Progress toward reduced-risk pest management

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Concerns about pesticides in the environment and their potential effects on human health have fueled increased regulation of their use in agriculture. The Food Quality Protection Act (FQPA) of 1996 is one such regulation. This act fundamentally changed how the U.S. Environmental Protection Agency (EPA) regulates pesticides.

Previously, pesticide tolerances were based on the toxicity of each individual pesticide considered in isolation. With the enactment of the FQPA, tolerances are determined not by individual pesticide toxicity, but by calculating cumulative toxicities of pesticide residues (along with other contaminants) in foods. As a result of this new legislation, many pesticides are being re-examined, with the possibility they might be restricted or removed from use in agriculture.

Fortunately, winegrape growers have already demonstrated their ability to adapt to a changing regulatory arena. As the FQPA enters its eighth year, this report will examine its dramatic impact on pesticide use. We will also review the latest trends in reduced-risk pest management in California winegrapes.[1]

Winegrape growing counties analyzed in this study include Madera in the southern San Joaquin Valley, and Napa and Sonoma counties in the North Coast region. Pesticide use trends (particularly FQPA pesticide use; see below) within each county are examined for the years 1993 to 2001. County averages of pesticide use are baselines to compare variation within counties.

In this study, FQPA pesticides refer to EPA-designated priority I and priority II pesticides, whose active ingredients have higher toxicities and are most at risk for restriction or elimination under FQPA. Many priority III FQPA pesticides are classified as reduced risk or biopesticides and therefore are considered separately. There are approximately 86 priority I and II FQPA pesticides and 47 priority III FQPA pesticides that are used on winegrapes and are under review.

Pesticide Use Reports (PUR) are the main data source for this report. PUR data contain records of pesticide use for every commodity, grower, and pesticide application going back to the early 1990s. In the PUR data, every grower or operator is assigned a unique identification number that is associated with each reported application. These data are submitted monthly to local agricultural commissioners, who then report the data to the Department of Pesticide Regulation.[4]

A productive use of PUR data is to identify conventional growers who apply fewer pesticides than average, particularly pesticides being reviewed under the FQPA. The cultural and biological practices of these low-use growers can then be investigated to provide information on regionally specific, reduced-risk pest management strategies. The success of these grower pest management models can then be shared with other growers in the region to promote alternatives to some of the most toxic pesticides.

Measures of pounds of active ingredient (AI) are used in this analysis. To facilitate trend analysis, AIs are grouped into four pesticide classes: fumigants, fungicides, herbicides, and insecticides (the latter includes miticides unless otherwise noted). While grouping allows data summation and interpretation, it should be noted that this is an aggregation of pesticides that vary in recommended label rates. Use intensity refers to pounds of chemical per acre planted. Pounds of chemical per acre treated refers to the use or label rate.

Pesticide use trends

From 1993 to 2001, total pounds of pesticide applied on winegrapes decreased by 33% in Madera County, 46% in Napa County, and 41% in Sonoma County. During the same period, winegrape acreage increased by 22%, 9%, and 48%, in the three counties, respectively

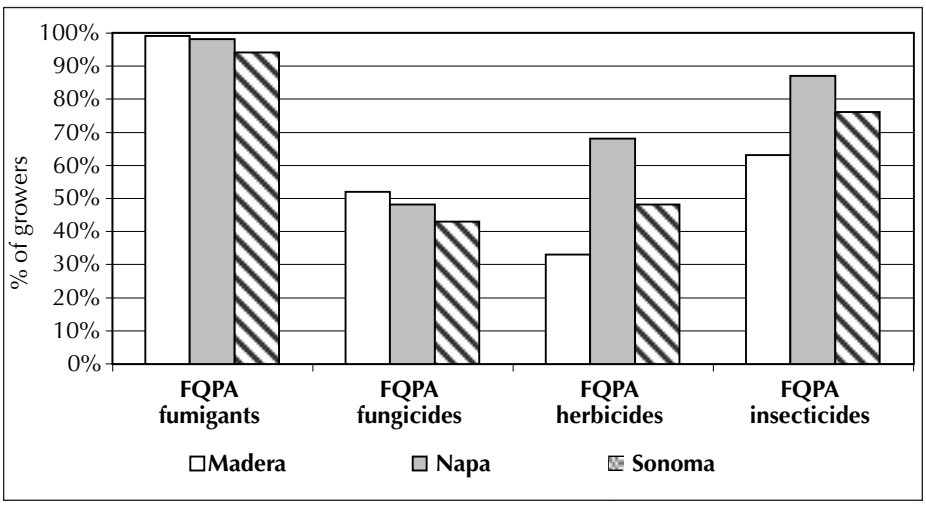

Figure I. Percentage of growers in Madera, Napa, and Sonoma counties that did not use FQPA fumigants, fungicides, herbicides, and insecticides in the year 2000.

Table I. Winegrape acres planted and percent change of acres planted from 1993 and 2001 in Madera, Napa, and Sonoma counties

	acres planted 1993	acres planted 2001	percent change 1993–2001
Madera	48,357	58,828	22%
Napa	44,308	48,487	9%
Sonoma	40,778	60,179	48%

(see Table I). Consequently, reductions in use intensity were more signficant, decreasing by 45%, 51%, and 53%, respectively. A significant decline in sulfur use over the years contributes to this overall decline.

In analyzing use by pesticide category among winegrape growers from 1993 to 2000, greater reductions in FQPA fumigant and insecticide use were observed than for FQPA fungicide and herbicide use. Sulfur is not under FQPA review and is therefore not included in the totals for FPQA fungicides.

Results from the year 2000 show that in all three counties, only 6% of growers used FQPA fumigants (Figure I). Similarly, only 37%, 23%, and 24% of growers in Madera, Napa, and Sonoma counties used FQPA insecticides in 2000.

In contrast, reliance on FQPA herbicides and fungicides was more widespread among growers in all three counties for the year 2000. This result indicates a need for more effective reduced-risk herbicide and fungicide options and/or increased extension and education about reduced-risk practices.

FQPA fungicides were used by 48%, 52%, and 57% of growers in Madera, Napa, and Sonoma counties, while 67%, 32%, and 52% of growers used FQPA herbicides in 2000. FQPA herbicides, such as oxyfluorfen (Goal®) and simazine (Princep®), and FQPA fungicides, such as mancozeb (Dithane®) and myclobutanil (Rally®), remain popular options among winegrape growers.

Reduced-risk pesticide use trends

The EPA classifies a pesticide as "reduced-risk" if it has a low impact on human health, low toxicity to non-target organisms (birds, fish, and plants), low potential for groundwater contamination, lower use rate than conventional pesticides, low pest-resistance potential, and compatibility with integrated pest management (IPM).[6] Given the evidence that use of FQPA fungicides and herbicides is still important for many winegrape growers, a review of the reduced-risk pesticide alternatives is warranted.

Reduced-risk fungicide use has increased among growers in the counties studied. The EPA classified, reduced-risk fungicides used in winegrapes include: azoxystrobin (Abound®), cyprodinil (Vanguard®), fenhexamid (Teldor®), potassium bicarbonate, QST 713 strain of *Bacillus subtilis* (Serenade®), and trifloxystrobin (Flint®, Stratego®).

Azoxystrobin first appeared in the PUR database in all three counties in 1997. By the year 2000, 8%, 10%, and 15% of growers in Madera, Napa, and Sonoma counties, respectively, reported using it.

Potassium bicarbonate first appeared in the PUR in 1998. Its use as a reduced-risk fungicide for powdery mildew (*Uncinula necator*) has risen sharply in Napa and Sonoma counties, while its use in Madera has steadily decreased since 1998. Napa and Sonoma counties observed 417% and 472% increases in potassium bicarbonate use from 1998 to 2001, while use in Madera County decreased by 88% over the same time period.

Decreased use in Madera County could be due to the fact that sulfur is very effective in the southern San Joaquin Valley compared to the more humid North Coast region. Potassium bicarbonate has activity against existing infections only and has little residual activity against new mildew infections.

The OST 713 strain of dried *Bacillus subtilis* (Serenade®) mixed with horticultural oil has been used successfully in Sonoma County to combat powdery mildew. Success with this mixture offers an alternative to FQPA fungicide applications and allows reduced sulfur applications.

Glyphosate (Roundup®) is currently the only EPA-categorized reduced-risk herbicide. In the year 2000, this post-emergence herbicide was applied to 71%, 75%, and 84% of acres in Madera, Napa, and Sonoma counties. While its use remains popular among winegrape growers, pre-emergence herbicides are also widely used.

Current efforts to reduce herbicide use are focused on reducing the amount used and/or narrowing the treated area under vines. In Napa and Sonoma counties, respective 21% and 10% reductions in FQPA herbicide use intensity were observed from 1993 through 2000.

In Madera County, however, a 3% increase was observed for the same period. Economics is key to understanding the adoption or non-adoption of reduced-risk pesticides. Depending on growers' profit margins, it may not be feasible to use reduced-risk herbicides because of increased cost associated with repeated post-emergence herbicide applications. The allure of pre-emergence herbicide is that only one spray is needed pre-season, reducing overall labor and fuel costs.

Pesticide use variation

Although widespread pesticide use reduction has been documented (particularly for FQPA pesticides), there is still significant variability among growers

Table II. Average FQPA pounds per acre planted from 1993 through 2001, % of growers using very low rates of FQPA pesticides, % of growers using very high rates of FQPA pesticides, and percent change of growers using very low and very high rates of FQPA pesticides from 1993 to 2001

County	Average FQPA pesticide use in lbs/acre planted (1993–2001)	% of growers using very low rates of FQPA pesticides*			% of growers using very high rates of FQPA pesticides**		
		1993	2001	% change	1993	2001	% change
Madera	2.56	44	58	32	26	3	–90
Napa	1.46	74	93	21	9	<1	–80
Sonoma	8.8	57	8	–58***	10	2	–80

*very low equals 0-25% of county average lbs/acre planted of FQPA pesticide use
**very high equals over 100% of county average lbs/acre planted of FQPA pesticide use
***Sonoma County numbers skewed by methyl bromide use before 1999.

for use intensity and rate. Some growers apply little pesticide, implementing such practices as increased mechanical tillage for weed control, use of electrostatic sprayers and other equipment to limit application rates, or reliance on biological or other cultural practices.

Innovations of low-use and low-risk winegrape growing should continue to be shared among local growers, as case studies and/or personal experiences of successful pest management practices provide relevant information for growers in similar ecological conditions.

An analysis of FQPA pesticide use from 1993 to 2001 found that overall, the number of growers using very low rates (0 to 25% of county average) of FQPA pesticides increased over the years, while the number of growers using very high rates (more than 100% of county average) decreased (Table II).

The results for Sonoma County are skewed by a high average resulting from high rates of methyl bromide use prior to 1999. Methyl bromide is typically applied when new fields are planted, however efforts to reduce methyl bromide use in Sonoma County resulted in a 93% decrease in use from 1999 to 2001, with an 8% increase in winegrape acres planted in the same period, indicating that alternatives to methyl bromide were used.

Growers who are above the county average in use intensities represent a target population for continued education and extension programs that promote alternatives to FQPA and other higher risk pesticides.

Why have reductions occurred?

The trends in winegrape pesticide use in Madera, Napa, and Sonoma counties demonstrate decreased dependence on pesticides under FQPA review. Interpreting the data and understanding the factors that contribute to pesticide use reduction are essential for effective promotion of reduced-risk farming practices.

Factors that may have affected pesticide-use trends in California winegrapes over the last decade include regulatory pressure, grower innovation, grower and community concerns about human health and environmental effects, economics, and winery and consumer influences, among others.

Regulatory pressure clearly can have an effect on pesticide use, particularly regulation like the FQPA, which has the potential to remove or restrict pesticides from agricultural use. Such regulation prompts growers to innovate and experiment with alternative products or practices in anticipation of loss of pesticide options.

Concerns among growers and the general population over the health and safety aspects of pesticides contribute to reduced use. Growers seek to reduce the use of those pesticides with undesirable environmental or safety profiles. Vineyard neighbors increasingly voice complaints about pesticide drift and odors from sprays and sulfur dust.

Winegrape organizations have been major players in providing grower education about reduced-risk pest management. Examples of local demonstration and outreach programs include: California Association of Winegrape Growers Pest Management Alliance, Lodi-Woodbridge Winegrape Commission, Central Coast Vineyard Team, Napa Sustainable Winegrowers Group; and Sonoma County Grape Growers Association. These programs incorporate direct involvement with growers, emphasizing farmer-to-farmer information exchange.

Grower innovation

Models of collaborative research and education have become widely recognized for their ability to utilize practical experience of growers in improving farming practices. Growers are intimately familiar with their farming systems and are able to assess factors affecting production to respond to complex, dynamic, and unpredictable conditions.[3]

Agro-ecological understanding obtained from real experience over time allows growers to develop approaches suited to their particular climatic, soil, and pest situations. Their accomplishments are the result of practical experimentation.[5] Those who learn to decrease reliance on chemicals do so through knowledge of local ecological processes.[1]

Winegrape commodity groups, such as those mentioned above, have applied these principles to promote reduced-risk pest management in winegrapes. The effect of these programs in pesticide-use reduction and innovation should not be underestimated.

Napa County innovation

Jason Kesner, vineyard manager at Hudson Vineyards in the Carneros region of Napa County, is a member of the Napa Sustainable Winegrowers Group. He is implementing a plan to farm in a more sustainable fashion, specifically by transitioning away from pre-emergence herbicides to a more integrated approach to manage weeds. The 185 acres of vines, 163 of which are bearing, are planted to Chardonnay, Syrah, Merlot, Cabernet Franc, and Pinot Noir.

Kesner is replacing pre-emergent herbicides at Hudson Vineyard with a combination of mechanical weed control and glyphosate application, depending on the individual block and field conditions. Cover crops are seeded to reduce the area requiring weed control, and bandwidths of herbicide applications have been reduced.

However, cover crops can attract gophers and other rodents. In response, Kesner has had owl boxes installed to provide an effective predator for rodents, and trapping has replaced baiting.

Kesner's approach to vineyard pest management is flexible, relying on multiple approaches throughout the vineyard. Much depends on the lessons learned each year, such as which blocks are amenable to mechanical weed control, and a constantly evolving knowledge of individual blocks and field conditions, such as soil type, water-holding capacity, and pest pressure relative to specific grape variety.

A Clemens weed blade and hoe plow are used for mechanical weed control. The crew had problems in the past with inadvertent vine removal in older trellising and in blocks with tight vine spacing.

Kesner's observations of variable weed and pest pressures throughout the vineyard have resulted in a customized and flexible vineyard management approach. In blocks with low weed pressure, he often is successful with one application of glyphosate per year in the late winter or early spring, or only mechanical weed removal. In other fields with more weed pressure or in years with late rains, he applies two sprays, or he uses a combination of mechanical weed control and glyphosate application.

The insecticide program at Hudson Vineyard has relied on imidacloprid

because of its selective pest toxicity. Applications of Provado (imidacloprid) at ½- to ¾-ounce per acre were foliar-applied early in 2003 in blocks with high thrip populations. This decision was based both on thrip counts, and the fact that a cold wet spring would compound the potential damage inflicted by the high populations. In years with rapid bud break and early shoot growth, those applications probably would not have been made.

The approach to leafhopper management has been one of increased tolerance. The blocks of Merlot and Syrah that mature later are affected by additional leafhopper lifecycles and increased leafhopper populations. In these blocks, Kesner has been successful with a late-season (September) imidacloprid application. No application was required in other fields with earlier harvest.

Kesner's decision on whether to spray for leafhoppers late in the season also depends on whether populations are so high that they would cause significant irritation to workers at harvest. (He often determines this simply by walking through the vineyard and shaking the vines to see if there are, in fact, enough to bother the pickers.) A harvest coinciding with high leafhopper populations can result in leafhoppers getting into the eyes and even the air passages of workers.

"Due to potential resistance issues, we don't want to ultimately rely solely on imidacloprid," explains Kesner. "We are exploring other options, such as timing of mowing of cover crops for thrips, dialing in vine vigor for leafhoppers, and working to sustain beneficial predator populations for both."

Reflecting on pest management at Hudson Vineyards, he continues: "We began our effort to reduce pesticide use in 2000 and 2001. In 2000, 100% of our blocks were strip-sprayed with pre-emergent herbicide. In 2001, it was 98%, 2002, 49%, and in 2003, only 8%. Our goal for 2004 is 0%, though new plantings remain a challenge. We try to avoid shovel work, and new plantings can pose a problem.

"The transition has been a continual learning process. For example, 2003 was not the best year to rely so heavily on mechanical weed control, given all of the late spring rains. It seemed as if we were growing weeds until August. I also think that, as the previous years of pre-emergent applications wear off, we will see and are seeing changes in the types and amounts of weeds we do have, and so new challenges will emerge.

"I don't plan on resting on glyphosate for the ultimate answer, and will continue to experiment and attempt to find better approaches to our overall goal of sustainability. We will, in all likelihood, be looking in the direction of mulching as one of those approaches.

"It has not been an easy transition, but it is simply the way we need to manage the vineyard in the future, and we will ultimately find the best and hopefully most sustainable way to do that via continued trial and error. While these efforts have increased our costs, they have also increased our confidence that we are doing better for the environment and our workers."

Madera County innovations

Jon Holmquist, agronomist and area manager for the Canandaigua Wine Co., has been a vocal leader and participant in CAWG's Pest Management Alliance (PMA) and Sustainable Winegrowing Project. He has hosted field days at Canandaigua's Paul Masson Vineyard near the town of Madera, where he has demonstrated and discussed approaches for managing weeds, other pests, and sulfur.

Canandaigua has 425 participating acres managed by Holmquist in the PMA project. For weeds, a Donnovator in-row cultivator is supplemented with conservative use of post-emergence herbicides (such as Roundup® at one quart per acre). The use of cover crops and drip irrigation allows tillage in the participating vineyards to be kept to a minimum, reducing the high cost associated with tractor operation.

An entomologist by training, education, and vocation for 15 years, Holmquist understands that reduced mechanical tillage will reduce dust in the vineyard, which could exacerbate mite problems. Field monitoring and trapping (carefully monitoring activities of growth and development of pest organisms or other factors on a regular basis; with use of colored sticky traps or other types of traps used to facilitate monitoring) are conducted so that miticides are used only when it is documented that an economic threshold (pest density at which controls must be applied to avert economic loss) is reached.[7] Trapping is for lepidopterous insects, primarily omnivorous leafrollers, not mites. Trapping gives Holmquist a biofix for spray timing.

Holmquist promotes the use of cover crops primarily to improve soil health and tilth, which tends to improve vine health. His cover crop mix includes barley, bean, vetch, and pea with exact proportions, depending on goals for vine vigor.

Owl and bat boxes are placed in the vineyard to enhance predation of vertebrate pests and omnivorous leafrollers (OLR). Holmquist has observed gopher bones in owl pellets under owl boxes. Further, he hopes that an increase in the number of bats will suppress OLR populations, (insectivorous bats and OLR are both night fliers).

Holmquist stresses that reduced-risk practices must be economically viable, particularly in Madera County, where profit margins are low compared to the North Coast. In 2002, Chardonnay grapes from Napa County sold for an average of $2,316 per ton. The same variety from the Madera area sold for $201 per ton, according to the 2002 California Agricultural Statistics Service Grape Crush Report.

Dan McCarty, independent winegrape pest control advisor (PCA) in Madera County, suggests the best thing a grower can do to reduce pesticide use is to plant cover crops in vineyards. He urges growers to plant and maintain cover crops throughout the growing season to promote insectaries of beneficial insects, such as spiders, lacewings, and parasitoids.

McCarty contends that if a cover crop can be maintained throughout the growing season in Madera County, some growers may not need to spray for leafhoppers or mites, and he sometimes sees an effect on omnivorous leaf roller (OLR) and grape leaf skeletonizer (GLS) populations.

To augment natural populations of beneficial arthropods, many growers release lacewing eggs into the cover crop for increased leafhopper control. This is typically at the end of February, but is timed with observations of aphid populations that will help sustain beneficial lacewings.

Table III. FQPA pesticides targeted for reduction in Sonoma County

Insecticides
Dimethoate
Diazinon
Fenamiphos (Nemacur®)
Carbaryl (Sevin®)
Fungicides
Mancozeb (Dithane®)
Iprodione (Rovral®)
Miticide
Propargite (Omite®)
Herbicides
Simazine (Princep®)
Oxyflurofen (Goal®)

The biggest challenge is for growers to maintain cover crops in a drip-irrigated vineyard. A drip line can be installed in the middle of the tractor row where cover crops are planted. Growers can seed cover crop every row, alternating rows, or even every 10th or 20th row. This adds an expense, but McCarty believes the benefits outweigh the costs for Madera growers.

The typical cover crop program in Madera is a six-foot wide band of field pea, vetch, bell bean, and barley in a 12-foot wide tractor row. McCarty says that some growers he works with let the vetch go to seed. Vetch reseeds well, so some growers will go four to five years without reseeding, reducing costs. Many fields are still flood-irrigated in Madera, making season-long cover cropping easy.

However, McCarty recognizes that one potential drawback of cover cropping is that vineyard temperatures can be lower in cover-cropped vineyards compared with non-cover-cropped vineyards, an important distinction if there is a threat of frost damage. At the first sign of an upcoming frost, growers should mow the cover crop and start sprinkler irrigation to increase the temperature and minimize or avoid frost damage.

McCarty confesses that some areas of Madera County have inherently low pest pressure. For instance, some areas around natural waterways support native berries, which serve as insectaries for the parasitic wasp, *Anagrus epos*, an egg parasite of grape leafhopper. Some growers have encouraged these natural enemies by planting blackberries and French prune trees, another *Anagrus* host.

Sonoma County innovations

The Sonoma County Grape Growers Association (SCGGA) began an integrated pest management (IPM) program in 2000 to provide a network for growers to exchange information on IPM and pest control practices.[2]

Four demonstration vineyards were established, one each in the Russian River Valley, Dry Creek Valley, Alexander Valley, and Sonoma Valley. Participating vineyard managers were committed to IPM and environmentally sound farming practices. A pest control advisor (PCA) monitored the four demonstration vineyards weekly from bud break through veraison, and all pest and predator counts or ratings were entered into a database.

Monthly grower meetings were held in each vineyard from April through July. Pest and predator populations were reviewed, and the PCA and vineyard manager discussed pest management decisions. Alternatives to pesticides listed under Proposition 65 and, beginning in 2001, under FQPA review, were discussed.

Grower participation increased from 60 in year-2000 to nearly 100 growers who attended the monthly meetings in 2002 and 2003. Peer education proved effective as growers shared real vineyard experiences with reduced-risk pesticides and alternatives to nine commonly used pesticides under FQPA review (see Table III).

Managers for each of the demonstration vineyards continue to actively seek pest control strategies that are reduced-risk, effective, and support IPM-program goals.

Joe Votek of Loma del Sol Vineyard Management manages a 7.6-acre Sonoma Valley hillside vineyard planted to Merlot on a VSP trellis. To control early season fungal diseases at budbreak, including powdery mildew, Votek applies one to two lbs of dry, flowable sulfur tank-mixed with 0.5 to one pint of Champ® per acre.

"If we have a warm and dry spring, one application would be adequate," explains Votek. "However it is much more likely that we make two applications. In a cold, wet spring, a third application may be required." This was followed by two applications of 1% horticultural oil in 50 gallons of water per acre (JMS Stylet Oil®), to suppress mite — and perhaps grape leafhopper — populations, and for powdery mildew control.

Sulfur dust, beginning at 10 lbs and later increasing to 14 lbs per acre, was applied by Votek for powdery mildew control through the remainder of the season. The Risk Assessment Index model (Gubler 1999) is used to monitor powdery mildew pressure and to adjust application intervals ranging from seven to 15 days.

In 2003, there was high powdery mildew pressure, so Votek shortened dusting intervals. Treatments were effective in controlling powdery mildew in the demonstration vineyard.

Votek suggests that one note of caution is needed when applying horticultural oil for powdery mildew. Multiple applications of horticultural oil alone may not provide adequate control. He has also successfully used Serenade® in combination with horticultural oil in vineyards with a powdery mildew-susceptible variety or a history of powdery mildew hot spots.

Dennis Devitt, winegrowing manager for E&J Gallo Sonoma Laguna Ranch in the Russian River Valley, oversees a 7.6-acre block of Pinot Noir on a modified Geneva Double Curtain trellis within a 108-acre vineyard.

Gallo has used an electrostatic sprayer for pesticide applications, enabling efficacious pest control with low use rates. This included one application of 1.8% horticultural oil in 40 gallons of water per acre for early season mite suppression and powdery mildew control on blocks with previous early-season mite infestations. This provided effective control in the treated blocks.

About 30% of the Laguna Ranch required one miticide application in 2003, including an application of AGRIMEK® at 0.024 lbs AI per acre to the demonstration block in August. The outbreaks were effectively controlled without treating the entire ranch. Spot-treating only infested areas of the vineyard has proven to be another way for growers to reduce pesticide use.

John Clendenen of Clendenen Vineyard Management (Healdsburg, CA) used a similar strategy for early season mite suppression in a 6.6-acre Dry Creek

demonstration vineyard planted to Merlot on a cordon Scott-Henry trellis. This hillside vineyard has a history of mite problems, and horticultural oil applications for early season mite and powdery mildew control were considered successful in 2002.

However, three applications of horticultural oil (2% and then 1.5% in 50 gallons per acre, followed by 1% in 65 gallons of water per acre) applied in 2003 did not provide season-long mite suppression. These results reinforce the need for pest and predator monitoring so that the efficacy of reduced-risk pesticides is tracked. If pest pressures are not maintained at tolerable levels, additional pesticide applications may be needed to protect the crop.

Keith Horn, vineyard manager at Clos du Bois Vineyards in Alexander Valley (Geyserville, CA), manages an 800-acre ranch on the Russian River. A 19.6-acre demonstration vineyard within the ranch is planted to Chardonnay, on a VSP trellis, and has riparian vegetation on two perimeters.

Pierce's disease, transmitted by blue-green sharpshooters, is present on the north side of the demonstration vineyard. In 2003, Surround®, a kaolin clay product reported to repel insect pests and reduce sunburn in grapes, was applied at the rate of 25 lbs per acre, beginning on May 19. Additional applications were made to a three-acre block within the vineyard on June 12, June 26, and August 7. Weekly monitoring demonstrated that Surround was effective in reducing grape leafhopper, mite, and bluegreen sharpshooter populations in 2003.

Horn thinks that more information is needed to determine what happens to those insect populations. Do they move to other vineyard blocks, driving those populations up? Do they move to the riparian area? Or do they simply not hatch? Other Sonoma County grapegrowers have reported that Surround is also an effective deer repellent.

Conclusions

Trends in pesticide use and pest management practices in California winegrapes and the factors contributing to these changes are complex and changing. Use of pesticides under FQPA review has declined. Winegrape growers have demonstrated innovation in reducing pesticide use by their willingness to experiment with biological and cultural controls and by implementing principles of IPM.

Grower innovation and experimentation with reduced-risk farming practices may be promoted through increased collaborative research and education programs. Winegrape growers and their representative commodity organizations represent a successful model for increasing grower adoption of reduced-risk farming practices.

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