wintering grasses:

If you have very fertile soils and are concerned about retaining nutrients, **over-wintering grasses**, like winter rye (Fig. 4b), are the best choices. They are very efficient at taking up extra nutrients (especially N), have been shown to reduce N leaching by about 70% compared to bare soil.[10]

Nutrient retention may be important for many gardeners. Several studies have shown very high nutrient levels in home and community gardens, perhaps because of large compost applications over small areas.[11-14]

Environmental Conditions

In addition to seasonal niche and priority management goals, gardeners must also consider environmental conditions when choosing cover crops. Cover crops will perform the best when planted under conditions to which they are adapted, including appropriate climate (see the Note at the beginning of this article on selecting appropriate cover crops for your climate), soils, and light availability.

Soils

- **In light-textured (sandy) soils and soils with low to moderate fertility, legumes will perform well.**[15]
- **In very fertile soils (particularly those with high weed pressure), non-legumes or mixtures are a better choice.** Non-legume cover crops take up soil N more efficiently, and grow fast enough to compete with weeds. In Brooklyn gardens with very high N fertility, legumes did not grow fast enough to compete with weeds, but winter rye covered the soil and reduced weed growth in fertile soils (Fig. 4).[1]

Figure 4. Photos illustrating different weed suppression outcomes for legume and non-legume cover crops in very fertile soils. a) Crimson clover, a legume, provided poor weed suppression (note chickweed mixed in with the cover crop). b) Winter rye, a non-legume, grew quickly and provided good weed suppression. (Photo credits: M. Gregory.)

Light availability

All cover crops will benefit from full sun, but some are more tolerant of shade than others. In gardens in Brooklyn, we analyzed how light availability affected cover crop growth: [1]

- **In shaded areas, the cover crops with the greatest biomasses were: rye/legume mixtures, rye, and crimson clover**. Crimson clover was the most shade-tolerant legume, and produced similar biomass in shade and sun. Hairy vetch showed intermediate shade tolerance.
- **Winter-kill cover crops (field peas, oats, and oat/pea mixtures) all performed very poorly in shade.** As light availability increased, the field peas and oat/pea mixtures produced more biomass. Therefore, we only recommend these cover crops for use in full sun.

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The table below summarizes planting dates and characteristics of several winter-kill and over-wintering cover crops for small-scale vegetable gardens. Once you've selected cover crops for each garden bed, check out Part IV of this series for tips on sourcing cover crop seed, and planting and managing cover crops in your vegetable garden.

Table 1. Promising cover crop options for gardeners in various seasonal niches, management goals each cover crop may help achieve, and appropriate environmental conditions for plantings. Legume cover crops are indicated by (**L**). DAS = Days after sowing.

Cover Crop Species	Plant date (Zone 7)	Termination date (Zone 7)	Management goals	Environmental conditions	Notes
WINTER-KILL COVER CROPS					
Field peas (L)	Late Aug	(Killed by frost)	Soil conditioner; Some N fixation	Full sun only	Avoid close rotations with legume vegetable crops (beans, peas)
Oats and Field peas (L)	Late Aug	(Killed by frost)	Soil conditioner; Some N fixation (but seed peas at higher rate); Fall weed suppression	Full sun only	Avoid close rotations with legume vegetable crops (beans, peas)
Brassicas	Late Aug	(Killed by frost)	N retention; Fall weed suppression; Disease management	High-fertility soils	Avoid close rotations with Brassica vegetable crops (bok choy, broccoli, cabbage, collards, etc.)
OVER-WINTERING COVER CROPS					
Crimson clover (L)	Early-mid Sept	Early May (at flowering)	Large biomass; High N fixation; Good spring weed suppression, except in high-fertility soils	Low- to moderate-fertility soils; Shade-tolerant	Winter-kills in Zones 5-6 and colder.
Hairy vetch (L)	Late Sept – Early Oct	Mid-May (at flowering)	Medium biomass; Very high N fixation; Excellent spring weed suppression	Low- to moderate-fertility soils; Somewhat shade-tolerant	
Rye	Mid-Sept – Late Oct	Early- to Mid-May (at flowering)	Very large biomass; Excellent N retention; Excellent spring weed suppression	High-fertility soils; Shade-tolerant	Allow ~2 weeks between cover crop termination and planting vegetables, to prevent N tie-up.
Rye and Hairy vetch (L)	Late Sept – Early Oct	Mid-May (at flowering)	Very large biomass; N fixation; N retention; Excellent spring weed suppression	Adapted to a range of soil fertility levels; Shade-tolerant	Allow ~2 weeks between cover crop termination and planting vegetables, to prevent N tie-up.
SUMMER COVER CROPS					
Buckwheat	June - August	1 week after flowering begins (35 – 45 DAS)	Very fast growth and soil cover; Soil conditioner; Excellent summer weed suppression	Light to medium, well-drained soils	Cut down 1 week after flowering begins to prevent seed set.
Buckwheat & Crimson clover (L)	July	Buckwheat – mow/trim at flowering; Crimson clover – allow growth into the fall	Soil cover, soil conditioning, & weed suppression from buckwheat; Moderate N fixation from crimson clover	Light to medium, well-drained soils	Mow or trim buckwheat at flowering to allow light to reach the crimson clover
Japanese millet and Cowpea (L)	July	Millet - 1 week after flowering begins (45+ DAS)	Summer weed suppression from Japanese millet; Moderate N fixation from cowpea	Medium to heavy soils (preferred by millet)	

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