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Orchard Floor Management

The primary objective in managing the orchard floor in most organic systems is to provide natural sustainable fertility to the trees. This usually involves the use of cover crops and the application of organic fertilizers to increase organic matter and a steady release of available nutrients to the trees as the organic matter breaks down. Many choices need to be made regarding the type of irrigation system to use in conjunction with a mowed or tilled cover crop as well as the choice of specific type of cover crop to grow.

The orchard floor is also managed to control weed competition and provide access to the trees for harvest and spray applications. Equipment needs, costs, and timing considerations for these operations are important. Soil type and drainage will have an influence on the ease of access into the orchard as well as for soil compaction. Growers need to know about their specific soil characteristics and the interaction with rootstocks, climate, irrigation, and fertility in order to manage the orchard floor profitably.

Weed Control

Weed control is one of the biggest challenges in organic apple production, due to the high costs of alternative methods compared to herbicides. Organic weed control methods include the use of living cover crops, cultivation to uproot or cut weeds, mulches to smother weeds, organic herbicides, and flamers to burn or "cook" weeds.

Removal of competition from tree growth is important in all orchards, but especially significant in the first few years of young orchards. Weed competition at the base of first-, second- and third-year trees can reduce the growth by as much as two-thirds and reduce the bearing surface development by several years. Trees, especially those on dwarfing rootstocks, that have been stunted are very difficult, if not impossible, to bring back to a good economically productive

state. Factors such as tree age, irrigation system, and weed type can have a big influence on weed impact in an orchard.

Any plant, even a cover crop planted by the orchardist, can be a weed if it is competing with tree growth and productivity. The worst weeds are those that are perennial in growth habit and vigorously compete with tree growth during the active growing season of the tree and fruit. Winter weed growth is not a problem to dormant trees if it is suppressed prior to resumption of tree growth in the spring. Weeds on the orchard floor growing during the dormant season can also help reduce erosion, and improve soil tilth and orchard accessibility.

Cultivation

Mechanical cultivation is expensive because it requires a mid sized tractor with specialized equipment, repeated passes, and more labor especially for the control of weeds within the tree rows. Orchards are cultivated to:

- Reduce weeds that compete for water and nutrients
- Facilitate subsequent orchard operations, such as irrigation, harvesting, orchard brush removal or spraying
- Incorporate cover crops and fertilizers
- Prepare seedbeds for cover crops
- Aid in the infiltration of water where operations have caused compaction.

Cultivation should not be any deeper or more frequent than is necessary to accomplish these objectives. Cultivation does not reduce water loss, except by killing weeds that use water. Unnecessary cultivation, especially when the soil is wet, not only increases operating costs but may also cause soil damage. Care should also be taken not to spread plant parts of perennial weeds like bermudagrass, field bindweed, or barnyardgrass through cultivation.

Perennial grass-sod culture, resident vegetation, or planted cover crops can be used between rows in apple orchards and offer the advantages of erosion control, improved water infiltration, lowered cost, ease of maintenance, and better access in winter. Such plant covers, however, may harbor insect & rodent pests, require additional water and nitrogen, and compete with trees.

To minimize these drawbacks, orchard floor plant cover located directly under the trees is usually cultivated mechanically using specially designed equipment that goes around the tree trunks, or hand hoed. Vegetation between the rows is mowed or flailed as needed, but can be cultivated as well to save water in non-irrigated orchards or to open soils that tend to without cultivation.

Specialized equipment used for cultivation within the tree row usually consists of an articulating blade or rotating head that is triggered by a switch; when near the tree trunk, the blade or head moves around the trunk to avoid injuring the tree. Equipment options include the French plow, triggered rototiller, triggered cutting blade, and triggered spinning heads with cultivation spikes. Whatever cultivation technique is used, it is essential to avoid injuring trees or roots. Such injuries can weaken trees permanently, and lead to disease infection.

Mulches

Organic mulches can effectively control weeds, retain moisture, provide a sustained low level of nutrition for the trees, and in some cases reduce root-rotting problems. Many of the municipal waste collection programs have green waste materials that are a combination of prunings, grass clippings and ground lumber.

Unfortunately, most organic mulches for weed control are usually only practical in small-scale operations because of the high cost of some materials or hauling fees. Recent research indicates that mulch chips need to be 3-4 inches deep to effectively control weeds; one inch of mulch actually encourages weed problems. This type of coverage requires a great deal of material – 200 cubic yards of organic mulch per acre would be needed for an orchard spaced 8 x 16 ft. and a mulch applied to a strip six feet wide and four inches deep under the tree. There is also considerable cost in application into the tree row if done by hand. Modified side-discharge livestock feed wagons have been used on larger scale operations.

An alternative to hauling in an organic mulch is to grow it in the orchard in the middles between tree rows, cut it, and move it into the rows under the trees for weed control. Specialized mowing equipment has been developed to efficiently relocate mulch material. Typically, low-nitrogen, high-biomass grass cover crop such as one of the cereal grains is grown for this purpose, since it

will not break down as rapidly as leguminous cover crops. Organic mulches sometimes provide favorable habitat for rodents such as meadow mice that can cause tree trunk injury.

Fabric mulches are another option for in-row weed control. These mulches control 100% of the weeds, allow for rapid water penetration from the sprinklers or emitters above, and provide a clean surface for leaf removal to reduce apple scab inoculum. Initial costs are high; however, some of the materials can last ten years, which makes the investment comparable to conventional herbicide costs.

There are many different brands of woven weed control fabric. Some have very high tensile strength (160 lbs. x 110 lbs.), and contain special UV inhibitors for extended outdoor life. They are usually guaranteed for several years and have lasted even longer than that in some experimental orchards. These fabric mulches can be applied in a 3-foot strip on each side of the tree row or at planting as a 6-foot-wide band cut out for the tree trunks. It is typically pinned down with 6-inch-long wire hoop stakes. For an orchard with a tree spacing of 8 feet x 16 feet the cost per acre is $730 for the polypropylene fabric and another $200 per acre for stakes and the labor to pin it down.

Organic Herbicides

Most spray-on organic herbicides have not worked very well, however, “pelargonic acid,” (a post emergent – contact material) trade name Scythe has been effective in some trials as a substitute for conventional herbicides. It is a fatty acid that is mixed with water at a rate of 3-5 % and sprayed on small weeds as an organic contact herbicide. It works best in the summer and multiple applications are usually necessary. It can be used just like any other herbicide with the same application equipment. Part of the reason for its success over time is that new weed seeds are not brought to the surface with tillage and eventually most of the weed seeds in the upper 1-2 inches of soil will have already germinated. A similar response is achieved with flamers.

Flamers

New technology over the last few years has greatly improved the effectiveness of propane burners as a weed control method. The system requires one or two large metal flame orifices to

direct the heat at the base of the tree trunks. They are connected to propane tanks with a safety switch and pulled through the orchard at a speed that "cooks" emerging weeds before they develop much size or vigor. Flaming may require several passes and weeds should be flamed before reaching 2 inches in height. This is especially true for grasses, which are tolerant and more difficult to control because the growing point is low within the plant. Care must be taken not to injure the young trees or to damage irrigation equipment or trellis materials. Dry weeds or leaves can create a fire hazard, and workers must use care in handling propane flamers to avoid injury.

Cover Crop Selection and Management

Choosing a cover crop depends on the orchard location, irrigation system, pest control considerations, and fertility needs. Fortunately, apples require somewhat less nitrogen compared to some other tree crops and research has shown that it is relatively easy to provide adequate nutrition with leguminous cover crops. For orchards with grass cover crops, nitrogen must be supplied through application of some type of organic fertilizer such as compost, blood meal, feather meal, etc.

Winter temperatures and rainfall will have a significant influence on the success of certain cover crops. Spring frosts can be more severe in cover cropped orchards compared to clean cultivated ground. Black moist soil absorbs heat during the day and releases it at night to provide 2-3^{o}F warmer temperatures. Permanent sod can also keep the orchard cooler and more humid in the summer leading to potential disease problems, but may provide habitat for beneficial insect predators and aid in pest control. Conversely some pests that attack apples may find harbor in a cover crop and increase pest damage.

There are many reasons in favor of growing cover crops in apple orchards, but there are also situations where a cover crop or specific type of cover crop could be detrimental to economic crop production.

Positive Attributes of Cover Crops

1. Add nitrogen
2. Add organic matter
3. Provide winter access
4. Enhance water penetration
5. Reduce erosion
6. Manage excess vigor
7. Provide habitat for beneficials
8. Compete with noxious weeds
9. Moderate temperature
10. Look attractive

Potential Problems with Cover Crops

1. Use water
2. Invade like weeds
3. Increase vertebrate pest problems
4. Cost to establish & maintain
5. Habitat for insects & diseases
6. Increase frost risk
7. Seal certain soils
8. Look unattractive

In organic apple orchards, cover crops supply organic matter that leads to soil aggregation, increased aeration, and a slow release of nutrients. The primarily use, however is to add nitrogen to the soil, since nitrogen may be a limiting factor. For this reason, most growers use nitrogen-fixing legumes or a blend of legumes and grasses. However, the decision as to what cover crop mix to use will depend on the individual orchard and the management practices in place.

In general, organic growers should avoid extremely aggressive perennial clovers, especially in young orchards, since they are difficult or impossible to control. These include white clovers (including Dutch, Ladino, and Wild White), narrowleaf and broadleaf trefoil, and strawberry clovers (including Salina, O'Connor, and Palestine).

The main factors to consider when selecting a particular cover crop species or mix are costs vs. benefits, irrigation method, tillage practices, soil type, soil depth, tree nutritional status, and especially, local weather conditions and frost concerns. The choice and performance of cover crops often depends on site-specific factors, so they should first be tested in a few rows before

planting large acreages. Understanding the basic cover crop types and management strategies can greatly improve the chances for using these inputs successfully.

Management Systems

Cover crops can simply be resident vegetation in the orchard. However, many growers like to plant specific cover crops for nitrogen fixation, to increase biomass, or provide better habitat for beneficial insects. There are four typical management systems that incorporate the use of various types of cover crops, (1) Clean Cultivation - Year Round; (2) Winter Cover - Summer Cultivation; (3) Winter Cover - Summer Mowed; and (4) Mowed Permanent Cover.

Clean Cultivation – Year Round

No cover crops are used in clean cultivated orchards that are tilled almost all year to control weeds in movable sprinkler system orchards and provide the ditches and basins for flood or furrow irrigation. They are not common in organic apple production. This system may save water when infiltration is not a problem by removing plants that compete with apple trees for water. Complete weed control also eliminates competition for nutrients, enhancing tree growth. A trade off is that bare soil can have greater evaporation losses compared to a surface covered with some dead, dry vegetation.

There are disadvantages to year-round clean cultivation. Frequent cultivation can increase soil compaction and lead to water infiltration problems and the need to rip the soil more often in order to break up the compacted layer. If soils are worked when wet soil structure is broken down decreasing soil surface friability and water penetration. This system usually has very low organic matter content in the soil and may require the liberal application of organic matter such as compost or manures to maintain soil tilth and nutrition, which can be costly.

Winter Cover – Summer Cultivation

High-biomass cover crop species and mixes can produce large amounts of organic matter and can be used in tilled orchards to gain the maximum potential nitrogen naturally. These mixes usually contain large seeded grasses and legumes that are easy to grow. Sown each fall and disked in the spring, they are referred to as a “green manure” cover crops or winter cover crops.

Green manure cover crops should be disked before the soil dries excessively to enable the disk to penetrate the soil, especially in drip or micro sprinkler irrigated orchards where the cover crop and soil can not be irrigated.

For sprinkler, furrow, or flood irrigated orchards the cover crop might need to be mowed early in the season prior to cultivation in order to facilitate water flow or coverage. Removing the cover crop and or weeds is an important consideration under drip emitters or mini sprinklers within the row. This can be accomplished with in-row cultivation equipment, flamers, mulching, or mowing. If this system is used the irrigation tubing must be suspended above the ground to avoid contact with the heat from the flamer or tines of the in-row cultivator.

Seed and farming supply companies offer two basic types of green manure mixes: pure legume and legume/grass blends. Pure legume blends usually consist of bell beans, field peas, and vetch, and are used to add a large amount of relatively rapidly available nitrogen to the soil when incorporated. Bell beans produce vigorous, upright growth and substantial biomass. However, they cannot be mowed closely, which may be a concern in areas prone to spring frost.

Field peas are also vigorous; those most commonly planted as cover crops include 'Austrian Winter' and 'Magnus.' 'Austrian Winter' pea is dormant during cold weather, producing nearly all its biomass during the spring. However, it will usually produce as much biomass as most other legumes if allowed to grow through the spring. 'Magnus,' which grows rapidly through the winter and matures earlier than 'Austrian Winter,' is a better choice in orchards disked early in the spring. Field peas are shallow rooted and therefore subject to drought on sandy soils.

Vetches are frequently used in legume blends, but may twine up trees or sprinklers if planted too close. In addition, if allowed to reseed they may become a weed problem in the rows. 'Lana' woollypod is one of the most vigorous vetches in the spring; it flowers and matures earlier than purple vetch. Common vetch has extrafloral nectaries on the stipules, which may provide nectar to beneficial insects. 'Cahaba White' vetch has been shown to suppress root knot nematodes. If these vetches are used they need to be planted far enough (2-3 ft.) away from trees or some hand hoeing will have to be done to remove plant material growing up into the trees.

Berseem clover is rarely sown in orchards, but may have some value to growers seeking to add large amounts of nitrogen to the soil. It grows through the spring and early summer and flowers in June. Highly palatable, it responds well to mowing and grazing.

Various legume/grass blends are also available for cover cropping. Adding grasses such as barley, oats, or cereal rye to a mix imparts several benefits. The fibrous roots of grasses greatly enhance soil tilth and water penetration. Grasses also take up excess nitrogen from the soil, improving the nitrogen fixing ability of the legumes. In addition, grasses provide structural support for the twining vetches and peas. Typical blends often consist of bell beans, vetch, peas, and oats or barley.

Barley/vetch or oat/vetch blends are relatively inexpensive and are a popular choice amongst growers. If you choose one of these blends, be aware that grasses may reduce or delay the availability of nitrogen to the trees from the legumes, especially if the grasses are planted at higher rates. For adequate nitrogen availability, grasses should not exceed about 10 to 15 percent of the mix. Grasses do, however, add more organic matter to the soil and take longer to degrade, thus helping to maintain higher organic matter levels in the soil.
Rotate to different cover crops every 2-3 years to avoid the buildup of diseases that can reduce the biomass of the planting just as you would in any annual system. Bell beans and Fava beans in particular have suffered in wet seasons when followed by the same cover crop the year before. Cover crop mixes offer some benefit in bio diversity as conditions change from year to year and favor one species over another.

Earlier fall plantings (Sept. – Oct.) of cover crops may require irrigation to get germination and early growth but will provide much more total growth and biomass than later plantings and can be tilled in earlier in the spring. Winter plantings (Nov. – Dec. – Jan.) will produce almost all of their biomass in the spring. When late planting is the only option choose a cover crop that will germinate under cooler soil conditions like the vetches (Lana, common, & purple) and large seeded grasses.

Winter Cover – Summer Mowed

With the increasing trend toward nontillage, many organic growers sow winter annual species that reseed and die in the spring and regenerate each fall with either irrigation or rainfall. This system is easily adapted to flood irrigation with permanent or semi permanent berms, movable sprinklers, solid set sprinklers, or with mini sprinklers & drip emitters when lines are suspended in order to mow or cultivate within the row. For ease of maintenance these cover crops should only be planted between rows and not within the tree row so that they do not become a weed control problem.

The benefit of this type of system is that these species use less water than perennial cover crop species, often choke out unwanted annual weeds, offer habitat for beneficial insects, and provide adequate fertility with natural reseeding. Such species include subterranean & other annual clovers, burr medic, 'Blando' Brome, and 'Zorro' fescue.

'Blando' Brome is often used for erosion control. 'Zorro' fescue is very expensive and is used mostly on hillsides, serpentine, low fertility soils or where initial erosion control is required on cleared land. These grasses should not be used alone in organic orchards unless adequate nitrogen is available or applied. If not replanted or if neglected, reseeding cover crop species may in time simply become minor components of the ground cover. Replanting cover crops every three or four years can ensure dominance by these species. Some grasses are hard to seed with many seeding implements. Zorro fescue for example should be coated by the supplier if a standard grain drill is used. Small areas can, however, be hand spread and lightly incorporated with a harrow or mulching ring roller.

Burr medic is well adapted to California's climate, grows well in neutral- to high-pH soils, and is occasionally a major component of resident vegetation. It effectively reseeds even under close mowing and, because of its high percentage of hard seed, it usually reestablishes well even when tillage is used. Subterranean clover, or subclover, usually performs best in acid to neutral soils low in nitrogen. Early-maturing varieties, frequently used on rangeland, include 'Nungarin' and 'Dalkeith.' It is advisable to plant a mixture of varieties with differing maturity dates to help ensure long term maintenance of the stand.

Mowed Permanent Cover

Perennial grasses and legumes provide a permanent cover that offers traction year-round, as well as dust control, and ease of management. Equipment cost and operating costs can be lower compared to cultivation because of speed of travel and smaller horsepower tractors can be used. Soil compaction is usually less problematic in sod or perennial clover systems. Surface sealing of soils is not a problem with permanent cover crop systems, but some soils can have slow percolation due to the surface plant material and may need to be cultivated periodically to enhance water infiltration. In most cases, however, perennial plant cover improves infiltration. Dry sod is often difficult to wet because of the hydrophobic nature of the organic material so water will run off. It may need to remain moist to prevent this.

The permanent cover system uses 20 to 30% more water than other systems and requires a sprinkler system to maintain the cover crop in the row middles over the dry summer months. Drip and mini-sprinkler systems just do not cover well enough. The best irrigation system for permanent sod is permanent or movable sprinklers. Controlling the cover crop around permanent sprinklers can become a problem and costly if control by hand is necessary.

Perennial clovers, such as white and strawberry, are low growing and add nitrogen, but are invasive and compete with trees for water. Birdsfoot trefoil, a legume, is slow to establish but forms a low-growing, dense cover. Some clovers may increase populations of detrimental nematode species and gophers.

Vigorous, perennial grasses, such as bermudagrass, ‘Berber’ wheatgrass, tall fescue and perennial ryegrass, can be problematic in organic orchards since they strongly compete for both water and nitrogen. Lower growing, fine-leafed fescues may be appropriate in some cases, because they use less nitrogen and water. Extra nitrogen will need to be applied for their growth through the addition of manures or composts.

General Cover Crop Management Strategies and Considerations

Planting

Winter annual and perennial cover crops perform best when sown by mid October, but can usually be successfully grown if planted by mid November. In general, lower seeding rates can be used for early seeding, and higher rates should be used for later seeding.

Good seedbed preparation is essential, especially with small-seeded species. Establishing small-seeded cover crops in years with little fall rain is very difficult without irrigation, especially on sandy soils. Seed early (October) in areas that are prone to erosion to provide some cover before winter rains occur.

To prepare a seedbed for cover crops, cultivate to eliminate weeds that are present in the orchard and provide a fine soil particle size for the seeds to germinate. This may be accomplished with 2-3 diskings or with a spader or rototiller. Seedbed preparation need only be 2-3 inches deep; deeper tillage is not necessary and may require rolling prior to seeding if large clods are created. Small seeds should be planted at a shallow depth of approximately ½ to 1 inch whereas large seeded cover crops can be seeded up to 2 inches deep. With a good seedbed, broadcast seeders can be used followed by a harrow and ring roller or just a mulching ring roller.

Another option is the use of a seed drill typically used in sowing grains. These can usually be modified to plant several different sizes and shapes of seeds. The advantage of a seed drill is obvious in the elimination of tillage for developing a fine seedbed. Most establishments that sell seeds also rent seed drills.

Legume seeds should be inoculated with nitrogen-fixing *Rhizobium* bacteria to ensure nitrogen fixation. Small-seeded legumes are usually preinoculated however large-seeded legumes (bell beans, vetch, and peas) must be inoculated by the grower, at least the first time they are sown. Use about 8 ounces of inoculant per 100 pounds of seed. The “wet” method is the most reliable – a slurry of inoculum and adhesive is added to the seed, which is then allowed to dry before planting. The dry inoculant can also simply be layered with seed in the hopper when planted with a drill; for broadcasting, inoculant must be applied with the wet method. Inoculant and

inoculated seed should be kept out of direct sunlight, so broadcast seed should be incorporated as soon as possible.

Mowing

Because cover crops can increase frost hazard, they are often mowed in late winter. Bell beans, peas, and tall growing green manure blends can be killed in spring if mowed close to the ground, so they should not be used in areas prone to frost, or they should be tilled in prior to frost season. For continued growth, vetch should be mowed high – no lower than 8 to 10 inches. Clover mixes should be mowed in late winter to suppress tall weeds and encourage spreading. Subclover and bur medic can usually reseed even under fairly close mowing (3 to 5 inches), while crimson and rose clovers flower above the foliage and therefore must not be mowed after about late March to allow for reseeding. Once seed is mature they can be mowed. In irrigated orchards, some cover crops will need to be mowed several times during the season.

With some cover crops mowing while they are in bloom and cutting off blossoms can help force bees to visit the targeted blossoms of the apple trees. Conversely, if thrips are a problem, they can be moved into apple blossoms from cover crop flowers causing russeting and scarring of fruit.

Nutrition

As with trees, soil fertility is critical to cover crop production. Legumes fix nitrogen, so nitrogen fertilizers should not be applied to the soil before or during their growth, as this will limit the amount fixed by the legumes. Legumes require adequate sulfur and phosphorus for good growth. Annual grasses require nitrogen additions if grown alone. In general, grasses predominate on highly fertile sites, while legumes will usually grow best in soils with low nitrogen content. Poor performing, solid legume plantings (especially clovers and medics), that are overtaken by grasses and mustards, may be the result of high soil nitrogen.

In general, vetches and peas can fix far more nitrogen than clovers and medics. A green manure cover crop disked in April can add 150 pounds or more of nitrogen per planted acre. Berseem clover can potentially fix 200 or more pounds of nitrogen per planted acre if mowed periodically and disked in late spring.

Nitrogen utilization in the orchard by mowed cover crops is not the same as when cover crops are tilled in. When residues are mowed and allowed to remain on the soil surface, a portion of the nitrogen will volatilize into the atmosphere. With about 80 percent of the nitrogen in leguminous cover crops contained in the aboveground portion, volatilization losses can be high – perhaps as much as half. Nontillage clovers and medics may add only about 30 to 40 pounds of nitrogen per planted acre. Late growing clovers that remain in the orchard after deciduous trees leaf out in the spring will also fix less nitrogen during that period due to tree shading and in-row weed management.

Specific Cover Crop Characteristics and Suggested Seeding Rates

Perennial Grasses [Mowed]

Bermudagrass: Competes for water and nutrients and can become an invasive weed that is difficult to control. It tolerates drought and traffic, prevents erosion, and grows best in warm locations not recommended for organic orchards (40 Bu sprigs/acre).

Buffalograss: A low growing (approximately 4-8”), drought tolerant, stoloniferous warm season grass from the Midwest. It is not as aggressive as Bermudagrass and has no rhizomes. It should be planted from seed in early spring. In Oregon and Eastern States it goes dormant in summer without water but will regreen when irrigated or with winter rains. (20-40lbs/acre).

Tall Fescue: Competes for water and nutrients but can tolerate abuse (i.e., orchard traffic). A clumping type grass that does not produce stolons or rhizomes; will only fill in bare spots if re-seeded. There are several varieties, from the old “Fawn” to dwarf “Mustangs” and double dwarf “Mini-Mustang.” Tall Fescue is quite drought tolerant, but dies if it does not receive some summer irrigation (12-15 lbs/acre).

Perennial Ryegrass: A lawn type, clumping turf that does best in cooler climates. Uses large amounts of water and dies if not irrigated frequently in the summer (6-10lbs/acre). Requires little nitrogen input.

Kentucky bluegrass: A lawn type turf does best in cooler climates. Uses large amounts of water and dies if not summer irrigated. Spreads by stolons. Requires higher nitrogen input for the grass to do well (2-3 lbs./acre).

Fine Fescues: Creeping Red Fescue, Hard Fescue, Sheep Fescue, are very shade tolerant grasses. Produce stolons that creep into open areas. Usually reach 10 in height and then flop over. They require nitrogen fertilization and frequent irrigation (6-8lbs/acre).

Winter Annual Grasses [Mowed]

Zorro: Is a short growing (12-18"), very fine bladed grass that reseeds well. Matures seed early in the spring so does not use much water. Mow after seeds are mature. (10-20 lbs/acre).

Blando Brome: (Soft chess) Is an intermediate height (16-24") grass and more aggressive than Zorro. Matures early and uses little water (6-12lbs/acre).

Annual Ryegrass: Is a very aggressive, easy to establish grass that matures late and uses considerable water. Is very good for areas requiring winter erosion control as the primary consideration (10-20 lbs/acre).

Grain, Barley, or Oats: Grow 3 ft. tall and compete well with weeds. Produce abundant biomass, which is variable by variety. The best choice for mulching between trees to reduce summer weeds, when cut and moved to the tree row (60-90 lb./acre).

Winter Annual Legumes [Mowed]

Subterranean Clover: Many varieties exist. This low growing (8-12") clover not only tolerates mowing but also successfully competes with weeds when mowed. Reseeds readily. Matures early in the spring and uses little water. Plant several varieties with different maturity times to assure a good stand (12-20 lbs/acre).

Rose Clover: This low growing (12") clover sets seed early and uses little water. Several varieties exist (9-12 lbs./acre).

Crimson Clover: Grows about 18" tall and is slightly more aggressive than Sub or Rose clover. Matures later and reseeds best under high moisture conditions (9-12 lbs/acre).

Bur Clover: This native medic clover can be mowed short. Reseeds early with little water use (6-10 lbs/acre).

Berseem Clover: This 14-18 inch clover can be mowed several times to produce continued forage. Needs more water than winter annual clovers like Subterranean (9-12 lbs/acre).

Annual Grasses [Tilled in]

Ryegrass, Cereal Oats, Barley, or Cereal Rye: Produce a large biomass. Start in October-November and irrigate. Till in prior to seed maturity. Require the addition of nitrogen for a good stand. Cereal rye is very effective on sandy soils. If mowed high in February, regrowth occurs for a second mowing in March or April (ryegrass 10-20 lbs/acre, erosion control 50-60 lbs/acre, and cereal oats/barley/rye 60-90 lbs/acre).

Annual Legumes [Tilled in]

Bell Bean/Fava Bean: Seed this tall growing (to 6 ft.) erect vetch annually by November 1 to get good growth prior to cold weather. Even though it grows quite tall it does not produce a lot of biomass. Can fix 100 lbs of nitrogen in low N soils (80-100 lbs/acre).

Lana Vetch: This prolific nitrogen fixer (up to 250 lbs/acre) is seeded in the fall and tilled in the spring. Amount of growth depends on seeding date, winter temperatures, rainfall, and tillage date. Grows well in cold weather: best choice if seeded late (15-30 lbs/acre).

Common & Purple Vetch: Very similar in growth habits, these two vetches grow well during the winter when seeded in early fall. They will tolerate 20° temperatures without injury (40-50 lbs/acre).

Hairy Vetch: This type vetch is better adapted to sandy soils. It is also very cold tolerant but does not grow much during the winter.

Field Pea (Austrian or Canadian Winter): Grows like garden pea, remains almost dormant in cold weather, but growth surges in the spring (70-90 lbs/acre).

Fenugreek: Germinates in cold conditions as late as December and provides a good stand.

Combinations: Legumes and grasses are often mixed to produce a dense biomass. Such combinations can be mowed for weed control in the tree row and/or tilled. One that has been used often and successfully in California is the combination of oats and vetch. Combinations with several different cover crop species usually end up with one or two dominating the others, because of differences in plant height, spread, or vigor due to moisture, temperature, and soil fertility conditions.