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Good Morning,
Please find below an excellent discussion of under-trellis ground cover management from Penn State.

~ Sonia Schloemann

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Why should we care about under-trellis cover crops?

By: Dr. Michela Centinari

In cool climate vineyards labor (hours/acre) employed for canopy management operations (*e.g.*, shoot positioning and thinning, cluster thinning, leaf removal, hedging) is estimated to be much higher than for floor management practices (approximately 32% vs. 11% of total labor hours, excluding harvest) [1]. Canopy management practices are critical for optimizing crop load, improving microclimate conditions in the fruiting zone and reducing disease pressure on the leaves and fruit. However, we tend to forget that floor management also has profound implications for the vineyard ecosystem, productivity and indirectly wine quality [2]. The main goals of vineyard floor management span from weed control, soil conservation, soil nutrient and water management, and biodiversity improvement [2]. Among many factors, the best floor management strategy for a given vineyard site depends on the age of the vine, growing region, soil type, and production goals of the grower [3]. Environmental regulations and public perceptions may also influence growers' choices toward a specific floor management practice [2].

The conventional floor management practice for mature vineyards in the eastern U.S. and other temperate regions around the world is a cover cropped inter-row combined with a vegetation-free area directly beneath the vines to reduce competition for soil resources (*i.e.*, water and nutrients). The under-trellis area is kept bare using herbicides and in some cases by soil cultivation (Figure 1).



Figure 1. Conventional vineyard floor management in the eastern U.S.

Why explore alternative under-trellis management options?

- **Seeking environmentally responsible and (potentially) affordable alternatives to the use of herbicides**

Herbicides are the most widely used pesticides in the U.S.; they are commonly used in vineyards because they effectively suppress weed growth and are easy to apply [4]. However, repeated herbicide use increases the risks of resistance development [5]. Also, bare soil left exposed after herbicide use or tilling is susceptible to erosion, soil structure degradation and crusting as well as increased water runoff and leaching of nitrates and pesticides [4].

- **Reducing excessive vine growth and the need for expensive canopy management practices**

Despite the presence of cover crops between the rows (inter-row area), grapevines can still exhibit excessive vegetative growth in regions with deep, fertile soils and ample precipitation during the growing season (Figure 2). Large and dense canopies with heavily shaded fruit may contribute to reduced fruit and wine quality as well as an increase in disease pressure [7]. In addition, excessively vigorous grapevines are more expensive to train and manage: main and later shoot thinning, multiple passes of fruit-zone leaf removal and hedging are costly management practices [1] often required to improve clusters light environment.



Figure 2. Overly vigorous Cabernet franc vines in the northeastern U.S.

What are the alternative under-trellis options?

One alternative option to the under-trellis herbicide-treated strip is to establish cover crops directly beneath the vines (intra-row) in addition to between the rows (inter-row) (*i.e.*, complete floor cover) (Figure 3). Under-trellis cover crops could serve multiple purposes depending on grower's needs and the cover crop species used. Cover crop species have different degrees of competition with vines for soil resources (*e.g.*, water and nutrients). For example, annual cover crops tend to be less competitive for soil nitrogen resources than perennial plants because of their shorter growth cycle and less root development [8]. Furthermore, fine fescues (*e.g.*, *Festuca ovina*) tend to be less competitive than other perennial grasses such as tall fescues (*Festuca arundinacea* Shreb) [8].



Figure 3. Complete vineyard floor cover cropping. Annual ryegrass (*Lolium perenne*) planted under the trellis (intra-row) and resident/native vegetation established in the inter-row.

Several studies have been conducted in the eastern U.S. over the last 10 years to test if and which under-trellis cover crop species could be used as an environmentally responsible means to suppress the use of herbicide and as a proactive measure to reduce excessive vine growth through competition with the grapevine root system for soil resources.

Do under-trellis management strategies impact leaching of nutrients and pesticide?

Yes, under-trellis management strategies can impact leachate composition [4;9]. For example dissolved organic carbon (DOC) leaching was reduced by maintaining a green cover under the trellis (white clover or native vegetation) as compared to conventional under-trellis strategies, as herbicide (glyphosate) application or soil cultivation [4]. Thus, not only herbicide application but also soil cultivation can increase carbon loss from the soil in addition to increasing its erosivity. Also, total nitrogen (N) concentration was higher in leachate samples collected from under-trellis glyphosate and white clover plots as compared to those from native vegetation or cultivation plots.

What cover crops can growers use to suppress excessive vine growth and increase crop load?

Cool season perennial grasses have been planted under the trellis in vineyard located in Virginia, North Carolina (Dr. Tony Wolf lab, Virginia Tech University) and in Long Island (NY) (Alice Wise, Cornell Cooperative Extension) to impose competition for moisture and nutrients early during the growing season, when grapevines grow vigorously (at least in the Eastern U.S.) [8;9;10].

Compared to an herbicide-treated soil strip, complete vineyard floor cover cropping reduced excessive vigor of Cabernet Sauvignon vines in a wet and humid region (NC) over a six-year-period [4]. Among the perennial grasses tested *Festuca arundinacea* cv. Elite II, a turf-type tall fescue, and cv. KY-31, a forage-type tall fescue, were the most effective in reducing vine vigor and increasing light available to the fruit with minimum impact on crop yield [4].

Creeping red fescue (*Festuca rubra*) planted under Cabernet Sauvignon vines in the fall of the second year of vineyard establishment reduced vine size in a favorable way (average of 26%) and increased sunlight fruit exposure by 35% over a 7-year-period as compared to herbicide-treated strip [10].

(Note: This study was conducted at the Virginia Tech's AHS, Jr. Agricultural Research and Extension Center, in a

'research' vineyard with high vigor potential. We don't suggest using under-vine cover crop in young vineyards without knowing the history and vigor potential of the site.)

Interestingly, the growth suppressive effect of the under-trellis fescue decreases over the years suggesting that the vines may be able to adapt to the presence of under-trellis cover crops by, for example, relocating absorptive roots to a deeper soil profile [11].

Chicory (*Chicorium intybus*) annually planted under the trellis of mature, vigorous vineyards in the Finger Lakes region of NY resulted in considerably diminished vine size, up to 35 % (Figure 3) [Dr. Justine Vanden Heuvel lab, Cornell University; 12; 13]. Furthermore, chicory effectively suppressed weed pressure underneath the grapevine canopy.



Figure 4. Reduced vegetative growth of vines growing with under-trellis chicory (right) compared to glyphosate herbicide (left). Photo credit: J. Vanden Heuvel, Cornell University.

When vine growth is vigorous, the balance between vegetative and reproductive growth tend to be below the recommended Ravaz index (yield /pruning weight) ratio ranging from 4 to 10 for high-quality wine production [14]. The devigorating effect of the under-trellis cover crops often translated to an increase in crop load (*i.e.*, Ravaz index) toward the 'optimal' values. Although the reduction in vegetative growth/vine size is usually greater than that of crop yield, growers should take into consideration a potential yield penalty associated with the use of under-trellis cover crops [10].

Can under-trellis cover crops impact fruit composition?

In several studies the use of under-trellis cover crops did not significantly impact, either positively or negatively, juice chemistry [total soluble sugar (°Brix), pH, titratable acidity (TA)] [4;9;15;16;17] or total phenolics or anthocyanins [10]. In other cases an increase in juice °Brix or reduction in TA (1 g/L) was attributed to the devigorating effect and increased fruit sunlight exposure brought on by the presence of under-trellis cover crops [10;12].

What causes the reduction in vine size associated with the use of under-trellis cover crops?

It depends on, among other factors, the seasonal weather conditions, soil resources available and nutritional requirements of the cover crop. Vines can also compete with cover crops for multiple resources at the same time making it in some situations very difficult to separate the effect of moisture vs nutrient competition. In most of the studies conducted in upstate NY, NC and VA vine water status (stem, pre-dawn water potential) never reached what we define a 'stressful' value indicating that under-trellis cover crops were not overly competitive with grapevines for soil moisture under the specific weather conditions of those regions and during the years studied [4;10;12;13]. However, during consecutive seasons of summer drought in Long Island,

vines with under vine green growth exhibited more symptoms of water stress than those with an herbicide-treated strip [9]

At several sites, cool-season grasses depressed grapevine nitrogen [4, 10; 12] levels relative to the under-trellis herbicide strip suggesting that under-trellis cover crops can affect vine nitrogen status and thus vine capacity [10].

What about leaving native vegetation growing under the trellis instead of planting cover crops?

At several research sites in upstate NY, native vegetation was allowed to grow under the vines (Dr. Vanden Heuvel lab, Cornell University). Compared to an herbicide-treated strip, native vegetation had a variable impact on vine size across sites, from nil effect at one site [16] up to 57% reduction in pruning weight in a young vineyard [17]. Site characteristics, plant material and age in addition to diverse weed populations at the research sites may explain the variable impact of native vegetation on reducing vine size.

Growers in Long Island (NY) have been experimenting with under-trellis mowing (*i.e.*, native vegetation mowed several times throughout the season). Costs of under-trellis mowing compare well to the herbicide regime (approximately \$120/acre) [9]. A. Wise pointed out that, while more growers are interested in under-trellis mowing, a deterrent for its adoption may be “the price of suitable mowers, which go from \$3,500 for a single head to over \$15,000 for two mowing heads with a row middle mower” (Figure 5). Wise also noted that “under vine mowing is a viable option for under vine management though it is best suited to mature, laser planted vineyards because of the risk of trunk damage to young vines and crooked trunks”[9].



Figure 5. Under-trellis mowing with a single head mower (left) and two mowing heads with a row middle mower (right). Photos credit: A. Wise, Cornell Cooperative Extension.

Can under-trellis cover crops be used to eliminate the use of herbicide while maintaining vine size?

Planting annual cover crops, such as buckwheat (*Fagopyrum esculentum*) or annual ryegrass (*Lolium multiflorum*) under the vines may eliminate the need for herbicide with little impact on vine size or fruit composition. Most of the work on under-trellis annual cover crops has been conducted in the cool and humid Finger Lakes region, upstate NY, at Cornell University by Dr. Vanden Heuvel lab [4; 15; 16; 17]. In the Northeastern U.S. perennial cover crop species are not suitable for the under-trellis area due to the need to mound soil from the under-vine row around the graft union for insulation to protect scion budwood from low winter temperature. For example, buckwheat planted in late-May in mature vineyards in upstate NY (seeding rate is approximately equal to 350 lbs/acre) was found to compete extremely well with weeds pressure without compromising vine size [13; 16] or fruit composition [15] (Figure 6).



Figure 6. Buckwheat (*Fagopyrum esculentum*) planted beneath Cabernet franc vines.

How much will establishing and maintaining under trellis cover crops cost?

A partial budget analysis was developed for one of the studies on under-trellis cover crops using information gained from the research trial and grower cost estimates (Table 1). In this study establishing and maintaining white clover or native vegetation was a cheaper under-trellis groundcover options than repeated soil cultivation or glyphosate applications. However, vines maintained with herbicide (glyphosate) generated the highest revenue because of their higher yield. Thus, yield penalty associated with vines growing with under-trellis cover crops was the cause of reduced grower's income. Outcomes could definitely change if crop yield is maintained or only slightly reduced, or if other cover crops are used. Compared to white clover (seeding rate: 5 lbs/acre), creeping red fescue can be more expensive to establish because of its higher seeding rates, as much as 220 lbs/acre [9]. However, fescue can persist for more than four years, while white clover would need to be reseeded every 2–3 years [9].

	Cost of under-vine groundcover maintenance	Yield (t/ha)	Crop value (\$/ha)	Crop value minus cost of under-vine groundcover maintenance (\$/ha)	Revenue in comparison to glyphosate (\$/ha)
2012					
Glyphosate	548	10.2	14,198	13,650	-
Soil cultivation	1,036	5.6	7,795	6,759	-6,891
Native vegetation	84	5.2	7,238	7,154	-6,496
White Clover	169	6.0	8,352	8,183	-5,467
2013					
Glyphosate	548	15.3	22,200	21,652	-
Soil cultivation	1,036	13.0	18,863	17,827	-3,825
Native vegetation	84	12.0	17,412	17,328	-4,324
White Clover	169	14.7	21,330	21,161	-491

Table 1. Partial budget analysis comparing the impact of under-vine groundcover on yield and management cost for 2012–2013. Adapted from Karl et al. 2016 [17].

These figures should be used only as an example because there are many variables that could change the outcomes and growers interested in experimenting with under-trellis cover crops should develop their own cost analysis [9]. Also, vigor suppression associated with under-trellis cover crops may result in reduction of costly canopy management operations.

For grape growers managing vigorous vineyards and interested in reducing pesticide input, complete vineyard floor cover could be a viable option. However, **to avoid an undesirable decline in pruning weight, vine nutrient deficiency or water stress it is recommended to monitor pruning weight and Ravaz index on sentinel vines.** It is also important to annually **assess vine nutrient status** and be prepared to efficiently apply fertilizer if needed. In a dry season growers should **look closely for visual symptoms of vine water stress.** To avoid over-devigorating the vines it may be possible to start with an 'aggressive' cover crop and switch after a few years, when vine balance is achieved, to a less competitive cover crops species.

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