Title: "Chemical alternatives to methyl bromide for nematode control under vineyard replant conditions"

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The compound *methyl bromide* has been effectively used for decades to control nematodes, particularly under vineyard replanting situations. But due to its ozone-depleting effects, an international treaty signed in Montreal in 1993 prohibits its production and importation after January 1, 2005.

- "*Vineyard replant disorder*" is a disease referring to the lack of vigor, or possibly even failure, of newly planted vines. Even though the exact cause is not known, the disorder has been associated with the presence of nematodes, with *phylloxera*, and with soil-borne diseases. Grape roots are able to survive and act as a reservoir for pathogens for more than 8 years after a vineyard is removed! Fumigation with methyl bromide, followed by letting the vineyard rest under cover, used to be the way to minimize infection. Unfortunately -or fortunately-, since 2005 this practice is no longer allowed. This article is the search for an effective, less environmentally harmful substitute for methyl bromide.

- Alternative products can be divided into two groups, depending on whether they are commercially available or not. Among the first group, we have: 1) **1,3-dichloropropene** (also referred to as *InLine*), which is a nematicide, 2) **chloropicrin**, a broad-spectrum fumigant, and 3) **metam sodium**, both a fumigant and a "weedicide". Not yet commercially available, but worth considering, are: 4) **iodomethane** (which, when combined with chloropicrin, is called *Midas*), 5) **propargyl bromide** , and 6) **sodium acide** (also known as *Agrizide*). The compounds in the latter group have been around before, but they had been discontinued because the old formulations were considered either dangerous (i.e. propargyl bromide is explosive), or ineffective (i.e. sodium azide).

- **2001 trial.** In the first of two trials that the authors performed, they compared a total of 10 treatments (too long to enumerate here). These treatments involved the 6 products mentioned above, each combined with one of 2 methods of delivery (shank injected or drip-line applied), and also combined with one of 2 methods of "capping" the drip-lines, (capping refers to finishing the irrigation using either water or metam sodium, which helps control weeds). They also included an untreated control and the traditional methyl bromide treatment. The design was a randomized complete block, with 5 replications per treatment. The type of soil was Hanford sandy loam located in a commercial nematode-infested vineyard that had been planted to Thompson Seedless for 85 years!

- **2003 trial.** In this second trial, the authors compared 7 treatments. This time, they looked at different doses of the same product, different depths for placing the irrigation tape, as well as products they had not included in the first trial. For this trial they used a second "real situation" site: a 70-year-old Thompson Seedless commercial vineyard, heavily infested with nematodes, and scheduled to be ripped out. All other trial details were the same.

• To evaluate the performance of the different treatments, in each treated plot the authors planted one row each of the following material: 1) own-rooted Thompson Seedless (nematode-susceptible), 2) Merlot on 1103P (moderate nematode resistance), and 3) Thompson Seedless on Freedom (nematode-resistant). During the course of the trials, the authors performed the following measurements across treatments: 1) nematode counts from soil samples at planting, 2) dry weight of above-ground weed biomass, 3) nematode counts from soil samples after a full growing season, 4) pruning weights, and 5) yield. For summary purposes, I will report here the main findings from both trials combined.

• **Alternative compounds**. 1) Both *Midas* (a combination of iodomethane and chloropicrin) and propargyl bromide were able to control nematodes as effectively as methyl bromide. This was true when applied both by deep shank injection or by drip-irrigation. 2) *Agrizide* (sodium azide) showed good nematode control in soil samples taken at planting, but not after one year of vine growth, therefore not passing the test. 3) *InLine* (chloropicrin + 1,3 dichloropropene) and chloropicrin by itself showed somewhat intermediate effects. Still, and as the authors note, not even the most effective compounds were able to match the amount of vine growth (based on pruning weights and yields) achieved in the methyl-bromide treated plots.

• **Alternative application methods**. 1) Both shank injection and drip irrigation seemed adequate delivery methods. Burying the irrigation tape at 25 cm was more effective against nematodes than burying it at 5cm, because the greater depth seems to reduce compound volatilization and reach larger nematode populations. This was not, however, true for weeds, which were beter controlled with shallow applications. 2) Capping the irrigation with water resulted in plots with unacceptable levels of weeds. Capping with metam sodium, on the other hand, reinforced the effects of the main compound. The authors attributed this to the water cap moving the chemicals deeper into the soil, thus making them less available. The authors suggest a **combination of a deep drip-applied fumigant coupled with a metam sodium cap or a surface herbicide to get good control of both nematodes and weeds.**

• **Resistant rootstocks**. Even thought resistant rootstocks can be very effective against root-knot nematodes, suppressing one specific type of nematode population can create an opportunity for other types to increase. In this study, vines grafted to all Harmony, Freedom, and to a lesser extent 1103P, supported lower nematode populations than own-rooted Thompson Seedless. This was true for both root-knot and citrus nematodes. But long-term studies have shown that resistant rootstocks tend to increase the numbers of citrus nematodes, while maintaining root-knot nematode populations low. As the authors point out, identifying a rootstock that is resistant to the diverse populations of nematodes and pathogens that are present in an old vineyard, “can be difficult or impossible”. There is simply a greater diversity of pest problems than there is diversity in rootstock resistance.

In conclusion, this study shows that *Midas*, propargyl bromide, and to a lesser extent *In-Line*, are all good alternatives to methyl bromide for control of nematodes in sandy loam soils. Even though these compounds are not quite as effective as the prohibited material -as shown by the reduced vine growth compared to methyl-bromide-, they are the best compounds we have around. Of these three products, the authors point out a current lack of effort to commercialize propargyl bromide. *In-Line* is currently commercially available. As for *Midas*, it is not yet currently available, but an application has been submitted with the U.S. Environmental Protection Agency, meaning availability may be around the corner.

(continued)

Product name	Composition	Nematode effectiveness	Status
In-Line	Dichloropropene + Chloropicrin	Medium	Available
Chloropicrin		Medium	Available
Metam sodium		Reinforces main compound when used for “capping”	Available
Midas	Iodomethane + Chloropicrin	Good	Application submitted
Propargyl bromide		Good	Discontinued*
Agrizide	Sodium azide	Poor	Discontinued

* Authors believe interest in this compound should be renewed

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