PRACTICAL Winery&Vineyard

# Landscape Diversity Influences Leafhopper Biocontrol

## Cover crops attract beneficials, but overwintering habitat is key to biological control

*Houston Wilson, Kent Daane, Serguei Triapitsyn, Albie Miles and Miguel Altieri*

**Houston Wilson** is assistant cooperative extension specialist, Dept. of Entomology, University of California, Riverside.

**Kent Daane** is cooperative extension specialist, Dept. of Environmental Science, Policy & Management, University of California, Berkeley.

**Serguei Triapitsyn** is principal museum scientist, Entomology Research Museum, Dept. of Entomology, University of California, Riverside.

**Albie Miles** is assistant professor, Dept. Social Sciences, University of Hawaii-West Oahu.

**Miguel Altieri** is professor, Dept. of Environmental Science, Policy & Management, University of California, Berkeley.

**FLOWERING COVER CROPS, HEDGEROWS** and other on-farm habitat plantings are a popular way to enhance vineyard aesthetics, contribute to biodiversity conservation and improve crop production. By providing shelter, pollen, nectar and/or alternate prey, habitat plantings can help conserve beneficial insects, native pollinators and butterflies, as well as birds and other wildlife in and around vineyards.

Habitat plantings can also improve soil quality, reduce erosion, act as wind breaks and, by supporting beneficial insect populations, possibly lead to increased biological control of key vineyard pests. In recognition of all these benefits, the U.S. Department of Agriculture-Natural Resource Conservation Service (NRCS) provides growers with subsidies for on-farm habitat plantings through the Environmental Quality Incentives Program (EQIP), and numerous seed providers regularly market various "insectary blends" of cover crops to growers.

Interest in the use of habitat diversification to enhance biological control is, in part, driven by concerns about the impacts and future availability of some chemical control options, which could become more limited due to changes in product efficacy, increased costs and/or regulation. For example, the European Commission is proposing a ban on neonicotenoids, one of the more popular insecticides used in vineyards. It is also a response to rising

### Key Points

- Flowering summer cover crops were evaluated for their ability to enhance biological control of Western grape leafhoppers (WGLH) in North Coast vineyards.
- While the flowering cover crops did attract a lot of beneficial insects, they did not lead to enhanced control of WGLH.
- Biological control of WGLH was greatest in vineyards with nearby overwintering habitat for *Anagrus* spp., the key parasitoids of WGLH.
- Coyote brush and blackberry are the key overwintering habitats used by *Anagrus* spp.
- Vineyard habitat diversification can produce benefits, but there are also risks, and outcomes can be variable, so it is important to consider broader vineyard management goals.

Wild coyote brush (*Baccharis pilularis* spp. consanguinea) grows in large clumps up to 12 feet tall in left photo at Preston Vineyard, Dry Creek Valley. The prostrate form (*Baccharis pilularis* spp. pilularis) is a low growing alternative that may be easier to manage at Ridge Vineyards, Dry Creek Valley (middle photo). Wild coyote brush in foreground of right photo at Fetzer Vineyards, Mendocino County.

# FARMING FOR OUR FUTURE

**In these challenging times,** remember the Farm Credit System is built for the long haul. We're here for you today, and for all the tomorrows to come.

WE ARE FARM CREDIT

A nationwide network of customer-owned associations supporting rural communities and agriculture with reliable, consistent credit and financial services.

**FarmCreditAlliance.com**

**(855) 611-4110** toll free

American AgCredit CoBank Farm Credit West Northwest Farm Credit Services

EQUAL HOUSING LENDER

consumer demand for sustainable farming practices more generally, which is especially pertinent in a crop like winegrapes where consumers regularly visit the vineyard and inquire about production practices.

Collectively, these drivers are not new to viticulture, and many growers have experimented with various ecologically-based pest management practices for years—including the use of flowering cover crops. Yet much remains to be learned about how to effectively use these practices. While there is an abundance of information available about which plants are known to attract beneficial insects, it is still unclear how to best integrate these plants into vineyard production systems in a way that can produce consistent benefits. As such, more rigorous evaluations are needed in order to generate reliable recommendations for growers that are interested in the use of on-farm habitat manipulation to enhance biological control.

## UC Berkeley Flowering Cover Crops Project (2008-2013)

In 2008, North Coast winegrape growers and researchers at the University of California, Berkeley came together to develop and evaluate the use of summer flowering cover crops to enhance biological control of the Western grape leafhopper (*Erythroneura elegantula*). Key natural enemies of this leafhopper include the egg parasitoids *Anagrus erythroneurae* and *A. daanei*, and various generalist predators, such as spiders, green lacewings (*Chrysoperla* spp.) and minute pirate bugs (*Orius* spp.).

The first step involved selecting which species of flowers to work with. Review of the scientific literature identified dozens of flowers that had been used (with varying degrees of success) to enhance biological control in vineyards and other perennial cropping systems. Growers then provided a number of criteria for flower selection in order to narrow the search. Ease of integration with vineyard management was key, so no flower species could be used that required supplemental irrigation or created significant competition for water or nutrients for grapevines.

Arrangement of flowers in the vineyard needed to be done in a way that would not interfere with crop development or disrupt workers or machinery access to the grapevine canopy. The species need to be seeded in the fall, to coincide with the planting of overwintering cover crops.

With these criteria in mind, from 2008-2011 numerous pilot studies occurred across several dozen vineyards in Napa and Sonoma counties as growers and researchers experimented with various arrangements and densities of different flower species.

Flowering cover crops tested included annual buckwheat (*Fagopyrum esculentum*), sweet alyssum (*Lobularia maritima*), California bluebells (*Phacelia campanularia*), Queen Anne's lace (*Daucus carota*), purple tansy (*Phacelia tanacetifolia*), Bishop's flower (*Ammi majus*) and various mustards (*Brassica* spp.).

Growers experimented with flowers sown underneath the vine row and/or in tractor rows, broadcast seeding or use of seed drills, and timing of winter/spring sowing. Grower-researcher exchanges were a key part of the development and evaluation process. Each year, two or three meetings and/or site visits occurred in which growers and researchers shared information about their experiences working with the flowers. Which type of seed drill was best for the small seeded flowers? Which flowers attracted the most beneficial insects? Which flowers seemed to best tolerate low soil moisture? It was through this process of dialogue that allowed the group to solve problems and determine the best way to use flowers in a vineyard.

Ultimately, three species of flowering cover crop were selected for use in vineyards: purple tansy (*P. tanacetifolia*), Bishop's flower (*A. majus*) and

Queen Anne's lace (*D. carota*). These species can be sown in combination within alternate tractor rows in the fall, have a sequential bloom sequence the following spring/summer and do not require any supplemental irrigation.

A seed drill with the outer two ports blocked off is used to sow the flowers in a narrow strip (6 inches wide, 1 to 2 inches deep) in the tractor row at a rate of 0.5 to 2 lbs. per acre (see **TABLE 1**). With this method of sowing, competition with the vines and obstruction of the canopy are minimized, and an open space is left between the stand of flowers and the vine row that allows access for workers and machinery.

**TABLE 1.** Seeding rates and bloom period for the flowering cover crops used in this experiment.

| Common Name | Species Name | Seed Rate (per acre) | Bloom Period |
|---|---|---|---|
| Purple Tansy | *Phacelia tanacetifolia* | 2 lbs. | April - May |
| Bishop's Flower | *Ammi majus* | 0.5 lbs. | May - June |
| Queen Anne's Lace | *Daucus carota* | 0.5 lbs. | July - September |

The flower seeds are sown after harvest and then germinate and establish in the late fall and winter. In the spring, the purple tansy is the first to bloom, beginning around mid-April. Following peak bloom, the purple tansy is mown to about 10 to 12 inches in height. This keeps the flowers from setting seeds and spreading to other areas of the vineyard, where they might become weeds, and also opens up the stand of flowers in order to allow the next species, Bishop's flower, to come up and bloom.

A similar mowing occurs after peak bloom of the Bishop's flower to make space for the Queen Anne's lace to bloom. Just before harvest, the flowering cover crops are mown, and then, following harvest, they can be re-seeded for the following year. Flower seed can be purchased from most commercial seed companies for about $20 per lb.

With the flowering cover crop treatment worked out, a large-scale replicated experiment was set up. In 2012-2013, paired plots with and without flowering cover crops (2 acres each) were established at 10 vineyards across Napa and Sonoma counties to evaluate the flowering habitat's influence on numbers of beneficial and pest insects, pest parasitism rates, and crop vigor, yield and quality.

Results found that while the flowering cover crops attracted a lot of beneficial insects, this never translated into higher populations of beneficial insects in the vine canopy itself or to any impacts on leafhopper numbers on the vine. On the upside, the flowers did not seem to have any negative impacts on crop vigor, yield or quality.

Similar outcomes have been observed in other cropping systems—flowering cover crops attract a lot of beneficial insects, but actual reductions in pest populations are much less common. These variable outcomes have a lot to do with the specific needs of the target organisms that a researcher or grower is trying to manipulate.

For example, while flowering cover crops can indeed provide additional shelter, nectar, pollen and/or alternate prey for beneficial insects—to what

extent are each of these a limiting factor for the specific beneficial insect that you are trying to support in the vineyard? Research was focused on the control of grape leafhopper, and the suite of beneficial insects that arrived at the flowers may have been more interested in simply acquiring nectar and pollen and/or feeding on some other species of insect.

## Importance of Landscape Diversity for Biological Control

During analysis of this experiment, a lot of variability in the data was noticed between study sites. At some vineyards, leafhopper eggs were being consistently parasitized by *Anagrus* spp., regardless of the flowering cover crop, while at other vineyards parasitism was consistently low. *Anagrus* spp. parasitoids seasonally move between vineyards and overwintering sites. This is because *Anagrus* spp. require leafhopper eggs to successfully overwinter, and the grape leafhopper overwinters as an adult. As grape leafhoppers stop laying eggs at the end of the growing season, the *Anagrus* spp. are forced to seek out alternate leafhopper species that lay eggs through the winter.

Alternate hosts are most likely found in natural habitats outside of vineyards, which was confirmed by a recent North Coast survey conducted in parallel with this flowering cover crop project. Our survey revealed these parasitoids primarily overwinter on coyote brush (*Baccharis pilularis*) and blackberry (*Rubus* spp.). While blackberry was identified as an overwintering host for *Anagrus* spp. many decades ago, use of coyote brush by these parasitoids was unknown until this survey.

Furthermore, total abundance of *Anagrus* spp. that overwintered on coyote brush was significantly higher than on blackberry, indicating that this plant plays a major role in supporting regional populations of these parasitoids. As such, it may be that vineyards located closer to these overwintering sites experience earlier colonization by *Anagrus* spp., and this may subsequently lead to higher parasitism rates and lower leafhopper densities.

The proportion of natural habitat within one-third of a mile of each study site was calculated as an analog for the abundance of suitable overwintering habitat (most natural habitats in the North Coast contain blackberry and/or coyote brush). This new measure of "landscape diversity" was then used to reevaluate key measures from the flowering cover crop experiment. The new analysis revealed that vineyards located in areas with greater amounts of natural habitat within one-third of a mile tended to have higher early season populations of *Anagrus* spp., which led to higher early season parasitism rates and subsequently lower late season leafhopper populations.

## Conclusions and Implications

These studies support the conclusion that summer flowering cover crops attracted an abundance and diversity of beneficial insects, but this did not lead to increased rates of biological control of leafhoppers. Instead, the availability of overwintering habitat for *Anagrus* parasitoids close to vineyards was the critical factor.

What were those beneficial insects doing on the flowers then? It may be that they were simply acquiring nectar and/or pollen and then feeding on some other, non-leafhopper species of insect. Alternately, beneficial insect populations attracted to the flowering cover crops may have simply not been sufficient to adequately reduce leafhopper abundance.

Given these findings, growers interested in the use of on-farm habitat plantings to enhance biological control of leafhoppers would be advised to focus on conserving native plant habitat or establishing more blackberry and coyote brush in particular. These are the key plants that support the alternate leafhopper host species utilized by *Anagrus* parasitoids in the winter, and vineyard proximity to these *Anagrus* overwintering habitats allows the parasitoids to colonize the vineyard and start attacking Western grape leafhopper earlier in the growing season.

Habitat diversification can certainly play a role in any integrated pest management program, but the selection, arrangement and scale of plantings must address the specific needs and limiting factors of the organisms being targeted by such interventions. Additionally, ecological and economic tradeoffs must be carefully weighed when considering on-farm habitat plantings.

For all of the benefits mentioned above that these plantings may bring, they can also interfere with frost protection, harbor field mice, compete for soil nutrients and moisture and even support secondary pests, like mites and thrips. Ultimately, the decision on how, when and where to include habitat diversity in the vineyard will depend on the specific needs and objectives of the grower and the perceived benefits.

For example, in this study flowering cover crops were found to support wild bee populations, which may be of interest to growers concerned about biodiversity conservation, regardless of impacts on biological control. Alternately, growers concerned about Pierce's disease may be actively removing blackberry from their vineyard since this plant can harbor vectors of *Xylella fastidiosa*, such as blue-green sharpshooter (*Graphocephala atropunctata*). In this situation coyote brush could still provide *Anagrus* overwintering habitat while the use of blackberry remains confined to areas where Pierce's disease is not a major threat or concern.

While this study demonstrated that summer flowering cover crops do not enhance biological control of leafhoppers, vineyard cover crops are still highly recommended for soil quality maintenance. Winter-spring cover crops typically consist of blends of legumes and grasses (e.g., bell beans, clover, vetch, barley, oats and fescue), which can help control erosion, improve water penetration, reduce compaction and restore soil fertility.

Spring-summer cover crops usually consist of low-growing legumes (strawberry clover and white clover) and grasses (sheep fescue and perennial ryegrass), which can help control dust, reduce nutrient run-off and moderate overly vigorous vines. This last point can have implications for leafhopper control, as previous studies have demonstrated that leafhoppers prefer overly vigorous vines, although moderation of vine vigor can be achieved much more economically by adjusting irrigation regimes, soil amendments and pruning practices.

Clearly there is not a "one size fits all" approach when it comes to the use of habitat diversification in vineyards, but in some instances it can be an effective way to enhance vineyard aesthetics, promote biodiversity conservation and/or improve crop production. **WBM**

**Additional Resources on Vineyard Cover Crops and Hedgerows:**


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.

McGourty, G., J. Nosera, S. Tylicki and S. Toth. 2008 "Self-reseeding annual legumes evaluated as cover crops for untilled vineyards" *California Agriculture* 62(4): 191-194 *https://doi.org/10.3733/ca.v062n04p191*.

UC Cooperative Extension Hedgerow Resource Listing: *http://ccpestmanagement.ucanr.edu/Hedgerows/*.

Long, R.F. and J.H. Anderson. 2010 "Establishing Hedgerows on Farms in California" University of California Division of Agriculture and Natural Resources, Publication 8390, Oakland, CA.

Earnshaw, S. 2004 "Hedgerows and Farmscaping for California Agriculture: A Resource Guide for Farmers" 2nd Edition. CAFF (Community Alliance with Family Farmers) *http://www.caff.org/*.

Dufour, R. 2000 "Farmscaping to Enhance Biological Control" ATTRA (Appropriate Technology Transfer for Rural Areas), National Center for Appropriate Technology, Fayetteville, AR. *http://www.attra.ncat.org/attra-pub/farmscape.html*.