

## Potassium Phosphite As A Potent Fungicide: Review

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### Abstract

Potassium phosphite is emerging as a vital fungicide in agriculture practices. It is a reduced form of traditional fertilizer phosphate. Being a systemic fungicide, it works effectively against oomycetes and fungi. It is known to

induce defence responses in plants against certain diseases. Phosphite works by boosting the plant's own natural defences and thereby allowing susceptible plants to survive. It moves through the plant fast, both by basipetal and acropetal transport. Potassium phosphite is a fungistatic molecule with low risk of pathogens developing resistance, and it is an environmentally acceptable active material. Its results can be enhanced by combination with other fungicides. Thus use of Potassium phosphite is an effective way of prevention as well as curative mode and indirectly for yield of crops. In this study, the review covers the chemistry, mode of action and research data of Potassium phosphite use in modern agriculture.

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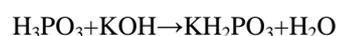
## 1. Introduction

Phosphorus and Potassium are primary nutrients required by plants. Phosphorous is necessary for plant growth and it exists in nature as a fully oxidised form as phosphate anion (PO<sub>4</sub>) and with one less oxygen as phosphite anion (PO<sub>3</sub>). On the other hand Potassium plays vital role in plant photosynthesis. Potassium phosphite is widely used in the management of fungal diseases in agriculture, horticulture and natural environments (Daniel R. et al, 2005). Potassium phosphite has also been widely used in agriculture for the many advantages that it offers, especially to increase phosphorus uptake by the plant compared to products based on traditional phosphate (Cohen and Coffey, 1986; Jackson, 2000). Potassium phosphite is also known as Potassium Phosphonate, Potassium salt of Phosphorous acid and Potassium dihydrogen phosphite. Monopotassium phosphite is the potent form of Potassium phosphite.

### 1.1 Chemistry

Potassium phosphite has a white-powdery appearance and a molecular formula of H<sub>2</sub>KO<sub>3</sub>P.

In addition to its solubility in both water and ethanol, the compound is also used to form foliar fertilizer and as a fungicide. Phosphorous acid (H<sub>3</sub>PO<sub>3</sub>) is neutralized with KOH, it forms the salt of Phosphorous acid, potassium phosphite (KH<sub>2</sub>PO<sub>3</sub>) to form Potassium Phosphonate. Also Phosphorous acid reacts with Potassium carbonate to give Potassium phosphonate.



Or



Phosphite works by boosting the plant's own natural defences (Burra et al., 2014; Eshraghi et al., 2011; Lim et al., 2013; Massoud et al., 2012). Phosphite is not toxic to people or animals and its toxicity has been compared to table salt. There is a very low pollution risk associated with phosphite. When phosphite is sprayed on to the foliage of plants, it is applied at a very low rate, so any phosphite that reaches the soil is bound to the soil and does not reach the water table (Tomlin, 2006).

Potassium phosphonate is an agent that has a systemic effect against fungal diseases, in particular against downy mildew (Pereira et al., 2010).

### 1.2 Mode of Action in Plant

Potassium Phosphonates are systematically absorbed by the plant and are mobile, within the plant, trans-locating to the new growth, via both the phloem element and the xylem. They are a highly soluble form of Phosphorus and Potassium, which is beneficial to plant growth, rooting and root development, accelerating foliar uptake of other cations such as potassium, calcium, magnesium, and most micro elements, when applied in combination and by supplying more phosphorus per molecule than phosphate. Not only does phosphite help roots, but is actually beneficial to the regeneration of mycorrhizae on the roots of trees. Phosphorus and Potassium, are rapidly absorbed by the leaf tissue and roots for maximum and efficient plant use by moving systemically upward and downward in the plants vascular system, phloem and including the root system, bypassing typical soil phosphorus tie-ups with other soil, inorganic compounds. Once applied and rapidly absorbed, by the plant, phosphites undergo an oxidation or conversion process resulting in the continual release of soluble phosphorus. The phosphonates have been observed to activate defense mechanisms that kick into gear when attacked by disease or insects. This product has fungistatic activity against major fungal pathogens and has shown to promote the trees natural defense systems capable of stimulating host defenses through induced systemic resistance. The mode of action of phosphorous acid is two fold, by acting first within the fungus, inhibiting fungus growth, and also by changing the nature of the fungal cell walls by activating the plants own immune defense response through rapid cytological action, and triggering other cellular phytoalexin accumulations and metabolic changes and other resistance inducers. Phosphonates are highly selective, non-toxic fungicides against numerous fungal pathogens, and provide both protective and curative responses against such plant diseases. It is a highly systemic sterol inhibitor that penetrates and Trans-locates, preventing fungal cell development, by interfering with cell wall formation and growth throughout the plant by inhibiting sterol biosynthesis. Once the phosphite moves up the tree and enters the leaves, it stimulates the production of infection-fighting chemicals within a layer known as the cambium. (www.chemjet.co.uk).

Phosphites are quickly absorbed by plants; therefore, they present a high degree of solubility and mobility. The systemic character (ascending and descending) and quick absorption by the roots,

stems and leaves, allow various methods of application in accordance with the type of plant and characteristics of the pathogen to be controlled (Claudio O. et al, 2013) The Phosphite is highly mobile in trees and moves bi-directional in the phloem and upward to the leaves in the vascular systems. Because Phosphite has one less oxygen molecule than phosphate, a higher degree of solubility and mobility, within the plant is achieved. This unique characteristic permits phosphites to be rapidly absorbed or taken up across the membranes of plant foliage and/or roots, in both their nutritive and plant protective roles, with immediate activity on contact. The efficiency of phosphite application in certain pathosystems is due to the fact that the plant presents better assimilation in the presence of phosphorus, making it capable of activating defense (Claudio O. et al, 2013; Nojosa et al., 2009).

Potassium phosphite moves through the plant fast, both by basipetal and acropetal transport. It stops mycelium growth and indirectly stimulates the resistance of plants because phosphite encourages the production of elicitor, which increases immunity (Guest & Bompeix, 1990; Guest & Grant, 1991; Johnson et al., 2004, Lobato et al. 2008).

### 1.3 Phosphate vs. Phosphite

Phosphite (Phi), a reduced form of phosphate (Pi). Many of us are familiar with MAP and DAP (mono and di- ammonium phosphate) and possibly even MKP (monopotassium phosphate) all of which provide phosphorous derived from phosphoric acid ( $H_3PO_4$ ). Plants use phosphate in the form of  $HPO_4$  and  $H_2PO_4$  which once applied to the soil is rapidly converted from fertilizers. Phosphite is completely different in nature from phosphate. Chemically phosphate and phosphite are similar, however phosphate has one more oxygen than phosphite and this markedly changes the nature and reactivity of the resultant molecule. These three oxygen molecules give phosphite formulations increased mobility in plant tissue and soils so that they can be successfully applied to all areas of the plant. The recognized, traditional source of phosphorus, as  $H_3PO_4$ , has long been phosphoric acid, and forms a salt when neutralized with a base. The salt is referred to as phosphite,  $H_3PO_3$ , as opposed to the phosphate  $H_3PO_4$ .

### 1.4 Remarkable results of Potassium Phosphite Use

The use of potassium phosphite in the control of the severity of plant diseases has shown satisfactory results in diverse pathosystems, mainly those phytopathogens of the oomycota class, such as grape downy mildew, whose etiologic agent is *Plasmopara viticola* (Pereira et al., 2010) and root

rot caused by *Pythium* and *Phytophthora* (Daniel and Guest, 2006; Lobato et al., 2008). In many research works it has been reported that Phosphorus as phosphonate group has some fungicidal effect (Coffey and Joseph, 1985; Pankhurst, et al., 1998; Zainuri et al., 2001). Nojosa et al. (2009) reported that potassium phosphite at 10.0 mL.L<sup>-1</sup> provided inhibition of 62.3% of mycelial growth of *Phomacostarricensis*, standing out compared to the other treatments tested. This direct effect of potassium phosphite on mycelial growth of fungi has also been verified for other systems, such as for *Colletotrichum gloeosporioides*, the causal agent of gala leaf spot and *Glomerella* leaf spot in apple (Araujo et al., 2010).

In some results phosphonates showed direct inhibiting effect on growth and sporulation of oomycetes (Fenn and Coffey, 1989; Grant et al., 1990; Smillie et al., 1989). However, the precise mode of action is still unclear. In some developing countries phosphite salts have been promoted and are used against late blight since they pose lower risks for human health and the environment compared to conventional fungicides (Kromann et al., 2012). Several recent laboratory studies show that application of phosphite compounds improves plant defence (Burra et al., 2014; Eshraghi et al., 2011; Lim et al., 2013; Massoud et al., 2012). Boneti and Katsurayama (2005) found satisfactory results in the control of apple scab (*Venturia inaequalis*) by spraying potassium phosphite at the dose of 3 mL.L<sup>-1</sup> seven days before inoculation of the pathogen, showing that the product can act indirectly in inducing resistance to the disease. A proteomics study by Lim et al. (2013) reported that phosphite triggers complex functional changes in potato leaves, which may explain induced resistance against *P. infestans*. The results indicated that phosphite influences primary metabolism and cell wall associated processes. Mayton et al. (2008) reported that potassium phosphite protected against both foliar late blight and tuber blight at least as well as the fungicide chlorothalonil. Pink rot of potato tubers, caused by *Phytophthora erythroseptica*, was reported to be controlled by potassium phosphite (Miller et al., 2006; Taylor et al., 2011). Works published on the use of potassium phosphite with other pathogens of coffee plants is moderate. The efficiency of potassium phosphite to control microorganisms is dependent on its direct microbial activity against phytopathogens (Guest and Grant, 1991). In addition, Oka et al. (2007) observed that potassium phosphite applied to the shoot was effective in controlling *H. avenae* and *M. marylandi* in wheat and oats. This result may be due to the ability of phosphite to translocate through the

plant via the xylem and phloem (Quimette and Coffey, 1990).

In a research, potassium phosphite was not effective in reducing *P. brachyurus* populations in soybeans, may be due to a different response that plants exhibit when exposed to the product, as treatment with potassium phosphite was also not effective in controlling *M. incognita* on sugar cane, compared to the control (Assunção et al., 2010). Wang-Pruski et al. (2010) reported a significant protecting effect of phosphite when used in combination with chlorothalonil. In a study, the effect of potassium phosphonate on the control of *Phytophthora* root rot of lettuce was evaluated in a liquid hydroponic culture. Phosphonate 100 ppm strongly inhibited mycelial growth of *Phytophthora* species in vitro (Hyeong et al. 2002). Some synthetic phosphonate compounds also have shown antimicrobial effects in a study (Zainuri et al., 2001). On the other hand, few reports showed that phosphonate compounds have nematocidal effects. (Feldmesser, et al., 1983) reported that the use of phosphonate had nematocidal activity which decreased root gall of tomato plants.

## 2. Discussion

Cutback in the use of pesticides is essential for the production of safe food and protection of the environment. It can be achieved through their controlled use. Another strategy is to use environment-safe chemical treatments to reduce the quantities of active substances that are usually damaging to the environment and health. Potassium phosphite may be a solution remedy. It was classified in the FRAC lists of fungicides (FRAC, 2011) under the code 33 and in the group of fungicides with low risk of pathogens developing resistance, and it is an environmentally acceptable active material because it is harmless to bees and aquatic organisms (Tomlin, 2006). Potassium phosphite has significantly improved the agricultural credibility and acceptability of the new era. There are indications that potassium phosphite has a curative effect on fungi, which requires further study. Role of fungicide-Potassium phosphite as bio stimulator / fertilizer is unclear. More research is necessary in this direction.

## Conclusion

Phosphites are found to be much better than traditional phosphates. The use of Potassium phosphite as a systemic fungicide is remarkable. It works by boosting the plant's own natural defence system. It could be an environmentally acceptable fungicide. Genetic study of pathogens, kinetic and dynamic study of phosphite after

entering plants cell will be milestone work for this reliable product.

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