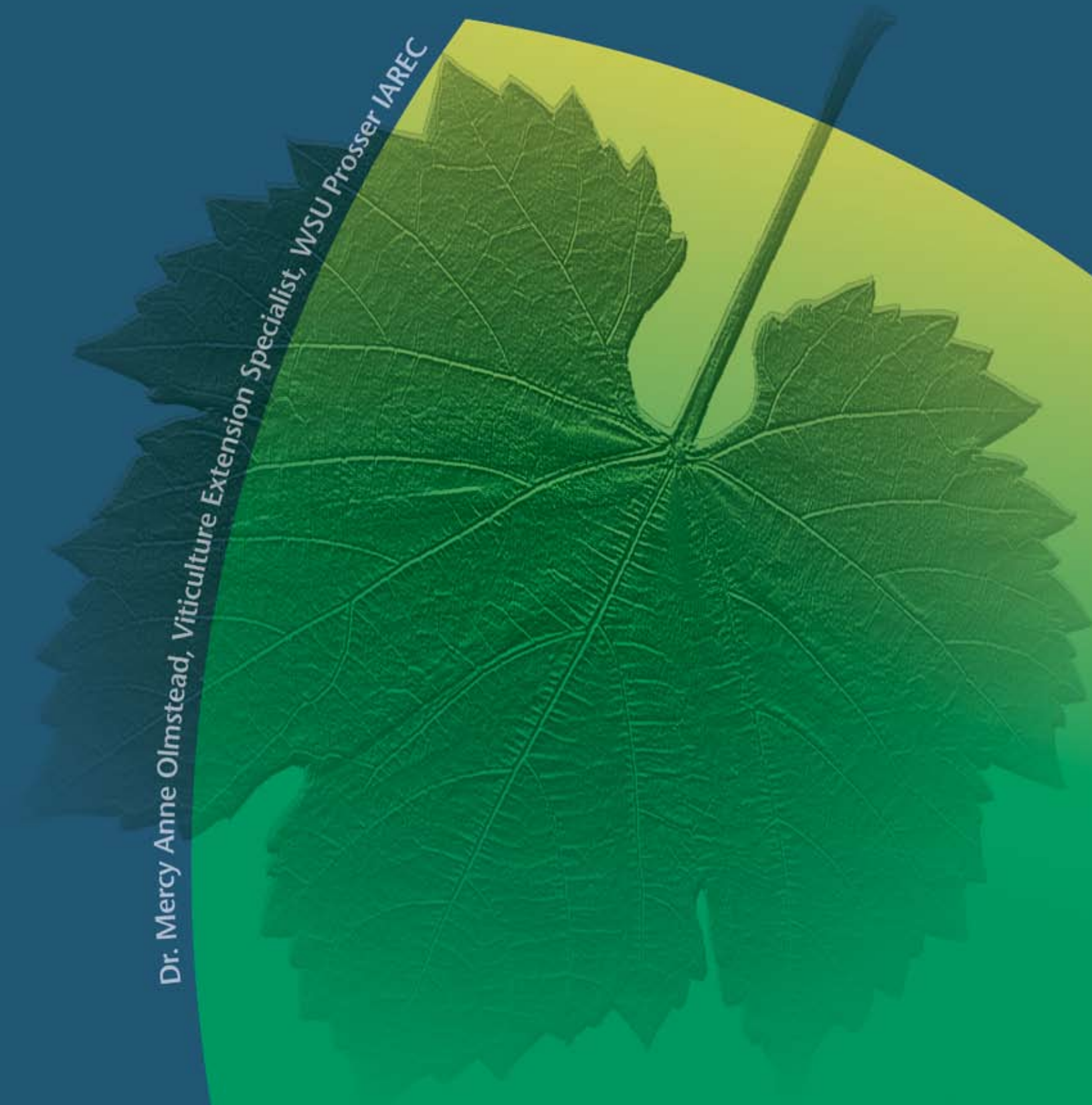
EB2010

Cover Crops as a Floor Management Strategy for Pacific Northwest Vineyards

Dr. Mercy Anne Olmstead, Viticulture Extension Specialist, WSU Prosser IAREC



Introduction: Vineyard Floor Management

Vineyard managers should consider the entire ecosystem as the context for the sustainable production of quality grapes. Vineyard floor management can have a large impact on the abiotic (e.g., temperature, wind, and precipitation) and biotic (e.g., beneficial insects, pests, and disease) factors in a vineyard, especially microclimate modifications and soil health. Decisions about what floor management system to use should take overall vineyard management into account.

Types of Floor Management Systems

Resident vegetation. Resident vegetation consists of all plant species growing within the vineyard. These include both native plants and invasive weeds. The diversity of native plants varies by region of viticulture production. A major advantage of this system is the lack of planting costs; however, invasive weed species may be difficult to eradicate once established.

Management of resident vegetation usually requires mowing to reduce plant height to accommodate vineyard traffic. Mowing frequency is determined by the type of plant species present. In vineyards not certified organic, the area under the vine may be kept weed-free with an herbicide application in the spring. Resident vegetation management is an economical alternative, as the primary expense is limited to the cost of mowing.

Clean cultivation. In conventionally managed systems, vineyard alleys are disked or sprayed with herbicides to reduce vegetation, while in organically farmed systems, mechanical means or approved organic products are used to keep vineyard alleys weed free. While this method reduces competition with the grapevine for water and nutrients, the exposure of bare soil can increase erosion in prone areas such as slopes (Figure 1). Tillage and equipment travel through clean-cultivated alleys can also contribute to root zone compaction and problems with water infiltration.

Figure 1.
Sloping vineyards with clean cultivated alley rows can be particularly vulnerable to soil erosion.

Cover cropping. Vineyard cover crops can be managed a number of different ways. Most commonly, crops are seeded in every alley to provide cover throughout the vineyard (Figure 2). They can also be planted in alternate alleys, each with a solid stand of a different cover (e.g., grass and legume), or alternating with alleys that are clean cultivated. In some vineyards using sustainable management, the area immediately underneath the vine is kept clean with herbicide applications or cultivation to reduce competition for nutrients and water with the vine, especially with drip-irrigated systems. Vineyards using an organic management strategy must utilize mechanical means due to strict regulations on the use of synthetic chemicals for organic certification.

Figure 2.
Perennial grass mix in a young vineyard.

Utilizing Cover Crops as a Floor Management Tool

One of the biggest impacts of cover crops is the protection of the soil surface. Wind and water erosion can strip the upper soil layers up to 2.5" in a growing season. Conversely, soil accumulates in areas that contain vegetative cover (Coldwell et al. 1943). Cover crops, especially grasses, protect the soil by minimizing the dislodging impact of raindrops and reducing water runoff (Goulet et al. 2004; Stredansky 1999). During the growing season, cover crops can help to reduce soil compaction and erosion from equipment traffic (Kaspar et al. 2001), while increasing traction for equipment. This can be especially important when Pacific Northwest harvesting extends into the autumn season after precipitation begins to fall.

Cover crops can also reduce surface crusting and improve rainfall penetration, which is important for soils subject to saline conditions or with high percentages of clay (Folorunso et al. 1992; Gulick et al. 1994). Plant species with large root systems, like oilseed radish (***Raphanus sativus*** or ***R. sativus*** var. ***oleiferus***), have proved successful at penetrating hard pans to improve water infiltration and drainage (Cline 1992) by aerating the soil with the pores created as roots decompose.

Increasing soil organic matter and nutrient availability is a popular reason for utilizing cover crops in vineyards. However, the impact of cover crops on actual levels of organic matter and nutrient availability is highly dependent upon soil type, temperature, and rainfall. Many of the microorganisms involved in the decomposition of organic material need some type of moisture to maintain their activity; therefore, in semi-arid and arid regions, it is very difficult to greatly affect the percentage of organic matter in the root zone unless supplemental irrigation (i.e., handlines or microsprinklers) is applied in vineyard alleys.

Cover cropping may also enhance the mycorrhizal fungi population in a vineyard. Mycorrhizal fungi are symbiotic fungi, also known as arbuscular mycorrhizal fungi (AMF), that colonize grapevine roots. Mycorrhizae can improve water status in grapevines and has been shown to increase some nutrients in other crops (Kaya et al. 2003), a benefit for vineyard sites with marginal soil status (Augé 2001; Biricolti et al. 1997; Linderman and Davis 2001).

Simply the presence of a cover crop can increase the population of vesicular arbuscular mycorrhizae (VAM) (and other types of mycorrhizae) fungi in vine alleys, but VAM colonization of grapevine roots requires direct contact between grapevine and cover crop roots (Baumgartner et al. 2005). Planting a cover crop that is a host for AMF fungi has been shown to boost resident populations in other crops (e.g., Kabir and Koide 2002); however, research in vineyards is limited.

Mycorrhizae require living roots in order to grow and reproduce. It may be fairly expensive to inoculate an entire vineyard with AMF, thus inoculating individual vines when establishing a vineyard is more practical.

To gain the most benefit from mycorrhizal inoculations and cover crop partnerships, do not fumigate prior to planting (unless there is a pre-existing condition necessitating fumigation), reduce high inputs of phosphorus fertilizers, and reduce tillage practices to avoid disrupting existing AMF colonies (Schreiner 2004). Also, be cautious when using mycorrhizal supplements, as existing research under field conditions has not definitively shown consistent benefits. If you do choose to use mycorrhizal supplements, be sure that the source is a reputable vendor and that some type of plant material is part of the supplement.

Cover crop choice can also affect insect populations. For example, some vineyard pests (e.g., cutworms) prefer to feed on broadleaf covers rather than grasses; therefore, the presence of broadleaf covers can reduce the number of bud strikes during the early spring season. The elimination of the broadleaf cover crop can drive cutworms upward into the grapevine in their search for food. Cutworms can feed on grapevine buds, causing damage to the current season's crop. Although barrier sprays to prevent upward movement of cutworms are effective to prevent bud damage, a more sustainable approach would be to allow the broadleaf cover to remain until the threat of cutworm damage has passed. In addition, vineyards with dusty, dry conditions can use cover crops to reduce dust and spider mite populations, but the presence of cover crops can also increase populations of voles, moles, and gophers (Figure 3; Ingels et al. 2005).

Figure 3.
Gopher hole in a vineyard with a grass mix cover crop.

Vineyard age should be considered before planting cover crops, as vigorous cover crops can compete with young vines for water and nutrients, which can reduce vine growth and delay development in the early stages of establishment. Once a vineyard is established and vines are mature (> 4 years old), cover crops may be used in areas of excessive vigor to reduce canopy size and maintain an optimal balance between the vegetative and fruiting sections of the vine.

The growth habit of certain cover crop species can alter microclimate in the vineyard. This is especially important in the early spring or late autumn season when frost events are more likely to occur. The presence of a high-biomass producing cover crop can decrease the vineyard temperature near the ground due to reductions in soil warming during the day and cooling via plant transpiration. Vineyards with clean cultivated soil typically absorb more solar radiation throughout the day and release the stored heat at night. In addition, cover crop species with tall growth habits can cool temperatures closer to the fruit zone, causing damage to flowers or fruit.

To summarize, the benefits of cover crop floor management include:

- Reduced soil erosion due to wind and water
- Prevention of soil compaction from equipment use
- Increased water infiltration
- Reduced invertebrate pest populations and increased beneficial invertebrate populations
- Reduced chemical use
- Reduced weeds (depending upon the competitive nature of the cover crop)
- Reduced vine vigor
- Recycling of nutrients within the soil ecosystem
- Prevention of nutrient leaching
- Increased soil organic matter

Potential problems with cover crop floor management include:

- Negatively altered microclimate such as increased frost risk during early spring and late autumn
- Increased vertebrate pest populations
- Can be more expensive to incorporate than resident vegetation
- Nutrient release may not coincide with vine uptake or demand

Cover Crop Choices and Their Management

Seed-Bed Preparation

Different cover crop choices may require different methods of seeding; however, seed-bed preparation is fairly standard. Seed beds should be moist (via natural precipitation or irrigation), well-mixed, and free of existing plant material. Depending upon the soil profile, shallow ripping or rotovation (10–15") of the soil may be necessary to ensure optimal establishment conditions. When ripping in the vineyard, be sure to select a time period when the soil is fairly dry to ensure good mixture of the soil profile with small particles, not large chunks. Water (from either precipitation or additional irrigation) is required before and after seeding for good germination. Most cover crops in the Pacific Northwest are planted in the autumn to take advantage of winter precipitation. The vineyard alleys are disked and leveled to provide a firm seed bed, and then seeded to a depth depending upon the size of the seed (e.g. smaller seeds typically require a shallower planting depth). This is especially important with many of the clovers and medics.

Cover crops can be seeded by drilling or broadcasting. Since broadcasting usually requires a higher seeding rate than drilling, check with the seeding equipment manufacturer before seeding. Also note that some cover crops establish more uniformly when drill seeded rather than broadcast.

Cultivation of Cover Crops

Depending upon the cover crop choice, tillage or mowing may be required. Annual cover crops such as grasses (including cereal grains) may need to be mowed a couple of times per year to facilitate access throughout the vineyard, or for frost protection in the spring. Tillage is another option, especially for some annual legumes and forbs that can release nitrogen in the soil that becomes available for vine uptake; however, knowing the decomposition rate of the cover crop is important for timing tillage to ensure that nitrogen release coincides with the appropriate vine growth stage. With perennial cover crop systems mowing may also be necessary as some cover crops can reach heights of 3'. Tillage can be applied to perennial cover crop systems as stands diminish and need to be reseeded.

Overview of Cover Crop Types

Choosing a cover crop depends largely upon the objectives in the overall vineyard management plan. There are three main categories of cover crops—grasses, legumes, and insectary mixes. Details on specific varieties of cover crop selections are included in the appendix.

Grasses. Many grasses form large, fibrous root systems, which prevent soil erosion in windy areas. In vigorous vineyards, grass can take up nitrogen and tie it up over time. Unlike legumes, nitrogen in grass is not readily available to vines for uptake when the plants decompose; however, grass cover crops can provide a substantial amount of biomass that, over time, may aid in increasing vineyard soil organic matter.

Grasses like cereal rye, oats, barley, and triticale are often used as annual cover crop systems. Typically these are planted in the autumn and tilled under or mowed in the spring for frost protection. As mentioned previously, particularly tall cover crops can negatively affect temperatures in the fruiting zone due to transpirational cooling by the cover crops. Tilling and mowing will increase exposure of the soil surface, allowing for greater absorption of solar radiation (heat) during the day. At night, this heat is released to the atmosphere in the vineyard, at a rate that depends upon soil type and soil water content. Darker colored soils absorb more solar radiation than do lighter colored soils.

Mowing grasses can leave stubble in vineyard alleys. Grass stubble can reduce dust, provide traction for field equipment, and compete with weed species. Grasses are usually more competitive than legumes or forbs with existing weed populations.

Legumes. Legumes are broad-leaved, annual or perennial species known for their ability to fix nitrogen. Nodules on the roots are the "factories" that house nitrogen-fixing bacteria (***Rhizobium*** spp.) that form a symbiotic relationship with legume roots. However, legume seeds must be inoculated with the proper strain of bacteria to effectively fix nitrogen. Nodules that are actively fixing nitrogen appear pink when cut in half. Nitrogen is released and available for mineralization after the cover crop begins to decompose. Nitrogen is also released when a portion of the roots die in response to mowing, which maintains a balance between the shoot and root systems (the resulting loss of leaf surface area from mowing reduces the photosynthetic leaf area, thereby decreasing the amount of root biomass the plant can support). Legume root systems include a tap root that can aid in increasing water infiltration, but can also attract rodents to the vineyard; therefore, legumes are often used only in established vineyards to avoid damage to young root systems.

Insectary mixes. This category includes broad-leaved, flowering plants that include both annual and perennial species. A number of species make up mixes that contain a number of different wildflowers and are available from local cover crop seed suppliers. Insectary mixes can be attractive and some studies indicate that they attract beneficial insect populations, depending upon the diversity of species in the

mix. Wildflower mixes can be difficult to establish if they contain species that are not appropriate for the region in which the vineyard is located. Establishment can be enhanced by breaking up the soil prior to seeding. Seed contact with the soil surface is increased by running a ring roller through the vine alleys.

When using these mixes, be sure to contact your local extension agent or weed specialist to determine if any of the components are listed on the Washington State noxious weed list (http://www.nwcb.wa.gov/). A number of introduced species have inadvertently become noxious weeds and are very difficult to control (e.g., yellow starthistle and purple loosestrife).

Annual Cover Crops

Annual ryegrass ***(Lolium multiflorum).*** Annual ryegrass is also known as Italian ryegra ss, and is a cool-season bunchgrass (Sattell 1998) with an extensive fibrous root system, useful in areas with excess water or nitrogen. In vineyards with marginal nutrient status, annual ryegrass can compete with the vine during bloom and early shoot growth. This grass is quicker to form a good stand than perennial ryegrass (Verhallen et al. 2001) and tends to perform better on finer-textured soils (e.g., silty or clayey), although sandy soils may be adequate for growth. Annual ryegrass matures between June and September, is typically seeded in the autumn, and tilled in late spring or early summer (Ingels et al. 1998).

Cereal cover crops. Barley ***(Hordeum vulgare),*** oats ***(Avena sativa),*** triticale ***(Triticosecale hexaploide),*** and wheat ***(Triticum aestivum)*** are known as cereal cover crops and can be interplanted with vetches because their stems are often strong enough to support the vine-like growth (Sattell 1998). Care should be taken when choosing varieties that are resistant to diseases that could infect nearby fields of grain crops. Barley and wheat are more drought-tolerant than oats or triticale. Cereal crops are often tilled into vineyards in early summer, but can be mowed for extra frost protection in the spring. They form a fibrous root system, adequate for reducing soil erosion and removing excess nitrogen. Cereal crops are planted in the autumn to take advantage of winter moisture for germination.

Cereal rye ***(Secale cereale*** L.***).*** Cereal rye or winter rye can be used to increase organic matter and can produce about 3,000–10,000 lbs/acre in dry biomass (Satell 1998). It has an extensive fibrous root system that can take up excess water and nitrogen in a vineyard. It can be combined with any of the vetch species to increase residue in vine alleys, and can be helpful to degrade certain herbicide residues (Zablotowicz et al. 1998). It is normally planted in the autumn or early spring and mowed before it begins to senesce. Cereal rye is a very cold tolerant cover crop, enduring temperatures down to -30°F.

Clovers ***(Trifolium*** spp.***).*** Crimson clover ***(T. incarnatum),*** rose clover ***(T. hirtum),*** and subterranean clover ***(T. subterraneum)*** are annuals often used in vineyards managed without tillage. Crimson and rose clovers can reach a height of 6–8," but subterranean clovers exhibit a low, prostrate growth habit (Ingels et al. 1998; Sattell 1998). Unlike other clover species, subterranean clovers produce seed underground, perhaps lending advantage to providing a continual stand. As with many clovers and medics, a large quantity of hard seed is produced that will germinate over multiple years. Clovers perform best when part of a mix that includes multiple clover and medic species. In soils with poor nutrition, it may be difficult to establish a good stand, thus adequate phosphorus, calcium, and sulfur is necessary. Amendment of the soil before planting can ensure good establishment.

Field pea ***(Pisum sativum).*** Field pea has been used in a number of vineyards in the eastern Pacific Northwest as a winter/spring annual and tilled or mowed in early summer to supply organic matter and release nitrogen. Stems of the plant are succulent and breakdown rapidly, providing a burst of nitrogen in the soil. Much of the biomass is accumulated in the early spring, and is often a component of cereal crop mixes.

Medics ***(Medicago*** spp.***).*** Bur medic ***(M. polymorpha),*** barrel medic ***(M. truncatula),*** and black medic ***(M. lupulina)*** are cover crops originally used for establishing pastures. All are considered to be reseeding annuals or short-lived perennials. Bur medic performs well on soils with a pH > 6.5, establishes with relatively little seed (~5 lb/ac), and produces large quantities of hard seed for future season's growth. Seed pods from bur medics are often spiny, although some cultivars such as 'Santiago' have no spines. Bur medic performs well in vineyards with minimal irrigation in vine alleys, provided winter rains are adequate. Barrel medic prefers soil pHs that range from neutral to alkaline, and requires about 11" of precipitation to adequately establish (Schnipp and Young 2004). It too produces a large number of hard seeds, maturing in mid-spring. Black medic performs well on soils similar to barrel and bur medic. The cultivar 'George' was developed for dryland production with approximately 15" of precipitation per year. It is easily controlled with mowing and herbicide applications.

Mustards ***(Brassica*** and ***Sinapsis*** spp.***).*** Mustards are forbs and are often grown to produce chemicals called glucosinolates that break down via microbial degradation to isothiocyanide, which can act as a soil fumigant and weed suppressant. Mustard cover crops can be grown and incorporated before a vineyard is established if a chemical fumigant is not desired (Figure 4). If grown in vine alleys in an established vineyard, it is treated as a reseeding annual and should not be mowed until seeds have set. Both white mustard ***(Sinapsis alba)*** and oriental mustard ***(Brassica juncea)*** have shown success in dry environments. ***Brassica napus*** can also be grown as a cover crop; however, it is mainly grown for oilseed production.

Vetches ***(Vicia*** spp.***).*** This group of covers include hairy vetch ***(V. villosa)*** and common vetch ***(V. sativa).*** Vetches are commonly seeded or present as volunteer plants in vineyards. They can be seeded in stands alone or with grain crops to provide a structure for climbing. Hairy vetch is more prone than common vetch to climbing beyond the vine alley into trellises, especially on deep soils. Both types of vetches

are shallow-rooted plants, unlike many of the tap-rooted legumes (Ingels et al. 1998), and have bluish-purple flowers that can be an effective cover for attracting beneficial insect populations as well as provide aesthetic benefits. Hairy vetch is more cold-tolerant than common vetch, with most of the biomass production in the early spring and summer. Allow vetches to reseed if a continuous stand is desired.

Figure 4.
A mustard cover crop can be used before planting when establishing a vineyard.

Perennial Cover Crops

Fescues ***(Festuca*** spp.***).*** This group includes tall fescue ***(F. arundinacea),*** sheep (or hard) fescue ***(F. ovina),*** and red fescue ***(F. rubra).*** Sheep fescues are bunchgrasses, while red fescues can have a slow, spreading growth habit. Many turf-type fescues can form a dense mat in vine alleys, providing excellent weed suppression and traction. During the summer, reduction in precipitation or irrigation will induce dormancy, providing a layer of mulch. Fescues are well suited for dryland vineyards and should be autumn-seeded to take advantage of available precipitation. Some varieties of fescue produce large root systems that make it difficult to eradicate. Most fescues are prolific seed producers that contribute to the following season's stand.

Indian ricegrass ***(Orzyopsis hymenoides*** or ***Achnatherum hymenoides).*** This grass is native to western North America, and is often used for erosion control on sand dunes and soils with large percentages of sand. Although green in the spring, it is a summer-dormant species that retains its hold on soil particles, making it useful for sandy, windy sites. It is a very drought-tolerant, cool-season cover crop.

Meadow barley ***(Hordeum brachyantherum).*** Meadow barley is a perennial grass that performs best in wetland or riparian areas. It is also known as California barley and can tolerate clay with low calcium and low water holding capacity or serpentine (high magnesium) soils (serpentine soils are most commonly found in California not in the Pacific Northwest). Since meadow barley is a poor competitor with weeds, weed control measures should be taken before planting.

Perennial ryegrass ***(Lolium perenne).*** Perennial rye is a cool-season, moderately drought-tolerant bunchgrass that can be competitive when overseeded. It establishes quickly and germinates early in the growing season (Hannaway et al. 1999). Because of its early germination, it is an ideal candidate for grass mixes in which the germination of other species is staggered (Figure 5). Grass mixes provide a green cover for a longer period during the growing season than a monoculture of perennial rye. Perennial rye is especially good for preventing soil erosion because of its extensive fibrous root system. In areas with mild winters, perennial rye can be seeded in the late autumn; in areas with potentially cold winters, it should be seeded during the late summer. Seeds should not be planted deeper than 0.5" to establish a good stand.

Figure 5.
Six-year-old grass mixture in vineyard alleys showing a stand of 'Fairway' crested wheatgrass (A) and perennial rye (B).

Wheatgrasses. This group of grasses includes crested wheatgrass ***(Agropyron cristatum)***, standard crested wheatgrass ***(Agropyron desertorum)***, pubescent wheatgrass ***(Agropyron trichophorum)***, and a number of other species. Wheatgrasses are known for their drought tolerance and persistent stands (5–7 years). With good early establishment, they can significantly reduce the weed population in vineyard alleys. They can be seeded in combination with forb mixes to aid in attracting beneficial insect populations, but to reduce competition with forbs during cover establishment, lower the suggested stand-alone planting rate (wheatgrasses) by 50%.

White clover (Trifolium repens). White clover is a perennial that performs better on heavy soils than on lighter, sandy soils because it is not as drought-tolerant as other clovers like subterranean clovers. It is considered a short lived perennial that may require replanting every 3–4 years depending upon stand establishment. Plants are hardy to about 17°F (Brandsæter et al. 2002). White clover seeds are small (see appendix) and seed/soil contact must be maximized to get good stand establishment. A properly prepared seed bed that is cultivated and packed will aid in establishment. Seeding depth should be no more than ¼".

Wildflower and forb mixes. These mixes often consist of various varieties of native flower and grasses to enhance ecological diversity. Choosing native varieties will ensure sufficient germination and persistence from year to year. Check with your local extension or agriculture office to get a list of native wildflowers for your area. Also, be sure to inquire about any component of the mixture that may become an invasive species. A mixture of species may necessitate a broadcast application within the vineyard alleys owing to variance in seed size. After broadcast seeding, a press wheel or cultipacker may be useful to maximize the seed/soil contact; however, seeds should not be pressed into the soil too deeply (>3 inches).

Summary

The annual cover crop choices for tilled vineyards include:

- Annual ryegrass
- Barley
- Oats
- Triticale
- Wheat
- Cereal rye
- Field pea
- Mustards and ***Brassica*** spp.
- Various vetch species

For no-till vineyards the cover crop choices include:

- Red, crimson, and subterranean clovers (***Trifolium*** spp.)
- Bur, barrel, and black medics (***Medicago*** spp.)

Perennial cover crop choices include:

- Tall, sheep (hard), and red fescues
- Meadow barley
- Perennial ryegrass
- White clover
- Bunch-type wheatgrasses, such as crested and pubescent wheatgrass
- Wildflower/forb mixes

Concluding Remarks

Vineyard floor management should take into consideration your overall goals for vineyard management and the surrounding area. Vineyards will benefit from cover crops that help in vigor control, compete with the existing weed population, and control soil erosion by wind and water. Keep in mind that sustainable grape production must take into consideration labor concerns, economics, and ecological impacts.

Appendix

Details on Specific Varietis of Cover Crop Selections ***ENGLISH UNITS***

	Common Name	Scientific Name	Common Cultivars	Category	Soil pH Range	Growth Habit	Maximum Height (in)	Seeding Rate (lb/ac)	Seeds/lb
Annual Systems	Annual Ryegrass	*Lolium multiflorum*	Rio	Grass	5.0-8.0	Upright, forms dense clumps	40	30-40	227,000
	Barley	*Hordeum vulgare*	Various varieties	Grass	5.0-8.3	Upright, erect stems	40	70-90	14,500
	Barrel Medic	*Medicago truncatula*	Parragio, Sephia, Parabinga	Legume	7.0-8.0	Low growing, slowly spreading growth	12	5-10	150,000
	Bur Medic	*Medicago polymorpha*	Santiago	Legume	6.5-8.3	Low growing, slowly spreading growth	12	5-10	150,000
	Cereal Rye	*Secale cereale*	Balboa, Elbon, Winter King	Grass	4.5-8.0	Upright	36	60-90	18,000
	Common Vetch	*Vicia sativa*	Willamette	Legume	5.5-8.2	Trailing vine, succulent growth	24	60-75	7,000
	Crimson Clover	*Trifolium incarnatum*	Dixie, Autauga, Auburn, Chief, Kentucky	Legume	5.8-6.5	Upright, flowering stalk	12	15-20	160,000
	Field Pea	*Pisum sativum*		Legume	4.2-8.7	Prostrate growth, trailing vine, can climb grain stalks if grown together	24	70-160	4,000
	Hairy Vetch	*Vicia villosa*		Legume	4.9-8.2	Trailing, climbing vine	24	25-60	28,000
	Oats	*Avena sativa*	Various varieties	Grass	5.0-7.0	Upright, erect stems	36	70-90	11,000
	Subterranean Clover	*Trifolium subterraneum*	Koala, Mt. Barker, Dalkeith	Legume	5.5-7.5	Prostrate and spreading growth	6	25-30	65,000
	Triticale	*Triticosecale x*	Various varieties	Grass	5.0-7.0	Upright, erect stems	36	70-90	11,000
	Wheat	*Triticum aestivum*	Various varieties	Grass	6.0-8.0	Upright, erect stems	36	70-90	11,000
	Mustards	*Brassica* spp.	White mustard, Oriental Mustard	Forb	5.5-8.3	Upright, flowering stalk, with allelopathic potential for weed suppression and nematode control	60	6-10	150,000
	Common Name	**Scientific Name**	**Common Cultivars**	**Category**	**Soil pH Range**	**Growth Habit**	**Maximum Height (in)**	**Seeding Rate (lb/ac)**	**Seeds/lb**
Perennial Systems	Black Medic	*Medicago lupulina*	George	Legume	7.0-8.3	Low growing, slowly spreading growth	18	15-20	175,000
	Crested Wheatgrass	*Agropyron cristatum*	Fairway, Douglas, Ephraim	Grass	6.0-8.3	Upright, forms dense clumps	40	20-25	175,000
	Hard Fescue	*Festuca duriuscula*	Durar	Grass	5.5-8.0	Upright, bunch grass	24	20-25	575,000
	Indian Ricegrass	*Oryzopsis hymenoides*	Nezpar, Paloma	Grass	6.0-8.5	Upright, bunch grass, good for soils with high percentage of sand	24	30-40	141,000
	Meadow Barley	*Hordeum brachyantherum*		Grass	5.0-8.0	Upright, best performs in wetland conditions	40	5-20	85,000
	Perennial Rye	*Lolium perenne*	Secretariat, Divine, Anaconda, Achieve, Majesty	Grass	5.6-6.2	Upright	36	20-40	227,000
	Pubescent Wheatgrass	*Agropyron trichophorum*	Luna	Grass	6.0-8.3	Upright, forms dense clumps	36	20-40	100,000
	Red Clover	*Trifolium pratense*	Arlington, Kenland, Mammoth, Marathon	Legume	6.2-6.8	Medium in stature	25	25-30	275,000
	Red Fescue	*Festuca rubra*	Molate	Grass	5.5-6.5	Low growing, with tolerance for wet soil	36	20-25	615,000
	Sheep Fescue	*Festuca ovina*	Covar, Azay, Bighorn, Elk Brand, Blackchap	Grass	5.5-6.5	Turf-type grass, good competitor for weeds	24	5-10	680,000
	Standard Crested Wheatgrass	*Agropyron desertorum*	Nordan	Grass	6.5-8.5	Upright, forms dense clumps	36	15-20	175,000
	Tall Fescue	*Festuca arundinacea*	Alta, Mazimize, Fawn, Enforcer	Grass	5.5-6.5	Upright	36	35-40	227,000
	Wheat	*Triticum aestivum*, spp.	Various varieties	Grass	6.0-8.3	Upright	36	20-25	11,000
	White Clover	*Trifolium repens* L.	Dutch, New Zealand, Haifa	Legume	6.0-7.0	Low growing, prostrate growth	12	10-15	850,000

	Common Name	Scientific Name	Growth Habit	Maximum Height	Seeding Rate (kg/ha)	Seeds/kg
Annual Systems	Annual Ryegrass	*Lolium multiflorum*	Upright, forms dense clumps	60-120 cm	33-45	103,000
	Barley	*Hordeum vulgare*	Upright, erect stems	120 cm	78-100	6,500
	Barrel Medic	*Medicago truncatula*	Low growing, slowly spreading growth	12″	5-10	68,000
	Bur Medic	*Medicago polymorpha*	Low growing, slowly spreading growth	12″	5-10	68,000
	Cereal Rye	*Secale cereale*	Upright	36″	67-100	8,200
	Common Vetch	*Vicia sativa*	Trailing vine, succulent growth	24″	67-85	3,200
	Crimson Clover	*Trifolium incarnatum*	Upright, flowering stalk	12″	16-22	72,500
	Field Pea	*Pisum sativum*	Prostrate growth, trailing vine, can climb grain stalks	24″ (unless grown with grain)	70-160	1,800
	Hairy Vetch	*Vicia villosa*	Trailing, climbing vine	24″	28-67	9,000
	Oats	*Avena sativa*	Upright, erect stems	36″	70-90	5,000
	Subterranean Clover	*Trifolium subterraneum*	Prostrate and spreading growth	6″	28-33	143,000
	Triticale	*Triticosecale x*	Upright, erect stems	36″	70-90	5,000
	Wheat	*Triticum aestivum*	Upright, erect stems	36″ (90 cm)	70-90	5,000
	Mustards	*Brassica* spp.	Upright, flowering stalk, with allelopathic potential for weed suppression and nematode control	60″	7-11	68,000
	Common Name	**Scientific Name**	**Growth Habit**	**Maximum Height**	**Seeding Rate (kg/ha)**	**Seeds/kg**
Perennial Systems	Black Medic	*Medicago lupulina*	Low growing, slowly spreading growth	45 cm	15-25	79,000
	Crested Wheatgrass	*Agropyron cristatum*	Upright, forms dense clumps	100 cm	25-30	79,000
	Hard Fescue	*Festuca duriuscula*	Upright, bunch grass	24″	22-28	260,000
	Indian Ricegrass	*Oryzopsis hymenoides*	Upright, bunch grass, good for soils with high percentage of	24″	33-45	64,000
	Meadow Barley	*Hordeum brachyantherum*	Upright, best performs in wetland conditions	100 cm	5-22	38,500
	Perennial Rye	*Lolium perenne*	Upright	36″ (30-90 cm)	16-22	103,000
	Pubescent Wheatgrass	*Agropyron trichophorum*	Upright, forms dense clumps	36″	16-22	45,400
	Red Clover	*Trifolium pratense*	Medium in stature	25″	25-30	125,000
	Red Fescue	*Festuca rubra*	Low growing, with tolerance for wet soil	36″	22-28	279,000
	Sheep Fescue	*Festuca ovina*	Turf-type grass, good competitor for weeds	24″	5-11	308,000
	Standard Crested Wheatgrass	*Agropyron desertorum*	Upright, forms dense clumps	36″	16-22	80,000
	Tall Fescue	*Festuca arundinacea*	Upright	36″	39-45	103,000
	Wheat	*Triticum aestivum*, spp.	Upright	36″	20-25	5,000
	White Clover	*Trifolium repens* L.	Low growing, prostrate growth	12″	11-16	385,000

References

Augé, R.M. 2001. Water relations, drought, and vesicular-arbuscular mycorrhizal symbiosis. Mycorrhiza 11:3-42.

Baumgartner, K., R.F. Smith, and L. Bettiga. 2005. Weed control and cover crop management affect mycorrhizal colonization of grapevine roots and arbuscular mycorrhizal fungal spore populations in a California vineyard. Mycorrhiza 15:111-119.

Biricolti, S., F. Ferrini, E. Rinaldelli, I. Tamantini, and N. Vignozzi. 1997. VAM fungi and soil lime content influence rootstock growth and nutrient content. American Journal of Enology and Viticulture 48:93-99.

Brandsæter, L.O., A. Olsmo, A.M. Tronsmo, and H. Fykse. 2002. Freezing resistance of winter annual and biennial legumes at different developmental stages. Crop Science 42:437-443.

Burton, C.J. and P.J. Burton. 2003. A manual for growing and using seed from herbaceous plants native to the northern interior of British Columbia. Symbios Research and Restoration. Smithers, BC. 168 pp. (available from symbios@bulkley.net).

Cline, R.A. 1992. Soil management for orchards and vineyards. Ontario Ministry of Agriculture and Food Fact Sheet #92-120. http://www.omafra.gov.on.ca/english/crops/facts/92-120.htm.

Coldwell, A.E., P.R. Loewen, and C.J. Whitfield. 1943. The relation of various types of vegetative cover to soil drift. Journal of the American Society of Agronomy 34:702-710.

Folorunso, O.A., D.E. Rolston, T. Prichard, and D.T. Louie. 1992. Cover crops lower soil surface strength, may improve soil permeability. California Agriculture 45:26-27.

Goulet, E., S. Dousset, R. Chaussod, F. Bartoli, A.F. Doledec, and F. Andreux. 2004. Water-stable aggregates and organic matter pools in a calcareous vineyard soil under four soil-surface management systems. Soil Use and Management 20:318-324.

Gulick, S.H., D.W. Grimes, D.S. Munk, and D.A. Goldhamer. 1994. Cover-crop-enhanced water infiltration of a slowly permeable fine sandy loam. Soil Science Society of America Journal 58:1539-1546.

Hall, M. H. White clover. Agronomy Facts 22. Pennsylvania State University Cooperative Extension. http://cropsoil.psu.edu/Extension/Facts/agfact22.pdf.

Hannaway, D., S. Fransen, J. Cropper, M. Teel, M. Chaney, T. Griggs, R. Halse, J. Hart, P. Cheeke, D. Hansen, R. Klinger, and W. Lane. 1999. Perennial ryegrass. PNW 503. http://eesc.orst.edu/agcomwebfile/edmat/html/pnw/pnw503/pnw503.html.

Ingels, C.A., R.L. Bugg, G.T. McGourty, and L.P. Christensen. 1998. Cover cropping in vineyards: A grower's handbook. University of California Division of Agriculture and Natural Resources. Publication #3338. 162 pp.

Ingels, C.A., K.M. Scow, D.A. Whisson, and R.E. Drenovsky. 2005. Effects of cover crops on grapevines, yield, juice composition, soil microbial ecology, and gopher activity. American Journal of Enology and Viticulture 56:19-29.

Kabir, Z. and R.T. Koide. 2002. Effect of autumn and winter mycorrhizal cover crops on soil properties, nutrient uptake and yield of sweet corn in Pennsylvania, USA. Plant and Soil 238:205-215.

Kaspar, T.C., J.K. Radke, and J.M. Laflen. 2001. Small grain cover crops and wheel traffic effects on infiltration, runoff, and erosion. Journal of Soil and Water Conservation 56:160-164.

Kaya, C., D. Higgs, H. Kirnak, and I. Tax. 2003. Mycorrhizal colonization improves fruit yield and water use efficiency in watermelon (*Citrullus lanatus* Thunb.) grown under well-watered and water-stressed conditions. Plant and Soil 253:287-292.

Linderman, R.G. and A.A. Davis. 2001. Comparative response of selected grapevine rootstocks and cultivars to inoculation with different mychorrhizal fungi. American Journal of Enology and Viticulture 52:8-11.

McGuire, A. 2003. Mustard. EB1952E. Washington State University Extension, Pullman, WA. http://grant-adams.wsu.edu/agriculture/covercrops/pubs/eb1952e.pdf.

Sattell, R. 1998. Using cover crops in Oregon. EM 8704. Oregon State University Extension Service, Corvallis, OR.

Schnipp, A. and R. Young. 2004. Barrel medic. Agnote DPI-264. New South Wales Department of Primary Industries. http://www.agric.nsw.gov.au/reader/past-templegume/dpi264.htm.

Schreiner, R.P. 2004. Mycorrhizas and mineral acquisition in grapevines. Proceedings of the soil environment and vine mineral nutrition symposium. San Diego, CA. American Society for Enology and Viticulture. Pp. 49-60.

Stredansky, J. 1999. Reduction of wind erosion intensity by vegetation cover. Ekologia 18:96-99.

University of California SAREP Cover Crop Database. http://www.sarep.ucdavis.edu/ccrop/

Verhallen, A., A. Hayes, and T. Taylor. 2001. Cover crops: ryegrass. Ontario Ministry of Agriculture. http://www.omafra.gov.on.ca/english/crops/facts/cover_crops01/ryegrass.htm.

Zablotowicz, R.M., M.A. Locke, and R.J. Smeda. 1998. Degradation of 2,4-D and fluometuron in cover crop residues. Chemosphere 37:87-101.

Seed Sources

Listing of companies is not an endorsement for a particular vendor.

- Brett Young Seeds, Winnepeg, MB
  http://www.byseeds.com/

- Landmark Seeds, North 120 Wall Street, Suite 400, Spokane, WA 99201
  http://www.landmarkseed.com/index.html

- Fedco Co-op, Organic Growers Supply, Fedco Seeds, PO Box 520, Waterville, ME 04903 (207) 873-7333 http://www.fedcoseeds.com/ogs/covercrop_listing.htm

- Peaceful Valley Farm and Garden Supply, PO Box 2209, Grass Valley, CA 95945
  http://www.groworganic.com/default.html

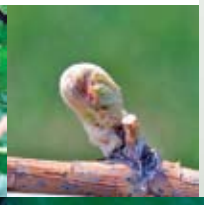
- S & S Seeds, PO Box 1275, Carpinteria, CA 93014-1275 (805) 684-0436
  http://www.ssseeds.com/index.html

- Seeds of Change, 1-888-762-7333
  http://www.seedsofchange.com/

- Silver Falls Seed Company, PO Box 885, Silverton, OR 97381 (503) 874-8221
  http://www.silverfallsseed.com/

- West Coast Seeds, 925 64th Street, Delta, BC,V4K 3N2
  https://secure.westcoastseeds.com/index3.cfm











Use pesticides with care. Apply them only to plants, animals, or sites listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

You may order copies of this and other publications from the WSU Bulletin office, 1-800-723-1763, or online http://pubs.wsu.edu

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. WSU Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, national or ethnic origin; physical, mental or sensory disability; marital status; sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended.

Published August 2006. Subject Code 233. EB2010