Using Ozone for Integrated Pest Management in Viticulture

Rumela Bhadra

Editor's note: Degree programs in viticulture and enology are few, but the number of universities offering courses—including grape growing and wine making in their departments of food science, plant science, and agriculture—is growing. As the author points out, the wine grape industry will benefit from new research and engineering efforts, including alternative treatments for pests and infectious diseases.

The common grape, *Vitis vinifera*, is native to the Mediterranean region, central Europe, and southwestern Asia—from Morocco and Portugal to southern Germany and northern Iran. There are currently 5,000 to 10,000 known varieties of *Vitis vinifera*, although only a small proportion are of commercial significance for wine (about 500 to 1,000 known subtypes), including the popular Cabernet Sauvignon, Chardonnay, Merlot, Pinot Noir, and Riesling. California's Central Valley is the main grape-growing region in the U.S., and there has been dramatic growth in the wine industry throughout the Midwest. However, while the Central Valley has ideal climate conditions for growing *vinifera* varieties—including ample sunshine, dry and windy summers, mild winters, and gentle slopes—the Midwest is known for its long, cold winters and hot, humid summers. In the Midwest, vines often suffer bud and stalk injury during the harsh winters, and the humid summers can increase the risk of pest-related diseases.

Agronomists and horticulturists have developed several hybrid varieties that can thrive in Midwestern climate and soil conditions. Frontenac was developed in Minnesota, NY81.0315.17 was developed at Cornell University in upstate New York, and Orion was developed in Wisconsin. In the northeastern part of Kansas, where I live, there has been much recent interest in viticulture. The gentle slopes of the Flint Hills and sufficient windy days are two main advantages for growing grapes here, but the summer heat and humidity, as well as the harsh winters, create challenges. Norton and Vignoles, two varieties that tolerate the local conditions, are very popular in northeastern Kansas and Missouri.

Because the budding-to-harvest season is short in the Midwest and Northeast, grape vines are particularly vulnerable to pest problems. High humidity, cold spells, and varying environmental conditions can trigger outbreaks of fungi, insects, bacteria, and weeds. Pesticides have been used in agriculture since the beginning of the Industrial Revolution, when maximum crop yield was a necessity. However, for the last few decades, environmental concerns and pest resistances have compelled agricultural scientists and horticulturists to take a new approach to applying pesticides.

Integrated pest management (IPM) is a systematic method for applying pesticides with the intention of minimizing risks to the environment and the agricultural economy. IPM includes carefully planned application schedules, sanitation, and physical and biological controls whenever possible. In addition, in order to minimize pest resistance, IPM alters pesticide types and applies chemicals only when necessary.

The advantages of ozone for IPM

As part of the goal of replacing chemical pesticides whenever possible, a potential method for controlling blight in viticulture is spraying the vines with ozonated water. Ozone is believed to have broad-spectrum germicidal properties against viruses, bacteria, fungi, and protozoa. Just as important, none of these pests can develop resistance to ozone because ozone destroys organisms through oxidation—a chemical reaction that damages cellular membranes, degrades lipid molecules, and ruptures cell walls.

The use of ozone in bottled water was first regulated by the FDA in the 1950s. In 1982, ozone received "generally recognized as safe" status for bottled water, and labeling as a "food additive" was approved. In 1997, an expert panel approved using ozone technology as a potent antimicrobial treatment in a variety of food and beverage processing industries. Finally, in 2005, the USDA and FDA approved the use of ozone in the meat and poultry industry for ready-to-eat products with no labeling requirements.

According to research reported for other food industries, ozone treatment increased the shelf life of white fish by 50% for North Coast Seafood Co., and the combined effects of ozone and UV treatment by Kraft Foods, Inc., showed an 80% reduction in mold growth on seafood. Fungal development in blackberries was suppressed by 20% when stored at 2°C with 0.3 ppm ozone; the ozone treatment did not cause surface discoloration and increased the shelf life up to 12 days. When potatoes were stored at 6°C to 14°C with 93% to 97% relative humidity, adding ozone treatment extended the shelf life to six months. A three-log reduction of bacterial populations was reported when carrots were washed with ozone-treated water.

Ozone treatment has the following advantages over traditional pest control methods:

- Ozone is generated on-site at low concentrations and pressures, and then immediately used in the treatment

Chardonnay grape vines planted in an experimental plot near Wamego, Kansas. Note the lack of foliage and growth for this variety compared to the rows shown in the other images.

Frontenac is a University of Minnesota hybrid that thrives in the hot, humid summers of the U.S. Midwest and produces red wines. Note the thick foliage and healthy vigor of these vines.

Cynthiana (left) is from a Norton variety native to the Midwest and mid-Atlantic states. It is the official grape of Missouri and produces mostly dry red wines. Rougeon (right) is a French-American hybrid developed in the Finger Lakes region of New York State.

process. Hence, there are no concerns about safe storage and handling.

- Ozone has a short life span, measured in minutes, so any accidental release of ozone is not harmful. The ozone molecule (O_3) breaks down into stable oxygen (O_2) and does not form recalcitrant hydrocarbons, as pesticides do.
- Accidental exposure to high concentrations of ozone, which is very rare, can be treated, and complete recovery is possible within a day.
- No residues are left behind. Unlike chemical pesticides, ozonation does not require post-treatment washing to remove residues from food surfaces.
- Because of ozone's effective mechanism, pests cannot develop resistance to ozone.
- When needed, ozone can be used to delay fruit ripening.
- Ozone is not a carcinogen.

Based on the above advantages, it is clear that ozone can be used safely and easily for treating pests, microbes, and fungal growth in food and beverage industries. Can ozone also be used for IPM in viticulture?

The use of ozone in viticulture

Ozone is already widely used in the wine industry for cleaning reactors, tank sanitation, and clean-in-place programs, and more applications of ozone in wine production will occur in the future due to ozone's advantages over traditional germicidal agents. In viticulture, traditional pesticides have become unpopular in recent years because of their inherent risks. For example, copper fungicides, which are used to fight powdery mildew on grape vines, can produce foliage injury and toxicity. Ethyl mercaptan fungicides are effective for downy mildew, but they require a four-day re-entry warning after application. Mancozeb is the active agent in many other fungicides, but it cannot be applied for 66 days after harvest. All these chemical fungicides also have a reasonable chance of losing their effectiveness in coming years due increasing pest resistance.

At a recent Kansas Grape Growers Conference in Topeka, we discussed the benefits of spraying ozonated water as a pesticide treatment in Midwestern viticulture. With the suggestion that ozone is the only good pesticide, the discussion became heated. If ozone can be used in drinking water,

The white powdery coating on a drooping, malformed leaf is evidence of powdery mildew infection on a Rougeon vine.

then surely it can be used in viticulture instead of chemical pesticides. Some growers have reservations about ozone because there is anecdotal evidence of leaf damage due to ozone application. However, the ozone concentrations used in pesticide treatment are very low, and the exposure of the vines to ozone lasts only a few seconds.

While ozone treatment has some advantages for IPM in viticulture, there are also some serious drawbacks. Primarily, there is a lack of scientific research on the effects of ozone in viticulture. Ozone's ability to control common fungal diseases is not clearly documented, and the efficacy of using ozone to prevent different diseases could vary. For a variety of fungal and bacterial diseases, there are no data on the effects of ozone application. Furthermore, even when ozone is effective, the dosage requirements and scheduling for safe application in viticulture must be determined.

In a recent on-line discussion, Wayne Wilcox, director of Cornell University's viticulture program, suggested that ozone treatment could provide effective control of powdery mildew growth, but only because ozone attacks powdery mildew on the surface of the plant. Ozone will not work for other fungal diseases such as downy mildew, black rot, and bitter rot—which are prevalent in humid climates—because those infections occur within the plant tissue. Wilcox expressed his skepticism about ozone treatment, and he agreed that scientific research is urgently needed to prove or disprove the usefulness of ozone for IPM in viticulture.

Considering the growing problem of pest resistance, earlier this year the USDA showed strong interest in approving GMO corn and soybean seeds that are resistant to 2,4-dichlorophenoxyacetic acid. Better known as 2,4-D, this herbicide was an ingredient in Agent Orange, a powerful defoliant used during the Vietnam War that caused severe damage to human health and the environment. In the late 1970s, farmers noticed weed resistance to Roundup when using GMO seeds; hence, 2,4-D was introduced to combat this resistance.

However, this on-going chemical "arms race" is not a long-term solution. Environmentalists and researchers can agree that GMOs with resistance to 2,4-D will encourage farmers to use more herbicide, which will eventually lead to weeds with 2,4-D resistance, followed by the need for yet another pesticide to replace 2,4-D. Michael White of Iowa State University Extension added that 2,4-D, dicamba, and Roundup have also shown evidence of drifting off the target site. Therefore, based on pest resistance, evidence of drift, and our need to protect the environment, we must develop non-chemical technologies for IPM in viticulture, and in agriculture generally.

Vast scientific knowledge is available for cereal grains in the U.S. Midwest regarding crop growth and stored-product handling, but this is yet not the case for viticulture. Ag and bio engineers should be proactive about researching IPM alternatives in viticulture. Growers interested in viticulture need access to that knowledge, and novel IPM technologies that succeed in viticulture can also be used in cereal grains. Pest resistance and pesticide drift are serious problems for growers—and for anyone concerned about the environment. Pest-resistant GMOs will buy us some time, but fresh thinking and better treatment alternatives are needed.

ASABE member Rumela Bhadra, Research Associate, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, USA, rumelabhadra31@gmail.com. The author invites reader comments related to this article.

Further reading

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