Cover Crops for Walnut Orchards

Joseph Grant
UCCE Farm Advisor, San Joaquin County

Kathy Kelley Anderson
UCCE Farm Advisor, Stanislaus County

Terry Prichard
UCCE Irrigation Water Management Specialist, San Joaquin County

Janine Hasey
UCCE Farm Advisor, Sutter-Yuba Counties

Robert L. Bugg
UC Sustainable Agriculture Research and Education Program, Davis

Fred Thomas
CERUS Consulting, Chico, California

Tom Johnson
Kamprath Seed Company, Manteca, California

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Cover crops can provide many benefits in orchards and vineyards and have seen increasing use in recent years. Walnut orchards present unique challenges to the successful use of cover crops. These include the short time between harvest and leaf fall for establishing the cover crop, a deep layer of leaf litter on the orchard floor that may inhibit germination and growth of cover crop seedlings, the relatively low light levels reaching the floor of most mature orchards during the growing season, and the need for a debris-free orchard floor at harvest. In spite of these difficulties, many walnut growers have established successful and productive cover crop stands and realized the benefits that cover crops can provide.

What is a cover crop?

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- Cover crops can be annuals, which germinate and die in one season, or perennials, which live for a number of years.
- Legumes and grasses can be used, either as annuals or perennials, depending on the species and management.
- Both winter and summer weeds can be allowed to grow and be managed like a cover crop. These weeds, also referred to as "resident vegetation," usually produce less biomass (organic matter) than planted cover crops.

Why should I plant a cover crop?

The main reason for planting a cover crop is to improve soil quality by adding organic matter and (for legume cover crops) nitrogen. Cover crops also

The main reason for planting a cover crop is to improve soil quality by adding organic matter and nitrogen (for legume cover crops).

- improve orchard access in winter and spring by removing excess water from the soil and providing a firmer surface for equipment traction.
- enhance water infiltration by stabilizing soil aggregates and creating root channels for better water penetration.
- extract nitrogen (when the cover crop includes legumes) from the atmosphere and convert it to soil forms available to trees. This "fixed" nitrogen is used

by the trees, reducing the amount of commercial nitrogen fertilizer required.

- reduce runoff of irrigation and rain water as well as the off-site movement of pesticides and nitrogen.
- reduce undesirable winter weed species by shading them out and competing for water. Summer weeds can also be suppressed if the cover crop is allowed to persist late in the spring.
- reduce erosion on slopes and river bottom areas subject to flooding.
- protect the soil surface against the impact of sprinkler and rain droplets and other soil compacting or crusting forces such as equipment traffic.
- extract leftover fertilizer nitrogen and mineralized nitrogen from the soil and convert it to more stable organic forms that are more easily conserved for later use by trees.
- reduce dust by improving soil structure and minimizing soil exposure to wind. Dust control may also minimize spider mite infestations.
- may increase the abundance of beneficial insects, although evidence of benefits to walnut orchard pest management is lacking.

What are the challenges I might face in growing cover crops?

Water use. Cover crops use water and will increase the total orchard water requirement. In spring, cover crops can deplete stored soil moisture from winter rains that would otherwise be available to trees. A typical 5,000 pound per acre (5,600 kg/ha) (dry weight) cool-season green manure cover crop, for example, consumes about 180,000 gallons (6.5 acre-inches, or 18.5 million cubic meters) of water. Perennial sod cover crops compete with the orchard for water throughout the season. A mature almond orchard with a perennial clover cover crop, for example, can use 10 to 30 percent more water than an orchard with bare soil (Prichard et al. 1989). On the other hand, cover crops often increase water penetration and soil water-holding capacity. These benefits may help offset the greater demand for irrigation water in cover cropped orchards. Water use by cover crops in walnut orchards may be lower than that in almond orchards because of greater shading of the orchard floor.

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Risk of frost. A bare, firm, moist orchard floor absorbs heat during the day and releases it at night, increasing the air temperature by as much as 3° to 4°F (1.6 to 2.2°C). A winter cover crop reduces absorption of heat by the soil during the day, increasing the risk of frost damage after trees begin to leaf out in spring. Close mowing of the cover crop before a radiation frost may help reduce this risk.

Conflict with orchard sanitation. Efforts to develop a good cover crop may be at odds with the need for spring mowing to destroy overwintering "mummy" nuts that harbor navel orangeworm. The low mowing needed to shred overwintering nuts can decrease cover crop biomass production and be detrimental to some cover crop species' growth or reseeding.

Impediment to orchard pruning activities. It is difficult or impossible to remove or shred orchard prunings on the orchard floor once a cover crop has grown up around them in late winter or early spring. If you plan to grow a cover crop, prune and dispose of brush in the fall prior to cover crop seeding or plant the cover crop in alternate middles and prune only in unplanted middles. Alternatively, plant cover crops in years when pruning is not planned.

Buildup of pocket gophers and voles. Pocket gophers feed on the roots of annual and perennial clovers, so these cover crops may increase gopher problems in orchards. Cover crop stands also hide the aboveground mounds that indicate the presence of gophers in the orchard and can provide protective habitat for voles by sheltering their runways.

Nematode hosts. Cover crops may affect the population dynamics of three plant-parasitic nematodes that attack walnuts: ring nematode (*Mesocriconema xenoplax*), root-knot nematode (several *Meloidogyne* species), and root-lesion nematode (*Pratylenchus vulnus*). Although experimental evidence shows that certain cover crops may suppress nematode populations, the impact of greater concern is that cover crops may serve as hosts for these nematodes and increase their populations in walnut orchards.

Ring and root-knot nematodes have wide host ranges, including many weeds and cover crop plants. These nematodes usually reach population levels damaging to walnut trees only in orchards on coarse-textured soils such as sands and sandy loams, but they may also be problematic on occasion in finer-textured soils as well. Because nematodes are less active during winter and spring when soil temperatures are low, cool-season green manure cover crops can be used in orchards on these soil types without increasing ring and root-knot nematode populations. Mow or disk these cover crops by mid-May when soil temperatures become favorable to nematode activity and reproduction.

Pratylenchus vulnus is the nematode of primary concern to walnut growers. Because its host range is primarily limited to tree and vine crops, most cover crops can safely be grown without risk of increasing populations of this nematode. Cereal and legume crops do support several other *Pratylenchus* species, such as *P. penetrans* and P. *neglectus*, but these root-lesion species are not damaging to walnut roots.

How do I choose a cover crop?

Types of cover crops. Three cover crop systems have been used most successfully in walnut orchards.

- Winter green manure crops (fig. 1), usually consisting of a mixture of large-seeded cereal grains (e.g., oat and barley) and nitrogen-fixing legume species (e.g., vetch, pea, bell bean), newly seeded each fall and mowed or cultivated in spring.
- Annual reseeding legumes (fig. 2) (e.g., common vetch, subterranean or crimson clover, bur medic) or grasses (e.g., Blando brome), planted initially in the fall and managed during the spring and early summer so as to allow cover crop plants to reestablish themselves by natural reseeding.
- Perennial sods (fig. 3), containing grasses (perennial ryegrass, various fescues) and/or legume (white and/or strawberry clover), planted in fall through spring and mowed to provide a year-round orchard floor covering.

These three groups of cover crops have a different array of potential benefits and drawbacks to consider when choosing the best cover for individual orchard situations (see sidebar).

One additional type of cover crop sometimes used in young orchards is a spring-planted cover crop of warm-season species such as buckwheat, sudangrass, or cowpea. These crops help increase soil organic matter and improve soil tilth and water-holding capacity. Cowpea also fixes some atmospheric nitrogen. These benefits are particularly helpful in sandy orchard sites with low organic matter content. Because these cover crops are grown in the spring and summer, on the other hand, they increase the irrigation needs of the orchard and may contribute to nematode buildup. Sample for nematodes and avoid summer cover crops that are hosts to plant-parasitic nematodes present in the orchard.

Benefits and problems of selected cover cropping systems

Desired benefits	Winter green manure	Annual reseeding	Perennial sod
add organic matter to the soil	●●	●	●
increase soil microbiological activity	●●	●	●
capture/convert atmospheric nitrogen to soil nitrogen	●● (legumes)	● (legumes)	● (legumes)
improve water infiltration	●●	●●	●●
reduce water runoff/ soil erosion	●	●	●●
reduce dust	●	●	●
reduce soil compaction	●	●	●
suppress weeds	●●	●●	●●
reduce excessive soil moisture (spring)	●●	●	●●
improve winter orchard access	●	●●	●●
Potential problems			
increase orchard demand for water	❍	❍	❍❍
spring frost damage	❍❍	❍	❍
interfere with sanitation for navel orangeworm	❍	❍	❍
favor gophers and voles	❍	❍	❍
interfere with pruning and brush removal	❍❍	❍	■
increase nematode populations	■	■	❍❍ (ring and root-knot, where present)

Key:
●● / ❍❍ Large benefit / potential problem
● / ❍ Moderate benefit / problem
■ Little or no benefit or problem

What orchard factors affect cover crop choice?

Orchard floor management. Winter green manure cover crops are well suited to cultivated orchards because the soil conditioning and fertility benefits of these covers are maximized when the cover crop residue is incorporated into the soil. These benefits, however, are reduced by subsequent cultivations because continued tillage accelerates the breakdown of soil organic matter. Winter green manure crops also provide many soil and fertility benefits in noncultivated orchards, where the cover crop residue is mowed and left to decompose on the soil surface. However, this practice reduces nitrogen recovery from legumes in the cover crop compared to incorporation. Annual reseeding and perennial sod cover crops can only be maintained in noncultivated orchard situations.

Irrigation method. The choice of cover crop may be dictated to some degree by the irrigation method used in the orchard. Winter green manure cover crops seeded in the fall and mowed or disked in the spring can be grown without full-coverage irrigation (e.g., in orchards with drip or microsprinkler irrigation systems), since they are normally removed before the irrigation season begins. A full-coverage system can sometimes be advantageous for "irrigating up" winter green manure and annual reseeding cover crops when fall rains come too late to supply moisture for cover crop germination. Because perennial sod cover crops are present throughout the year, full-coverage sprinkler or flood irrigation provides for the best cover crop growth and longevity. Perennial sods are used successfully in orchards that have partial-coverage systems such as microsprinklers, but the cover crop grows better and provides greatest benefit in areas wetted by the irrigation system.

Figure 1. *Triticale green manure cover crop in late March. Many growers report improvements in water infiltration as a result of growing this cover crop.*

Figure 2. *Annual reseeding brome cover crop in a Sacramento Valley walnut orchard.*

Figure 3. *Grass sods such as this perennial rye and fescue mix improve access by equipment in winter and reduce dust but require full-coverage or nearly full-coverage irrigation and at least some direct sunlight during the day in order to persist for multiple years.*

Walnut variety. Cover crop seedbed preparation and planting must take place between harvest and leaf fall when soil conditions favor rapid seed germination and seedling establishment. Early- and mid-harvesting walnut varieties allow more time for these operations than do late-harvesting varieties. With careful planning and favorable weather, however, successful cover crop stands can be established in all walnut orchards.

Cover crop seedbed preparation and planting must take place between harvest and leaf fall when soil conditions favor rapid seed germination and seedling establishment.

Orchard shading. Some cover crop species are more shade tolerant than others and are therefore better adapted for use as cover crops in walnut orchards. Orchard shade is of less importance for winter green manure and annual reseeding cover crops than for perennial sods since stand establishment and growth take place after leaf fall, when more light reaches the orchard floor. Winter green manure cover crops are generally removed by mowing or disking before orchard shading limits cover crop productivity. Annual reseeding grasses and legumes recommended for use in walnuts grow well in the partial shade of the developing canopy during April and May and will set sufficient seed before they are removed by mowing in early June. Some perennial grass and clover sod species (e.g., perennial ryegrass, creeping red fescue, white clover) have sufficient shade tolerance to establish and grow well in shaded orchards, though grass and legume sods are always strongest and persist longest in orchards where they receive some direct sunlight.

Soil type and climate. In orchards with heavy textured soils or where early fall rains occur, wet soil conditions can reduce equipment access for harvest operations. Cover crops that can be managed by mowing, such as annual reseeding, perennial sods, or a mowed winter green manure, provide a firmer orchard floor at harvest time than cover crops removed in spring by cultivation.

When and how do I plant a cover crop?

For rapid germination and seedling growth, plant winter green manure, annual reseeding, and sod cover crops between harvest and leaf fall when soil is still warm (fig. 4). Prepare the seedbed and plant before leaf fall because seed planting and seedling emergence is impeded by thick layers of fallen leaves, especially for small-seeded cover crop species such as fescues, ryegrass, clovers, and medics used in annual reseeding and sod mixes. Slugs can also severely damage young cover crop seedlings when the seedlings are covered by leaf litter. Germination and early stand establishment are substantially improved if rainfall occurs or irrigation water is applied soon after planting. One or two light (1/4 to 1/2 acre-inch) postharvest irrigations help ensure good germination if fall rains are late.

Orchard pruning operations can conflict with cover crop seeding because equipment traffic associated with pruning, brush removal, and brush shredding or chipping can damage the cover crop seedbed and emerging seedlings. Pruning should be completed before the cover crop is seeded. Where this is impractical, plant cover crops in alternate middles and perform pruning operations in the unplanted ones. Even after becoming well established, most winter green manure cover crops generally do not tolerate traffic associated with pruning or brush management without damage. Grass and legume sods, on the other hand, once established (that is, from the second winter on), provide good support and traction for winter pruning.

Cover crops are usually planted in orchard middles, and the tree rows are kept free of vegetation using preplant and postplant herbicides, cultivation, or other means. For maximum benefit, planted middles should be as wide as possible without risking damage to tree roots by cultivation, seeding, and mowing activities associated with the cover crop. Because of their creeping growth habit, perennial legume sod species should be planted at least 18 inches from the edge of herbicide-treated strips to reduce the risk that they will spread into the tree rows. For efficiency of management, the width of planted middles should also be based on the width of available seeding, mowing, and cultivation equipment.

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To maximize nitrogen fixation, inoculate legume seeds with the correct strain of *Rhizobium* bacteria before planting. There are a number of ways to inoculate seed, but the best results are obtained using "wet methods" that involve mixing the seed with small amounts of water and one of various adhesives to coat the seed with

Figure 4. *With careful planning, the short time available for planting cover crops—between harvest and leaf fall—will not be an obstacle to their successful use. In this orchard, the first of three preseeding cultivations is being performed (foreground) while nut harvest proceeds a short distance away (background).*

Figure 5. *In walnut orchards where middles are not cultivated, planting cover crops with a no-till seed drill helps minimize disturbance of the orchard floor. Multiple seeding passes may be needed if the drill is narrower than the width of the planted middles.*

inoculant. Seed may also be inoculated by layering dry inoculant with seed as it is added to the drill or broadcast seeder hopper, but this method is generally not as effective as wet method inoculation. Small-seeded legumes may be pellet-inoculated by the seed supplier, in which case additional inoculation is unnecessary.

Cover crops can be seeded by broadcasting or drilling. Broadcasting is faster than drilling and works well if the entire orchard floor is being seeded. Broadcast seeding should be preceded by shallow cultivation. For cover crops that will be mowed, any needed leveling and floating of the orchard floor should be done prior to seeding, since the condition of the orchard floor after planting determines its condition for harvest the following year. For winter green manure cover crops that will be disked in, these operations can be done after the cover crop residue is incorporated in spring. Use a springtooth harrow and ring roller after broadcast-seeding large-seeded cover crops to cover the seed and ensure good seed to soil contact. Do not plant small-seeded species such as clovers and sod-type grasses more than ½ inch (12 mm) deep.

Drilling seed requires less ground preparation than broadcasting, and it plants the seed more precisely (fig. 5). Seed drills can be adapted for most cover crop species but may have difficulties with multispecies mixes. Brillion-type grass seeders work well for small-seeded legumes and grasses but can become clogged by large seeds in some multispecies mixes. Seed dealers are usually good sources of information on specific techniques for seeding various cover crop species and mixes.

How do I manage the cover crop?

Winter green manure cover crops. Deciding when to remove a winter green manure cover crop is a matter of balancing the goal of maximizing biomass production (and, for legumes, nitrogen capture) with the need to conserve soil moisture for use by trees. Remove these cover crops by late April or early May to minimize water use (fig. 6).

Figure 6. *Bell bean, vetch, pea, and oat green manure mixture at flowering. This cover crop is ready for mowing or disking.*

Figure 7. *Two weeks after mowing in mid-March, little residue remains of the original bell bean, field pea, and oat green manure cover crop, seen unmowed at the left.*

Figure 8. *Annual reseeding mixture of subterranean clover and Blando brome in April. Mow annual reseeding cover crop stands twice: first in late February to early March to reduce winter weed competition and the risk of frost injury to emerging walnut shoots, and again in early to mid-June to remove the stand after seed has matured.*

Winter green manure cover crops may be removed by disking in cultivated orchards or by flail or rotary mowing in noncultivated orchards (fig. 7). Very tall or thick cover crop stands can be mowed prior to disking to facilitate incorporation of the residue.

Annual reseeding cover crops. In late February or early March, annual reseeding clover cover crops should be mowed at ½ to 1 inch (1.2 to 2.5 cm) in height to reduce competition from winter weeds, destroy mummy nuts that may harbor overwintering navel orangeworm, and help increase heat absorption and reradiation for frost protection. Most of the grasses commonly used in annual reseeding cover crop mixes do not tolerate short mowing as well as the reseeding clovers; they grow better after mowing at 1 to 1½ inches (2.5 to 4 cm). Mowing at this height will not destroy as many mummy nuts and may provide less frost protection than closer mowing, so these competing factors must be considered when selecting a first mowing height for each orchard situation.

A second and final mowing is done in early to mid-June once seed has fully matured to ensure satisfactory reestablishment of the cover crop the following winter (fig. 8). Experience suggests that a successful stand can be reestablished if half or more of plants in the cover crop produce mature seed before they are removed by mowing or disking. Mowing more frequently delays flowering and seed development by most annual reseeding species. Mowed residue left on the soil surface helps suppress summer weeds and will decompose by harvest.

Figure 9. *Perennial New Zealand clover sod in a young walnut orchard, mowed recently in alternate middles to reduce the risk of frost damage to developing walnut shoots and flowers.*

Perennial grass and legume sods. Perennial grass and clover sod cover crop species must be managed carefully to maximize stand quality and minimize potential problems. During the first winter after seeding, mow as soon as possible in February or March when the soil surface is dry enough to allow access without compacting the soil (fig. 9). This mowing is essential to reduce weed competition and prevent shading of the very small grasses and clovers. Mow frequently enough to ensure that small perennial seedlings are well exposed to sunlight and that thick clumps of clippings do not remain after mowing. These clumps can kill the underlying sod, reducing its quality and benefits. As the sod gets taller it should be treated like a lawn, removing only one-quarter to one-third of the top growth so that plants can get established and develop a good root system. Depending on the harvest equipment, the final preharvest mowing may have to be as low as 1 inch (2.5 cm) or less to ensure a debris-free orchard floor. If the sod is well established it will withstand this short mowing.

Cover crops as a nitrogen source

Cover crops that include nitrogen-fixing plants such as vetch, clover, peas, and beans can contain substantial amounts of nitrogen. However, a cover crop's ultimate nitrogen contribution to the orchard depends on the mass of cover crop produced, the types and relative amounts of legumes and nonlegumes it contains, and how the cover crop is managed. In general, green manure cover crops with a high percentage of legumes are likely to contribute more nitrogen than annual reseeding or sod cover crops containing legumes. More nitrogen is recovered from green manure cover crops incorporated into the soil by cultivation than when the cover crop is mowed and the residue left on the soil surface to decompose. Because the nitrogen contribution from cover crops depends on so many factors, estimates of the available nitrogen they supply to the orchard should always be considered only a rough estimate. Annual leaf nitrogen analysis and nitrogen budgeting should be used to validate these estimates and adjust fertilizer programs accordingly. More detailed information on selecting and managing cover crops for nitrogen supply, estimating their nitrogen contribution to the orchard, and adjusting fertilizer rates to account for this contribution can be found in Guide to Efficient Nitrogen Fertilizer Use in Walnut Orchards (Kelley Anderson et al. 2006), Cover Cropping in Vineyards (Ingels et al. 1998), and Cover Crops for California Agriculture (Miller et al. 1989).

How much will a cover crop cost?

The cost of a cover crop depends on the type of cover used, the seeding rate, the amount of seedbed preparation required, the planting method, and the need for extra management operations associated with the cover crop such as watering, fertilizing, mowing, and/or incorporation of the cover crop residue. Seed costs range from $15 to $50 per acre ($37 to $124/ha), but average around $35 per acre ($86/ha) for the most commonly used covers. Soil preparation and planting costs typically add an additional $45 to $65 per acre ($111 to $160/ha). For perennial sod or reseeding annuals, these costs are spread over their longer life span. Some savings can be achieved with winter green manure cover crop species that naturally reseed themselves, such as vetch, though extra water may be needed to sustain growth until the seed matures.

Suggested cover crop mixes for walnuts

The following suggested cover crop mixtures were provided by growers, seed sales representatives, and orchard consultants with experience in growing and managing cover crops in walnut orchards. These mixtures are just a few of many possible combinations used successfully in walnuts. The authors are grateful to the source contributors listed below for providing these suggestions.

Chris Locke, Locke Ranch, Lockeford, California (CL)

Fred Thomas, CERUS Consulting, Chico, California (FT)

Joe Baglietto, Baglietto Seed, Stockton, California (JB)

Janine Hasey, UCCE Farm Advisor, Sutter-Yuba Counties (JH)

Tom Johnson, Kamprath Seed, Manteca, California (TJ)

Wayne Ferrari, Ferrari Farms, Linden, California (WF)

The tables on pages 16 through 18 provide information on the growth and management of individual species used in walnut cover crop mixes. Many varieties of each species are available. The particular growth characteristics, adaptability to local soil and climatic conditions, or resistance to pests and diseases may make some varieties better choices than others for use as cover crops in your orchard. Consult with your local cooperative extension advisor, seed dealer, or conservation agency representative in choosing varieties best suited to your area.

Winter green manure mixes *(Can be removed by disking or mowing, depending on orchard floor management system.)*	**Planting rate (lb/acre)**	**Source**
30–45% bell beans 30–35% field peas 15–25% common vetch 10–15% forage grain (oat, triticale, cereal rye, wheat, or barley) Allow the vetch to bloom for maximum biomass; does not tolerate poorly drained conditions.	80–120	TJ
50% triticale or cereal rye 35% common vetch 15% mustard Useful mix for drainage problems due to deep-rooting plants.	50–80	TJ
34% common vetch 33% purple vetch 33% woolypod vetch Allow vetch to bloom for maximum biomass.	30–45	TJ
33% late-season oat 25% forage wheat 16% midseason oat 18% field peas 8% common vetch	80–100	JB
30% field peas 20% common vetch 25% common barley 25% forage wheat	110–120	JB
50% woolypod vetch 50% common vetch	50–60	WF
20% woolypod vetch 15% triticale 15% semidormant alfalfa 10% common vetch 10% purple vetch 10% oat 10% barley 10% crimson and/or Persian clover	50	CL

Note: 1 lb/acre = 1.12 kg/ha.

Perennial grass sod mixes	Planting rate (lb/acre)	Source
85–90% perennial ryegrass (turf type) 10–15% creeping red fescue	30–50	TJ
50% tall fescue (turf type) 30% perennial ryegrass (turf type) 20% creeping red fescue Aggressive moisture competitor.	30–50	TJ
50% perennial ryegrass (turf type) 25–30% creeping red fescue 20–25% Chewings fescue Irrigate up for best results; requires good seedbed preparation; can add 5% white clover or strawberry clover for some nitrogen fixing ability.	25–50	JB

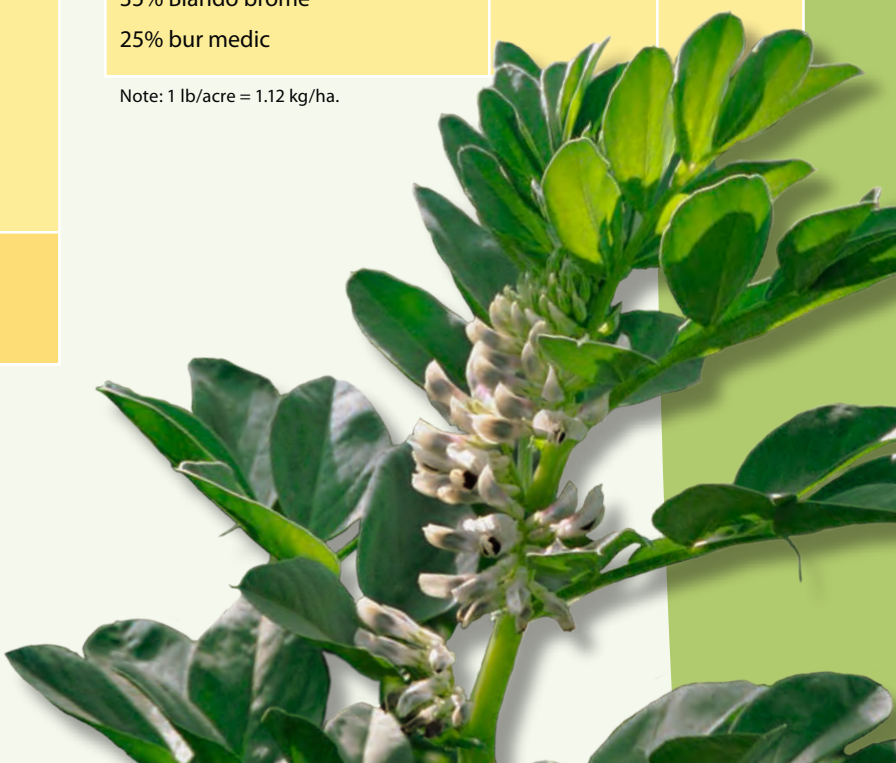
Perennial clover sods	Planting rate (lb/acre)	Source
50% New Zealand white clover 10% crimson clover 10% rose clover 10% subterranean clover 20% Persian clover For young (2–5 years old) orchards.	15	FT
100% New Zealand white clover For mature orchards.	12–15	FT

Note: 1 lb/acre = 1.12 kg/ha.

Warm-season green manure mix	Planting rate (lb/acre)	Source
60–70% buckwheat 30–40% cowpea	30–40	CL

Annual reseeding mixes	Planting rate (lb/acre)	Source
33% subterranean clover (early-maturing variety) 34% subterranean clover (midseason maturing variety) 33% subterranean clover (late-maturing variety)	25–30	JH
50% subterranean clover (early, midseason, and late-maturing variety mix) 50% Blando brome Adding brome to annual reseeding clover mixtures helps improve water penetration	25–30	JH
40% subterranean clover (early, midseason, and late-maturing variety mix) 35% Blando brome 25% bur medic	20–25	JH

Note: 1 lb/acre = 1.12 kg/ha.



Descriptive Information for Legume and Grass Species Used in Walnut Cover Crop Mixtures

Winter green manure cover crop species

Common name *Scientific name*	Growth habit	Maximum height (in)	Flowering period	Seeding rate (lb/acre)	Comments
Legumes					
bell (fava) bean *Vicia faba*	upright	36–72	Mar–May	60–100	Used successfully as pure stand cover crop by some walnut growers.
common vetch *Vicia sativa*	viny	18–24	Apr–Jul	30–50	Winter hardy; emerges well through leaf litter; may also used as annual reseeding cover crop by allowing seed to mature before mowing or disking in late spring.
field pea *Pisum sativum*	viny	18–36	Mar–May	60–100	Forage varieties work best.
hairy vetch *Vicia villosa*	viny	18–36	Apr–May	35–45	Very cold tolerant.
purple vetch *Vicia benghalensis*	viny	18–36	Apr–May	40–60	Late-maturing; may be included in mixes.
woolypod vetch *Vicia villosa ssp. dasycarpa*	viny	18–36	Apr–May	40–60	Produces hard seed; invasive.
Cereal grasses					
barley *Hordeum vulgare*	upright	24–36	Apr–May	60–100	Early maturing; can reseed.
cereal rye *Secale cereale*	upright	36–60	Apr–May	60–100	Merced most common cultivar.
oat *Avena sativa*	upright	36–60	Apr–May	100–120	Late-maturing varieties work best; tolerates wet soils.
triticale × *Triticosecale*	upright	36–60	Apr–May	60–100	A hybrid of wheat and cereal rye; deep rooted; Trios 102 and other winter types remain prostrate in winter for easy orchard access.
wheat *Triticum aestivum*	upright	24–36	Apr–May	100–120	Forage types produce more biomass and are better suited than grain types for use as cover crops

Note: 1 lb/acre = 1.12 kg/ha.

Warm-season annual cover crop species

Common name Scientific name	Growth habit	Maximum height (in)	First flowering (days after seeding)	Seeding rate (lb/acre)	Comments
buckwheat *Fagopyrum esculentum*	upright	12–24	25–30	10–15	Fast growing.
cowpea *Vigna unguiculata* ssp. *unguiculata*	upright to semiupright	12–36	60–70	10–15	Does not tolerate flood irrigation.
sudangrass *Sorghum sudanense*	upright	36–120	60–80	25–30	High biomass; requires supplemental nitrogen for maximum growth.

Note: 1 lb/acre = 1.12 kg/ha.

Annual reseeding cover crop species (small-seeded)

Common name *Scientific name*	Growth habit	Maximum height (in)	Flowering period	Seeding rate (lb/acre)	Comments
Legumes					
bur medic *Medicago polymorpha*	prostrate to semiupright	10–18	Mar–Apr	15–20	Adapted to alkaline soils and lower rainfall; invasive; does not consistently reestablish by reseeding every year because hard seed coat needs scarification.
crimson clover *Trifolium incarnatum*	upright	12–24	Apr	20–25	Good winter growth.
rose clover *Trifolium hirtum*	semiupright	12–18	Apr	15–20	Widely adapted to different soils and rainfall amounts; readily reseeds.
subterranean clover *Trifolium subterraneum*	prostrate to semiupright	10–16	Mar–Apr	20–25	Range of varieties available with differing maturities; adapted to range of soils; can be mowed frequently without affecting reseeding.
Grasses					
annual ryegrass *Lolium multiflorum*	upright	24–48	May–Jun	20–35	Rapid growth; later maturity may cause problems; high biomass production.
Blando brome (soft chess) *Bromus hordeaceus* ssp. *molliformis*	semiupright	12–30	Mar–Apr	12–20	Reliable reseeding; excellent for erosion control; host for ring (Mesocriconema xenoplax) and root-knot (Meloidogyne hapla) nematodes.
Zorro fescue *Vulpia myuros* var. *hirsuta*	upright	12–24	Mar–Apr	8–15	Tolerates poor soils; reliable reseeder; good for erosion control.

Note: 1 lb/acre = 1.12 kg/ha.

Perennial cover crop species

Common name *Scientific name*	Growth habit	Maximum height (in)	Flowering period	Seeding rate (lb/acre)	Comments
Grasses					
perennial ryegrass *Lolium perenne*	semiupright to upright	8–24	May–Sep	25–50	Fast to establish; vigorous and competitive; bunch grass; may thin over time; use turf types.
red fescue (creeping red, Chewings) *Festuca rubra*	semiupright	2–16	May–Sep	15–30	Slower establishment; sod-forming fine-leaf fescue; long lived; more cold and shade tolerant than tall fescue.
tall fescue *Festuca arundinace*	upright	8–24	May–Sep	25–50	Fast to establish; vigorous and competitive; better drought tolerance than ryegrass; use turf types.
Legumes					
strawberry clover *Trifolium fragiferum*	semiupright to prostrate	4–16	Jun–Aug	10–15	Vigorous and invasive; tolerates waterlogged soils; favorable to pocket gopher buildup.
white clover *Trifolium repens*	semiupright to prostrate	4–16	May–Jul	10–15	Vigorous and potentially invasive; shade tolerant; not drought tolerant.

Note: 1 lb/acre = 1.12 kg/ha.

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