Phosphite Treatments to Control Sudden Oak Death in California Oaks and Tanoaks

By Matteo Garbelotto

This article is adapted from a research article, "Phosphite Injections and Bark Application of Phosphite+Pentrabark™ Control Sudden Oak Death in Coast Live Oak," to appear in the September 2007 issue of Arboriculture & Urban Forestry.

Long known to be effective against *Phytophthora cinnamomi*, a destructive and widespread soilborne pathogen that infects woody plants, phosphites can now be used to fight *P. ramorum*, the cause of sudden oak death (SOD) on several oak species including California coast live oak (*Quercus agrifola*), California black oak (*Q. kelloggii*), Shreve oak (*Q. parvula* var. *shrevei*), and canyon live oak (*Q. chrysolepis*), as well as the oak-related tanoak (*Lithocarpus densiflorus*).

Girdling lesions on California coast live oak stems. On the left, one untreated tree displaying a large lesion initiated by the artificial inoculation of a round plug colonized by the sudden oak death pathogen. In the middle, a mock-inoculated tree displays no lesion; and on the right, the pathogen was not capable of growing out of the inoculum plug in a tree injected with phosphites.

Phosphites are salts of phosphonic acid, the simplest organic form of a phosphorous-based acid, bound to cations such as calcium, potassium, or aluminum. Phosphites have poor fertilizing power but, unlike the widely known phosphates, do not cause any eutrophization of the environment. In actuality, phosphites are compounds documented to be effective against oomycete pathogens, absolutely unique in their mode of action. Instead of only directly affecting the oomycetes responsible for many tree diseases, these compounds also trigger a range of defense mechanisms within the plant. Such mechanisms include thickening of the cell wall and an increased production of antimicrobial compounds produced by the plant upon treatment.

There are no known negative effects on useful microbes, invertebrates, or aquatic organisms related to the use of phosphites. However, side effects such as phytotoxicity and modified flowering processes have been reported for some plant species in association with phosphite treatments. Although the large majority of trees respond positively to the treatment, it should be noted that for best results of this plant-mediated process, plants need to be physiologically active at the time of treatment. Even though phosphite treatments have been successfully used therapeutically in many agricultural situations, data from their applications in wildlands in Australia (against *P. cinnamomi*) and in California (against *P. ramorum*) suggest they are most effective if administered preventively.

Our experience in fighting SOD has indicated that asymptomatic trees that have already been infected do not respond well to phosphite treatments. Thus, a strong effort is needed to educate landowners to invest in preventive treatment of their trees, well before the disease shows up in their property. Otherwise, by the time symptoms are evident, it may be too late to effectively protect trees. The timing of application should take into account the known epidemiology of the disease. Because three to six weeks will be required for the appropriate defense mechanism to build up, applications should be performed at least six weeks before that period of the year when tree infection may be at its highest levels. In the case of *Phytophthora* diseases, presence of water will be a requirement for high infection (of course, in artificially watered landscapes this requirement may not be limited in time), followed by species-specific temperature requirements. For instance, although *P. ramorum* contagion seems to peak in April to May, *P. cinnamomi* will peak in warmer months of the year.

A certain understanding of the epidemiology of the disease is also crucial to develop the most profitable pest management scheme. In particular, a reduction of inoculum (in other words, of infectious plant material or soil) is always essential when dealing with aggressive diseases. Phosphite treatments simply make plants more resistant, but even treated specimens will fall if under constant attack by voracious pathogens. Understanding how the pathogen reproduces and infects other plants is necessary to plan a sanitation program that may be capable of reducing the risk of infection. For instance, avoiding overwatering when soil Phytophthoras are present, or removing infected plant litter and overhead irrigation can all be important strategies that will maximize the efficacy of treatments. In the case of SOD, for instance, it is plants other than oaks that are responsible for contagion. Removing such plants from the landscape surrounding oaks will be the most important pest management decision one could make.

In an article by Garbelotto et al. titled "Phosphite Injections and Bark Application of Phosphite+ Pentrabark™ Control Sudden Oak Death in Coast Live Oak" (to be published in the September 2007 issue of *Arboriculture & Urban Forestry*), treatments employing different phosphite compounds were shown to be largely equivalent in their effect on controlling growth of girdling lesions caused by *P. ramorum*. The study also showed that not all application methods have comparable efficacy and side effects: topical and drench application of phosphites were mostly useless, while foliar applications had some positive effects; but such effects appeared to be rather short-lived and to cause extensive burning of the foliage. In oaks and tanoaks, two delivery approaches were proven to be successful: positive pressure injections and the application on the bark of phosphites amended with the organosilicate surfactant Pentrabark™.

Top left: Marley injectors placed around the stem of a Shreve oak. Bottom left: a Sidewinder apparatus drills a hole and delivers the product through a hollow bit and a pump mounted on a backpack. Right panel: the bark of a California coast live oak is sprayed with Agrifos™+Pentrabark™.

Injections in trees such as California oaks, characterized by very high internal pressure, require a device that constantly applies pressure during the injection process. We found Marley injectors and Sidewinder apparati to be well suited for this purpose. On the other hand, systems that do not deliver constant pressure during the entire time of injection failed to fully deliver the compound into the tree. During the study, it was also determined that injections must deliver the product in the outer rings of the xylem rather than in the cambium or in the inner sapwood. Maximum success was obtained when injecting small volumes (5-10 milliliters) of concentrated phosphites rather than larger and more diluted amounts.

In our field experience, all adult trees require multiple injections, and in gnarly older trees, delivery by injection is not always successful because of the presence of punks and nonfunctional vascular xylem in large portions of the trunk. On the other hand, the phosphite+Pentrabark™ combo can be applied easily, always takes a fraction of the time of the injection treatments, and requires only a simple sprayer. It should be noted that phosphite+ Pentrabark™ should only be applied on the bark, possibly even on the bases of branches where the bark is thinner, but not directly on the foliage, because it will burn it. In a forthcoming paper, we will present additional data showing that one phosphite treatment every two years should suffice. As a precaution, it may be a good idea to treat twice the first year.

In the course of our studies, we have gathered evidence supporting the efficacy of phosphite treatments of tanoaks if treated prior to infection by *P. ramorum*, and of oaks if treated prior to infection by *P. ramorum* or *P cinnamomi*. The effects on all other plant species–*Phytophthora* combinations may have to be tested, because not all plant species react equally to phosphites. Furthermore, the phosphite+ Pentrabark™ combo may not effectively deliver the active compound in some tree species, possibly because of the configuration of the bark. Currently, a phosphite called Agrifos™ and Pentrabark™ are registered in California for the treatment of *P. ramorum* in oak species and in tanoaks. All applications need to be performed following directions provided by the manufacturers in the labels. For more information on phosphite treatments, Google "Forest pathology and mycology."

Matteo Garbelotto is a forest pathology and mycology extension specialist at the University of California, Berkeley.