

Phosphoric Acids for the Prevention of Pythium

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Cycle Works of Minnesota

The use of Phosphoric Acids for the prevention of Pythium has become very popular in Minnesota during the past few years and is an effective alternative in preventing Pythium outbreaks to the more expensive use of fungicides. In an effort to help Superintendents understand more about how Phosphoric Acids work to prevent Pythium, Cycle Works of Minnesota has asked its manufacturer, United Agricultural Services (UAS), to provide information about how Phosphoric Acids works. The following article is a technical explanation about how and why Phosphoric Acids work to prevent Pythium and other fungus type diseases.

Potassium Phosphite

A lower cost alternative for the effective control of Pythium, Phytophthora and Fusarium

Phytophthora In Trees

Phytophthora diseases are often termed as damping-off of seedlings in the seedbed, root and crown rot in nurseries, foot rot and fibrous root rot, and brown rot of fruit trees. There are many different species of Phytophthora (*P. parasitica*, *P. citrophthora*, *P. nicotianae*, *P. palmivora*)

Pythium in Turfgrass

Pythium blight, also known as grease spot or cottony blight, is a major disease of the turf industry. Caused by several species of Pythium fungi, the two most commonly associated with Pythium blight are *Pythium aphanidermatum* and *P. graminicola*.

These fungi are in a group known as Phytophthora and are referred to as "water molds" because they function best under wet, saturated soil conditions.

The Pythium species that attack turfgrass can survive in thatch, in infected clippings, in roots and in the soil. They are known to be active from spring to fall and are more active when conditions are right.

Fusarium sp. in Ornamentals.

Control has been observed of *Fusarium sp.* in Madagascar Periwinkle (A Vinca Ornamental) by the University of Florida (IFAS)

CHEMICAL DIFFERENCES OF PHOSPHORIC ACID (Phosphate), PHOSPHOROUS ACID (Phosphite) AND PHOSPHONIC ACID (Phosphonate)

An organic derivative of phosphorous acid is a phosphonate. A breakdown product of a phosphonate is phosphonic acid.

Contrast which is phosphoric acid to which is phosphorous acid.

(For convenience, all forms of the salt are routinely referred to as "potassium phosphate" with potassium dihydrogen phosphate and dipotassium hydrogen phosphate serving as phosphate fertilizers).

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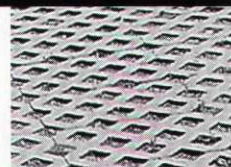
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Phosphoric Acid—

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When phosphorous acid (H_3PO_3) is neutralized with a base, such as potassium hydroxide (KOH) or ammonium hydroxide (NH_4OH), a salt results. The salt of phosphorous acid is a phosphite. For example: (See graph at right)

PHOSPHOROUS ACID

Potassium phosphite (H_3PO_3 Active ingredient)

Brief History: There are two main strategies whereby phosphite can be used to protect native flora against *P. cinnamomi* infestations. It may be applied either as proactive or therapeutic. The first literature cited in Australian forestry research, noted that the phosphite has been used to protect avocado, pineapple and cocoa crops against Phytophthora disease since the 1970s. In the late 1980s research staff at the Department of Conservation and Land Management's Dwelling office, led by Dr. Bryan Shearer, decided to investigate whether the fungicide provided any additional protection to Western Australian native species. These treatments, where phosphite solution was injected into jarrah (*Eucalyptus marginata*) and several

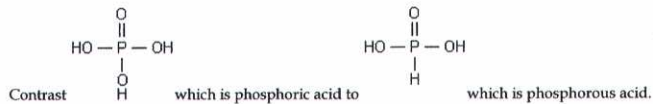
banksia species, showed considerable promise, slowing and stopping the growth of the pathogen within the plants under attack.

Phosphite, which is formulated from neutralized phosphonic acid, has shown

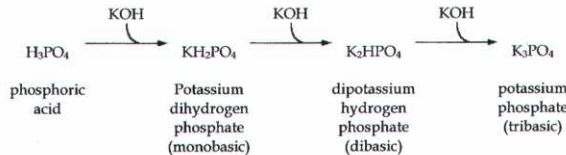
great promise in the battle to preserve rare and endangered citrus trees under threat from root-rot disease caused by the pathogen *Phytophthora* spp. Depending

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PHOSPHOROUS ACID Potassium phosphite (H_3PO_3 Active ingredient)

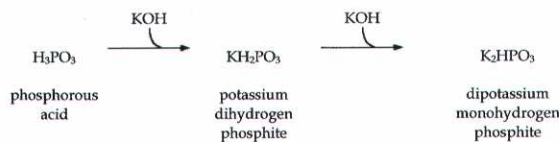


When phosphoric acid (H_3PO_4) is neutralized with a base, such as potassium hydroxide (KOH) or ammonium hydroxide (NH_4OH), a salt results. The salt of phosphoric acid is a phosphate. For example:

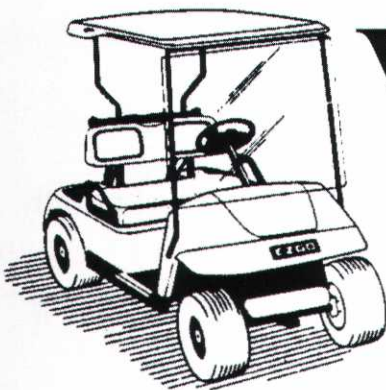


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Phosphoric Acid-

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on how it is applied, phosphite can provide protection for vulnerable plant species against the killer disease for up to five years. Phosphite is an environmentally safe, inexpensive chemical that is systemically transmitted throughout treated plants and has a very low toxicity to animals. This early success sparked a research effort, partly funded by Environment Australia grants, which was to continue over the next decade and included field trials ranging from the northern sand plain near Eneabba to the Fitzgerald River National Park east of Albany. Aerial application of phosphite to native plant communities was tested for the first time in 1993 in several reserves near Albany and proved a success. Aircraft allow for relatively cheap and rapid treatment of entire plant communities containing rare plant species, and are suitable for areas where ruggedness of the terrain would make ground application prohibitively expensive. One drawback with aerially applied phosphite, however, is that protection normally only lasts for about two years, whereas stem injection may provide protection for up to five years.

As an energy element: The phosphorus in potassium phosphite is in the form of "PO₃" (H PO₃²⁻) rather than "PO₄" (H PO₄²⁻) which is found in traditional fertilizers. It is theorized it was taking less energy by the plant to utilize PO₃ (H PO₃²⁻) than PO₄ (H PO₄²⁻).

Mode of action: In general, the mode of action of phosphite is not fully understood, but it appears that the progress of infec-

tion by phytophthora cinnamomi is halted when it comes into contact with phosphite in plant tissue. This may be because high phosphite concentrations interfere with the internal phosphorus utilization cycle essential for survival of the pathogen. The plant self-defense mechanism may also be triggered to wall-off and isolate the invaded root cells. Plants in poor health, which are treated in time, have been shown to fully recover and remain healthy for a number of years. Another literature cited by Smillee et al. (1989) stated that the phosphite has direct effect on the pathogen itself as a fungicide or fungi stat (an antimicrobial used to prevent mold or mildew from growing provided it hasn't already colonized) to either kill or halt its growth. They also opined that in addition to the phosphite, the other chemicals produced by phytophthora as a result of phosphite's direct action on the pathogen, might mobilize the plant's dynamic mechanism to ward off the invasion of root system. Another school of thought suggested that the potassium phosphate is not a naturally occurring substance and has a mixed mode of action involving direct toxicity to the plant pathogen, aided by natural plant defenses. Therefore, phosphorous acid is not classified as a biochemical. Another school of thought is evident that the action on plant diseases is both direct and indirect. It is almost certain that the phosphonate anion disrupts the phosphorus metabolism within the fungi, leading to fungi-stasis, and subsequently activating the host plants defense responses, giving an indirect activity of the phosphonate on the pathogen. As far as this indirect activity is concerned, it is stated that the phosphonates stimulated the production within the plant of phytoalexins. The phosphonate fungicides are the first in history to stimulate this effect in the plant (Schwinn and Urech. 1986).

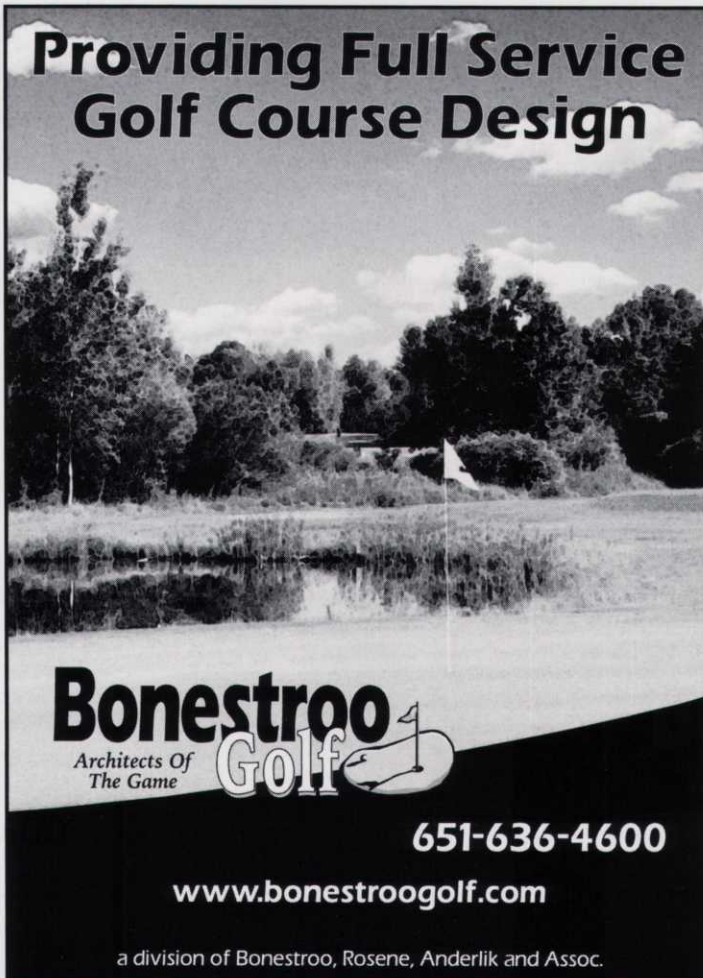
What is of interest to horticulturists and plant pathologists alike is that the presence of phosphonates in plants, at concentrations below those required to inhibit mycelia growth in vitro, seriously disrupts the activity of the pathogen. The main advantage of this complex mode of action is that phosphonate resistant pathogens do not appear to have arisen after 23 years of use (Guest et al. 1995). Its mode of action is either direct inhibition of the oxidative phosphorylation process in the sensitive fungi, or indirect activation of the plant's natural resistance to the specific Oomycetes.

Carswell et al. (1994) reported that phosphite has one less oxygen molecule than phosphate and, therefore, has a much higher degree of solubility and mobility. This unique characteristic permits phosphite to be rapidly absorbed or taken up across the membranes of plant foliage and/or roots. Phosphonate fungicides are derived from the reaction of phosphorous acid with bases in different solutions to form salts or esters of phosphorous acid. These then yield the phosphonate or phosphite ions (HPO₃²⁻) in solution. It is the hydrogen-phosphorus bond that forms the basis of the phosphonate fungicides. This P-H bond, which replaces the P-OH bond in phosphates, makes the phosphonate ion a poor source of phosphorus to a plant

Plant immunization is possible through the appropriate selection of plant inputs either organic or synthetic. Usage of phosphonate fertilizers act as Induced Systemic Resistance (ISR) for practically possible phytophthora control in citrus. ISR resistance utilizes the plant's own defense mechanisms to restrict development of pathogens.

* * * *

(Editor's Note: Contact Jim O'Neill at 612-751-0305 or Doug Daniel at 612-868-9615 for more information.)



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