Phosphite Fertilizers: What Are They? Can You Use Them? What Can They Do?

By C.J. Lovatt and R.L. Mikkelsen

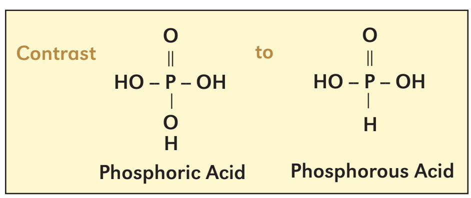
Interest is growing in phosphite as part of a total production program. Phosphite contains one less oxygen (O) than phosphate, making its chemistry and behavior quite different. Phosphite is more soluble than phosphate, making leaf and root uptake more efficient, thus high concentrations can be toxic for plants. Phosphite also has unique effects on plant metabolism. Phosphite supplied through the soil or foliage is slowly converted to phosphate. Soil and foliar applications are made at relatively low rates to prevent nutrition problems. For some plant species, phosphite may offer some unique benefits not seen with phosphate applications.

Phosphorus (P) is one of the essential elements required by all living organisms. But elemental P does not occur in nature because it is very reactive–rapidly combining with other elements such as O and hydrogen (H). When fully oxidized, P is bonded with four O atoms to form the familiar phosphate molecule. However, when it is not fully oxidized and H occupies the place of one O atom, the resulting molecule is called phosphite. This seemingly simple change in molecular form causes many significant differences that influences its relative solubility, plant uptake, and effect on plant metabolism and physiology.

Phosphorous acid (H_3PO_3) and its salt (phosphite) contain higher concentrations of P (39%) than traditional phosphate-based (H_3PO_4) fertilizer (32% P). Salts of phosphite are generally more soluble than the analogous salts of phosphate.

Since the fully oxidized phosphate is the most stable P form in the environment, phosphite undergoes a gradual transformation after addition to soil. Soil microorganisms are able to assimilate phosphite and release phosphate, gaining energy and nutrients during this biological conversion. Microbes will preferentially take up phosphate for their metabolism before taking up significant amounts of phosphite. The estimated half-life for phosphite oxidation to phosphate in soil is usually 3 to 4 months. However, due to its greater solubility, when phosphite is applied to soil during fertilization, it is more readily available to these microorganisms and plant roots than phosphate. Non-biological oxidation of phosphite may also occur gradually, but at a slower rate.

There is evidence that phosphite is adsorbed and attached to soil minerals to a lesser extent than phosphate. This property could possibly be used to enhance the mobility of applied P from a fertilizer band or from a drip emitter in soil. Although this potential benefit has not been investigated in detail, greater solubility has been utilized in the formulation of phosphite-based fertilizers that include calcium (Ca), magnesium (Mg), and potassium (K). Several studies have been conducted to determine the effectiveness of soil-applied phosphite



Phosphoric acid (phosphate) and phosphorous acid (phosphite) comparison. In phosphorous acid, the H is bonded directly to P and is always present.

as a nutrient source for crops. Early work with these materials focused on the toxic effects of phosphite and phosphorous acid on a variety of crops when used as the primary source of P.

When phosphite is supplied at concentrations equivalent to phosphate fertilization rates, most reports show that initially it is a poor source of plant nutrient for a short-cycle crop (**Figure 1**). Crops fertilized at high rates of phosphite consistently perform poorer than those fertilized with phosphate for the first weeks or months following nutrient addition. The biological oxidation process can be too slow (depending on soil conditions, temperature, and presence of phosphite-metabolizing microbes) to be of agricultural significance for some annual crops. However, when crops are replanted in the previously phosphite-fertilized soil, their performance is similar to crops grown in phosphate-fertilized soil. These toxic effects and the additional expense associated with phosphite materials limited further research for many years.

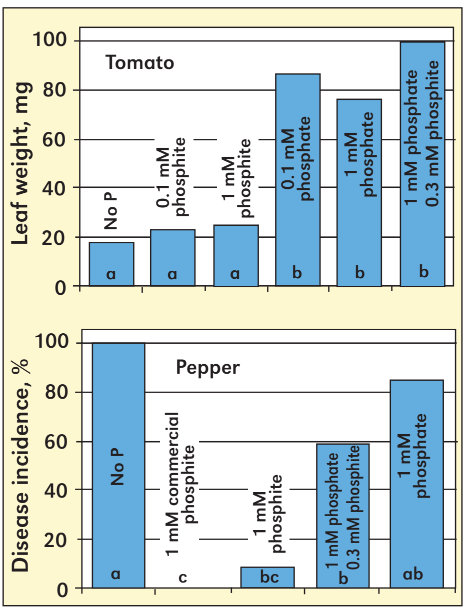


Figure 1. Effect of hydroponic P treatments on tomato growth (top) and *Phytophthora* infection (bottom) of peppers (Forster et al., 1998). Identical letters indicate there is no significant difference between treatments at the 5% level.

Recent work with phosphite has shown that at appropriate rates, it can provide stimulation to the plant which may not occur with phosphate. However, when used at recommended rates, phosphite supplies only 2 lb P_2O_5/A at each soil application, which may be far below crop removal rates. Less is known about the response of perennial crops to soil-applied phosphite sources, but this practice is growing too.

Interest in phosphite reemerged when a commercial product (aluminum phosphonate salt, called fosetyl-Al) was shown to move from the leaves to the roots in the phloem in the form of phosphite and provide control for some root diseases. Phosphite in roots has been shown to directly inhibit *Phytophthora* fungi and also stimulate the pathogen defense mechanisms in plants. While phosphite can effectively control specific species of Oomycetes, it has little effect on the majority of soil fungi. The relatively limited fungicidal effect—combined with its ability to stimulate plants to make a broad spectrum of biologically active metabolites—makes phosphite relatively benign to the environment and safe to use. However, as a treatment for pathogens other than *Phytophthora*, phosphite may reduce disease severity, but can be less effective than standard fungicides.

Other foliar-applied nutrients have the beneficial effect of reducing incidence of disease-causing organisms. Use of phosphite in some ways may be compared with other plant nutrients that have this benefit, although with different modes of action. For many years, foliar applications of zinc, manganese, copper, and sulfur have been used effectively for suppressing some plant pathogens. Similarly, single sprays of phosphate can induce systemic protection against pathogens, such as powdery mildew, in some annual and perennial crops.

Research shows that foliar applications of phosphite can replace phosphate in citrus and avocado crops suffering from P deficiency. The conversion of phosphite to phosphate may result from slow chemical oxidation or by oxidizing bacteria and fungi that have been found living on citrus and avocado leaves. There is consistent evidence that phosphite is more readily absorbed into plant tissues than phosphate. This has proven to be the case for citrus and avocado leaves, which are notoriously impervious to phosphate. In these and other crops, foliar application of phosphite has proven to be more than just a fungicide...it increases floral intensity, yield, fruit size, total soluble solids, and anthocyanin concentrations, usually in response to a single application. Phosphite is most effective when the rate and application are properly timed to match the needs of the crop. Since phosphite is chemically different from phosphate, these differences must be taken into consideration to avoid plant toxicity.

As an example of the beneficial effect of phosphite on plants, a single prebloom foliar application of phosphite to 'Valencia' oranges in Florida significantly increased flower number, yield, and total soluble solids approximately 10 months later at harvest compared with an untreated control (Abrigo, 1999). California navel oranges receiving foliar applications of phosphite in May and again in July produced more commercially valuable large fruit without reducing total yield (**Figure 2**). These results suggest that the effect from phosphite-based fertilizers was not due to the molecule's fungicidal properties, but to other growth-stimulating properties. Growers are encouraged to identify their production goal for the year... increased yield, increased fruit size, or improved fruit quality...and time phosphite applications accordingly. Production strategies are developed for a variety of tree crops, berry crops, onion, potato, and ornamental crops. Physiological responses to phosphite may be related to its effect on sugar metabolism, stimulation of the shikimic acid pathway, or internal hormonal and chemical changes.

Interest in using phosphite as part of a total production package is increasing, especially for some high-value crops. Phosphite fertilizers, if not formulated correctly, have significant potential to be phytotoxic and induce adverse reactions with other materials in the spray tank such as microelements and pesticides. All fertilizers, especially phosphite, should be used in close consultation with a crop professional to meet desired production goals. BC

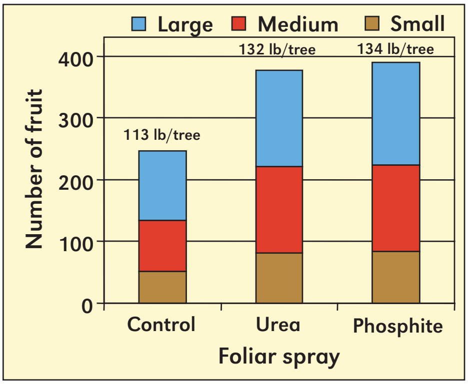


Figure 2. Effect of foliar-applied phosphite in May and July or foliar urea applied in July on fruit yield and size of naval oranges. Average "Large" fruit diameter is 3.3 in., "Medium" is 3.05 in., and "Small" is 2.8 in. (Lovatt, 1999).

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Additional information at:
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