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INTEGRATING COVER CROPS INTO GRAPEVINE PEST AND NUTRITION MANAGEMENT: THE TRANSITION PHASE

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Introduction

Cover crops are being studied because they may have substantial effects on several components of agroecosystems. In various locations cover crops have been used to enhance the natural control of arthropod pests, to suppress weeds, and as an alternative to synthetic nitrogen fertilizer. These uses of cover crops are usually examined independently, but there is reason to consider the interactions among them as well. In fact, cover crops can impact agroecosystems through a number of pathways, both direct and indirect (figure 1). If, for example, cover crops affect the nutritional quality (and water status) of crop plants, then we should expect these effects to also impact the performance of herbivores feeding on the crop plant, since plant nutrient and water status can significantly affect population dynamics of herbivores (Slansky and Rodriguez 1987, Dale 1988). Moreover, these indirect effects may increase incrementally through time, as the cover crop system undergoes a transition phase. A long- term, comprehensive assessment of the role of cover crops in crop production is necessary if we are to understand and successfully utilize them for arthropod, weed, and crop-nutrition management.

The research reported in this article assessed the value of cover crops in vineyard pest and nutrition management. Four experiments helped us determine the effect of various vineyard floor management systems on: 1) two species of leafhoppers, the variegated grape leafhopper (*Erythroneura variabilis* Beamer), and the western grape leafhopper (*Erythroneura elegantula* Osborn), which are major pests of grapevines in the San Joaquin Valley (Flaherty et al. 1992); 2) weed suppression and the need for soil-applied herbicides; 3) vine-nutrient status and the need for synthetic nitrogen fertilizer; and 4) vine growth, and grape yield and quality. We also developed a partial budget for each system.

Experimental Design and Cultural Methods

Fowler and Earlimart sites. Two experiments were initiated in 1992 comparing three vineyard floor management systems: 1) a 'conventional' clean-cultivated system with chemical weed suppression in row berms, 2) a fall-planted, oat-vetch cover crop mix which was mowed and placed on row berms for weed suppression without the use of soil-applied herbicides, and 3) a fall-planted, oat-vetch cover that was mowed and placed in row middles, with complete chemical weed control in row berms. These systems were compared at two locations: a 60-acre 'Thompson Seedless' vineyard located about eight miles west of Fowler (Fresno County), and a 33-acre 'Thompson Seedless' vineyard located about ten miles east of Earlimart (Tulare County). In both cover crop systems, the cover was mowed twice and then allowed to re-seed before soil incorporation, which typically occurred in early July at the Fowler site, and October at the Earlimart site. All systems were clean-cultivated for the remainder of the season at the Fowler site (a raisin grape vineyard), while a

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ground cover was maintained during the summer by periodic mowing of resident vegetation in all plots at the Earlimart site (a table grape vineyard).

Insecticide and miticide use differed between the Fowler and Earlimart sites. At the Fowler site, a low rate of Omite (two pounds per acre) was applied on 14 June, 1993 to control an outbreak of Pacific spider mite (*Tetranychus pacificus* McGregor). No other miticides or insecticides were applied for leafhopper and mite control at any other time during the experiment. At the Earlimart site, Pyrenone was applied in late May 1992 and 1993, and Lannate was applied in mid-August 1993, despite low numbers of leafhoppers. In 1994, the vineyard operator withheld insecticide applications for leafhopper control. Miticides were not used at any time during the experiments at the Earlimart site, where spider mites generally occurred in low densities.

Soil amendments also differed between the two sites. All plots at the Earlimart site received a yearly application of four tons per acre of steer manure in the fall, and two tons per acre of gypsum in June. At the Fowler site, all plots received 75 pounds of nitrogen per acre in June 1992, and four tons per acre of steer manure in October 1992. During the 1993 season, we added fertilized and unfertilized subplots to each treatment. Fertilized subplots received 75 pounds nitrogen per acre in June, and unfertilized plots did not receive any nitrogen fertilizer. The same design was maintained during the 1994 season, but nitrogen fertilizer was not added as vine nitrogen levels were adequate in all treatments.

Kearney and Madera sites. In 1993 we initiated two additional experiments using a Merced rye and vetch cover crop mix: one in a two-acre 'Thompson Seedless' vineyard located at the University of California Kearney Agricultural Center (Parlier, Calif.), and the other in a 53-acre commercial 'Thompson Seedless' vineyard located near Madera, Calif. The Kearney experiment compared a clean-cultivated system with a system that used the cover crop as dry mulch for partial weed suppression on row berms. The Madera experiment compared a clean-cultivated system with two cover crop systems: one in which the cover was mowed and incorporated as green manure in early April, and another in which the cover crop was mowed once (also in early April) and then allowed to reseed before incorporation in early July.

Insecticides and miticides were not used for leafhopper or mite control in the Kearney and Madera sites. Fertilizer was not added at the Kearney site, since the irrigation water at the UC Kearney Agricultural Center normally supplies vines with approximately 20 pounds of nitrogen per acre. All plots in the Madera vineyard received 20 pounds of nitrogen per acre in June 1993, but fertilizer was not added in 1994.

Sampling

We used several sampling methods (direct observations, sticky traps, D-Vac, sweep net, pitfall traps and vine shakes) to estimate the abundance of leafhoppers and their natural enemies (spiders and other generalist predators, and egg parasitoids) on vines and on the cover crops. In general, sampling of cover crops was conducted from March until plow down, while grape vines were sampled from May through September or mid-October. Controlled shoot-cage experiments were also conducted in 1993 at the Madera site, and in 1994 at the Fowler, Kearney, and Madera sites. The purpose of these cage experiments was to determine the impact of each treatment on leafhopper reproduction and survivorship in the absence of the actions of their natural enemies. We also conducted trace-element marking experiments in the Madera vineyard during the 1993 and 1994 seasons, to further determine the impact of cover crops on leafhoppers and spiders.

The effect of berm mulching with cover crop biomass on weed suppression was assessed at the Earlimart, Fowler and Kearney vineyards. Prior to each mowing and in the middle of summer, we determined weed species frequency, percent cover and total biomass on berms, and percent of berm area covered with mulch residues. Weed suppression was evaluated at each time by identifying and counting plant species using four 100-foot transects, and counting plants at each foot.

We used leaf petioles to determine vine nitrogen, phosphorus, and potassium status at two stages of vine growth: full bloom and beginning of berry ripening (veraison). At harvest, we estimated berry size and sugar content (all vineyards), pH and titratable acidity (Earlimart vineyard), and raisin yield and quality (Fowler, Kearney and Madera vineyards).

Results and Discussion

Leafhoppers. Our findings to date indicate that, if properly managed, winter legume/grass cover crops can reduce leafhopper abundance. Where leafhopper numbers were not very low and cover crops were properly maintained through early July, reduced infestations of leafhoppers were observed in the presence of cover crops. These reductions may be attributed in part to enhanced activity of certain groups of spiders, which are consistently found at higher densities in the presence of cover crops compared to the clean-cultivated systems. Trace-element marking of cover crops indicated that cover crops may also influence leafhopper populations by serving as non-host vegetation which interferes with their movement patterns and perhaps other aspects of their life history (Hanna et al., unpublished data). Although cover crops may affect vine physiology (through changes in soil fertility, soil-water status, etc.), which may in turn affect leafhopper biology, the changes we have observed in vine conditions to date were not sufficient to explain the differences in leafhopper abundance observed between the cover crop and clean-cultivated treatments. Cage data indicated that leafhopper reproduction and survivorship in the absence of predation were not affected by cover crop treatment.

Vine Nutrition. The effect of cover crops on vine-nutrient status varied between years and vineyards. Cover crops produced positive effects on vine nutrient status by the second or third year if the cover crops were well-managed, but produced negative effects if the cover or vineyard was poorly managed. The positive effects were usually delayed, and were best illustrated by the results from our Fowler site where by the third year, nitrogen levels (nitrate-N in petioles) in unfertilized cover cropped vines were similar to nitrogen levels in fertilized clean-cultivated vines, independent of the type of weed management in row berms. Potassium levels were also enhanced by cover crops by the third year at the Fowler site. We have not observed these effects in the Earlimart vineyard where the cover crop was not incorporated until fall, while weeds were allowed to grow in row middles during the summer. Under this system of ground cover management, much of the nutrient content of the cover is apparently either lost by volatilization, or used to grow the resident vegetation during the summer. At the Kearney and Madera sites (second year), although we have not detected statistically significant changes in vine-nutrient status in the cover crop treatments compared to clean-cultivated treatments, we have observed non-significant trends toward higher levels of nitrogen and potassium in vines associated with cover crops compared to clean-cultivated vines. Based on results from the Fowler site, we expect to see higher levels of nitrogen and potassium in cover crop treatments at the Kearney and Madera sites during the third and later years, since the impact of cover crops on vine nutrient status is often delayed and may not be statistically significant during the transition phase.

Weeds. The amount of dry biomass produced by cover crops for weed suppression varied between vineyards. During late winter and early spring, the mulched berms received 1,800 to 8,726 pounds of dry biomass per acre, with a total nitrogen content of 33 to 109 pounds per acre. Results to date from the San Joaquin Valley sites and from a north coast study indicate that with sufficient levels of biomass production, berm mulching should reduce the use of pre-emergence herbicides. The mulch, however, will not control all weeds equally. Perennial weeds such as field bindweed were not controlled.

Yield. The effects of cover crops on grape yield and operating costs depended on grape culture, and represented a trade-off in water, fertilizer, pesticide and resource use. Although significant differences in yields have not been realized in the Earlimart (third year) and Madera (second year) vineyards, berry weight and raisin yields were significantly higher by the second year at the Kearney site where cover crop biomass was used as dry mulch for weed suppression in row berms. Berry weight was also significantly greater by the third year in cover crop compared to clean-cultivated treatments at the Fowler site. Greater berry weights should have translated into greater raisin weights, but this effect could not be measured as the raisins at the Fowler site were badly damaged by early fall rain. The partial cost budget indicated that the use of cover crops (despite greater water demand) may significantly reduce operating costs if savings were realized by reducing chemical inputs for insects and mites. These savings are expected to increase if cultural methods (e.g., raised beds with adjacent furrows for irrigation are used instead of flood irrigation) are modified to maintain satisfactory cover crop growth while reducing water use.

Conclusions

Despite these encouraging results, some critical questions remain to be addressed in order to assess the long term impact of cover crops on several elements of grape production. At present we do not know what impact these cover crop systems will ultimately have on several aspects of soil fertility and water use in vineyards. For example, we do not know if the increased yields at the Kearney and Fowler sites were due to the greater amount of water used to grow the cover crop. In this case, water usage should be controlled as an experimental variable so we can understand why higher yields were obtained in the presence of cover crops.

Studies of more than three-year duration are needed to adequately determine the complex relationships between cover crops, arthropod pests, and weeds, and to evaluate their impact on soil fertility, vine nutrition, and vineyard water use. Our hypothesis is that benefits of cover crops to grapevines will increase incrementally through time, and can be measured. We are continuing our research in the Fowler, Kearney, and Madera sites, and have initiated a similar study in Napa. We are expanding our multidisciplinary expertise to include a soil scientist (Dr. R. Miller) and a grape physiologist (Dr. L. Williams).

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