SUMMARY
HOST PLANT RESISTANCE REDUCES FUMIGANT USE: A LESSON FROM GRAPE PHYLLOXERA

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Host plant resistance (HPR) has been an effective pest management tool in many crops, and resistant cultivars continue to be developed. An increased focus on development and deployment of resistant rootstocks is desirable. Resistant rootstocks could reduce the need to replant by increasing the longevity of perennial crops, as well as by providing immediate protection from pests. In tandem with other methods of control, fumigation could be less imperative in short-lived field crops on resistant rootstocks as well.

The first strategic use of HPR was in grapes, beginning in France in the late 1800s after the decimation of vineyards by infestation of grape phylloxera (GP). The discovery that *Vitis vinifera* scions could be grafted to North American *Vitis* spp. rootstocks to produce both quality grapes and effective control of a soil borne insect was revolutionary. Use of resistant rootstocks has continued as the only effective and sustainable method of control for this pest.

An apparent failure of HPR occurred in California in the early 1980s when vineyards planted on the rootstock AxR#1 became infested with GP. This resulted in replanting on a massive scale, especially in Napa County. AxR#1 was widely thought to be resistant to GP, based on long-running field trials in California—although poor performance was reported elsewhere. In retrospect it is clear that as acreage planted to AxR#1 in wine grape vineyards rapidly increased in the 1970s, the rootstock was rapidly attacked by some genotypes of GP. AxR#1 was never a truly GP-resistant rootstock. The impact on fumigant applications and grower costs is an example of what can happen when effective HPR is *not* implemented. With the benefit of the lessons learned from this experience, the replanting that growers engaged in from the late 1980s through the 1990s was more studied in selection of rootstocks and represented a wiser implementation of HPR. Besides greater resistance of rootstocks that were planted, there was greater diversity of rootstocks (up to 5 different rootstocks in a vineyard). This polyculture of rootstocks reduces the probability of pest encounter of any one rootstock.

I present preliminary data to test the hypothesis that highly resistant rootstocks and rootstock diversity have contributed to decreases in fumigant use, focusing on wine grapes in Napa County. I also compare patterns of fumigant use in wine grapes and table grapes statewide and in wine grapes by region. These comparisons are informative because the sandy soils of the Central Valley, where most California table grapes (but also wine grapes) are grown, are unfavorable to

GP. The ‘experiment’ with the susceptible rootstock AxR#1 did not occur there. Nematodes are a more serious problem for grape growers in the Central Valley, and nematode-resistant rootstocks are not as well developed as GP-resistant rootstocks; growers rely more on fumigants for nematode control. We would expect to see a greater reduction in fumigant use in wine grape growing regions where growers can rely on HPR to a greater extent, compared to the Central Valley. As a result fumigant use should be reduced in wine grapes compared to table grapes statewide.

I obtained data on applications of fumigants for grapes from the Pesticide Use Reporting (PUR) Database of the California Department of Pesticide Regulation (DPR). Data on patterns of rootstock use are spotty; some data come from a survey by R. Smith and E. Weber in 1998. I acquired crop data from the National Agricultural Statistics Services (NASS) database, and Napa County-specific data from the Napa county crop reports.

Fumigant applications for planting vineyards have increased when all grape classes are considered (Fig. 1). Applications of fumigants have tended to decrease in wine grapes and increase slightly in table grapes (Fig. 2). Regionally, since 2001 the highest fumigant use in wine grapes has been in the S. San Joaquin and the lowest in the North Coast and N. San Joaquin (Fig. 3). The most dramatic reductions in use of fumigants have occurred in Napa County, where they have played a marginal role since 2003. Fumigants were applied to an annual average of 75 acres since 2003, 1055 acres in 1992-2002, and 846 acres in 1982-1992.

In 1980 the only rootstocks used in Napa County were AxR#1 (poor resistance to GP) and St. George (good resistance to GP). By 1997 AxR#1 was still dominant but 11 other rootstocks with good resistance were in use. The proportion of the total grape acreage that is non-bearing vines in Napa County has decreased from ~20% in 1999 to 4% in 2011, consistent with reductions in replanting and new planting.

The promise and the limitation of HPR:

- The Napa County experience represents a model for how HPR can promote sustainable agriculture and reduce the need for fumigation.
- HPR has not acted alone; increased focus on sustainability, government regulation, and market forces have contributed to reductions in fumigant use.
- HPR has been successful, but developing rootstocks resistant to multiple pests is difficult.
- Genetic engineering (GE) has unique characteristics when applied to rootstocks that might make application more acceptable to detractors.
- GE could overcome some of the difficulties in developing rootstocks resistant to multiple pests.

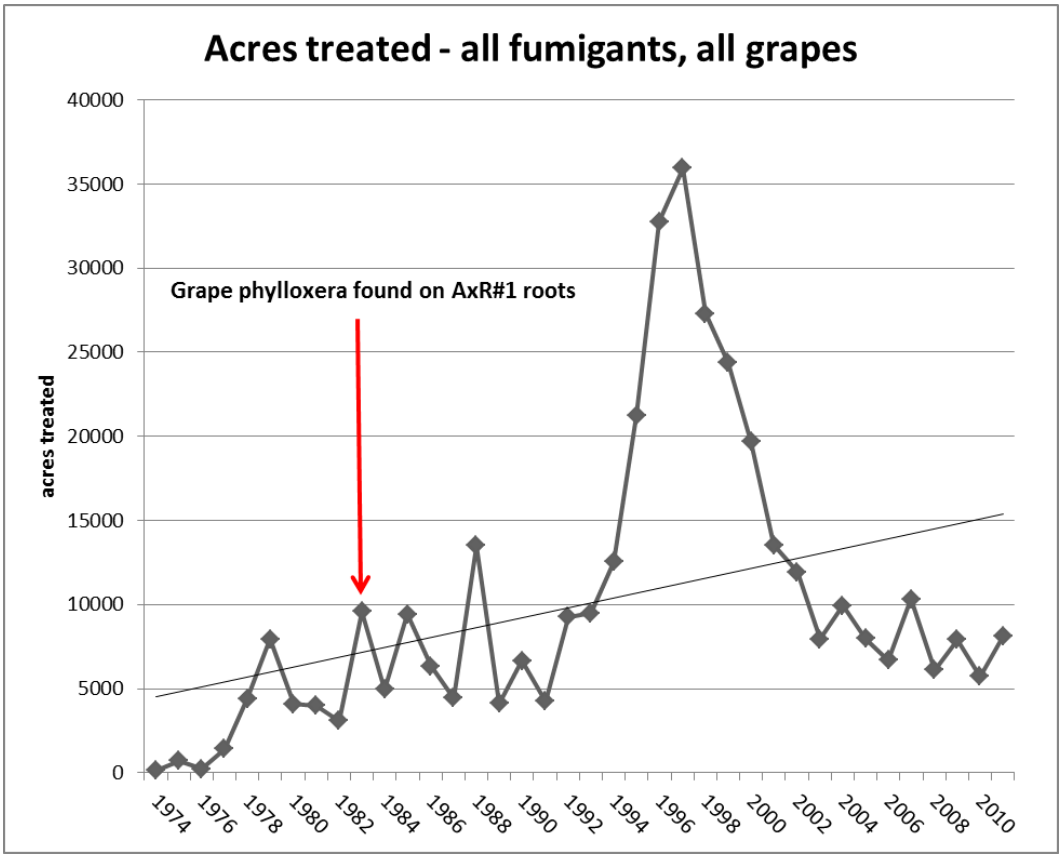

Fig. 1. Acres treated with fumigants annually, 1974-2011, all grapes. Grape phylloxera was initially found on AxR#1 rootstock in 1983 ($y = 292.7x + 4241.8$ $R^2 = 0.1467$, $P = 0.018$).

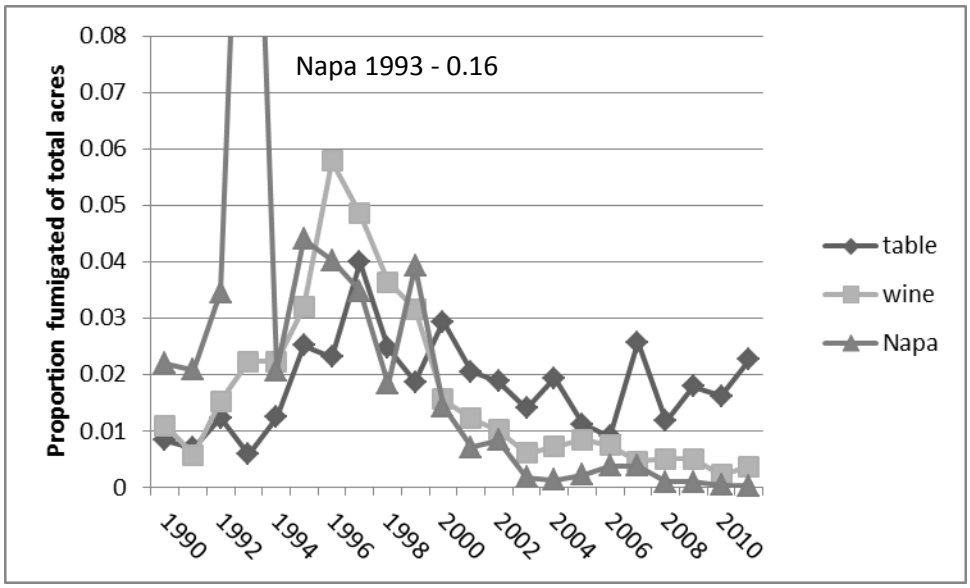

Fig. 2. The proportion of total acres planted statewide to table grapes and wine grapes, and in Napa County that were fumigated, 1990-2011.

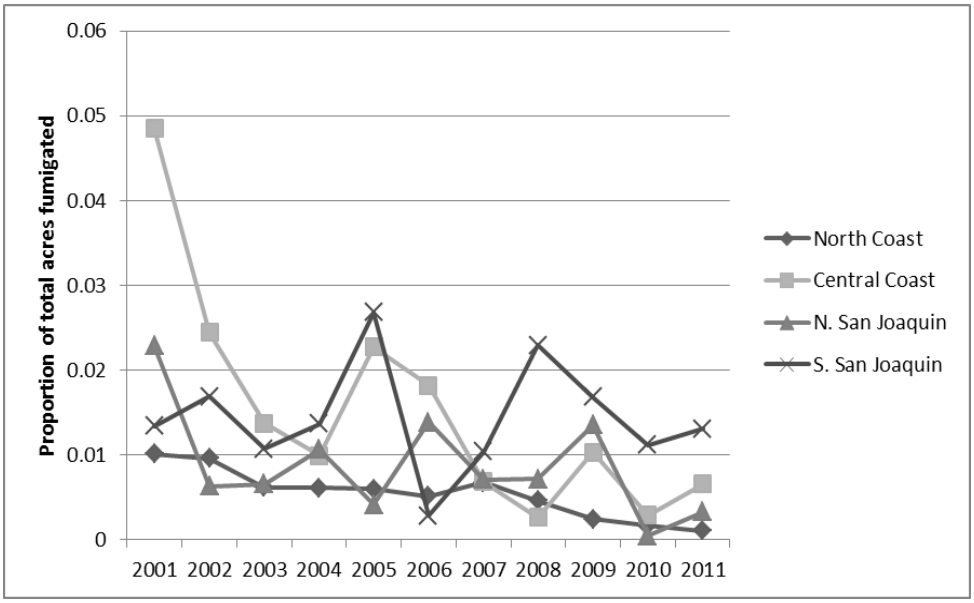

Fig. 3. The proportion of total acres planted to wine grapes in major grape growing regions that were fumigated, 2001-2011. The North Coast had a lower proportion fumigated than the S. San Jaoquin and the Central Coast regions (Kruskal-Wallis test, KS = 13.307; P = 0.004)