PLANT DISEASE MANAGEMENT
PHOSPHITES
IR-4 WESTERN REGION BIOPESTICIDE TRAINING WORKSHOP
APRIL, 2017
Today

- Section 1: Introduction of Phosphites, Early Studies
- Section 2: Phosphites & Phosphates
- Section 3: ProPhyt
- Section 4: Performance on Different Crops
Section 1: Phosphites: Introduction, Early Studies, Fungicide Resistance, Mode of Action

...phosphonate or phosphorous acid products are salts of inorganic phosphorous acid (potassium phosphites, etc.) and are sold on various agronomic and horticultural crops for disease control.
Phosphites: Early Studies

- Work in the 1980’s showed good activity in-vitro against several species of Oomycete fungi.
- Early in-vivo tests also revealed that phosphites decreased lesion development in plants (Smillie, et. al., 1989).
- According to Fenn & Coffey, 1984, the breakdown product of fosetyl was phosphonic acid which had strong antifungal activity. Earlier work showed fosetyl aluminum provided little or no direct antifungal activity.
Phosphites Studies

- Direct fungicidal activity was proven with phosphites
- Discovered - phosphites move systemically both acropetally and basipetally in the plant
  - Many application methods proved to be efficacious including; foliar, root dips, trunk injections, soil applications
- In-vitro work by Fenn & Coffey, 1984, with a mutagenic strain showed that resistant strains of Phytophthora capsici could be developed
One of the first articles addressing mode of action of phosphites (by Smillie, et al. 1989*):

“Our results, therefore, are consistent with a site of action for phosphite in the fungus, not in the plant, but strongly suggest that the plant’s natural defense system plays a critical role in arresting pathogen growth. The mode of action of phosphite might, therefore, best be described as mixed, rather than direct or indirect.”
Phosphites: Mode of Action
Studies Today

- More recent MOA studies have focused on the changes in host plant resistance.
- Research conducted in Volcani Institute, Israel 2015-2016, proved that Botryosphaeria control in Avocado by ProPhyt is due to induced resistance and that PR proteins are activated both through Salicylic acid and jasmonic acid pathways.
- In a study conducted by G. Upinder & K. Mysore, 2015 (APS Poster) confirmed that phosphites inhibit mycelial growth and determined there was an effect on plant defenses.
- In addition PR proteins were induced (chitinases).
- Disease control by phosphite fungicides is largely due to inhibition of the pathogen, but plant defense priming also contributes to control.
ProPhyt® (Potassium Phosphite): Mode of Action and Resistance Management

1. Has direct effect on the pathogen (MOA unknown but thought to interfere with phosphorous utilization)
2. Triggers host plant resistance (Upinder & Mysore)

In most cases, ProPhyt is a good choice for resistance management

- Only a few cases of resistance in field isolates
- Resistance risk is considered low (FRAC)

Defense Genes Involvement:
Global gene expression change in switchgrass to defense genes (phenylpropanoid pathway genes, chitinase-encoding genes and jasmonic acid-induced genes)
## Fungicides: Risk of Developing Resistance

<table>
<thead>
<tr>
<th>FRAC Code</th>
<th>Chemical Name (a.i.)</th>
<th>Trade Name</th>
<th>Risk of Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Triazoles - tebuconazole &amp; propiconazole</td>
<td>Folicur®, Tilt®</td>
<td>Medium</td>
</tr>
<tr>
<td>11</td>
<td>Strobilurins - azoxystobin, pyraclostrobin</td>
<td>Quadris®, Headline®</td>
<td>High</td>
</tr>
<tr>
<td>33</td>
<td>Phosphonates - potassium phosphite</td>
<td>ProPhyt®</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>Phenylamides - metalaxyl, mefenoxam</td>
<td>Ridomil®, Ridomil Gold®</td>
<td>High</td>
</tr>
</tbody>
</table>

[http://ipm.ifas.ufl.edu/resources/success_stories/T&PGuide/pdfs/Appendices/Appendix6-FRAC.pdf](http://ipm.ifas.ufl.edu/resources/success_stories/T&PGuide/pdfs/Appendices/Appendix6-FRAC.pdf)
Numerous phosphite fungicide and fertilizer products are currently on the market. These products appear to be similar but are quite different. They differ in trade name, rates, formulation, amount of active ingredient, label terminology, uses, ingredient source and price. Some of these products are registered as fungicides and others are sold as fertilizers.
Section 2:

Phosphites & Phosphates

From: Understanding the Phosphonate Products, Penn State Plant Science
http://plantscience.psu.edu/research/centers/turf/extension/factsheets/phosphonate-products

“Pythium aphanidermatum growing in cornmeal medium amended with A) potassium phosphite and B) potassium phosphate. The potassium phosphite is inhibiting growth of *Pythium* mycelia, whereas the potassium phosphate has no effect on growth.”

Annual bluegrass treated with a nutrient solution containing potassium phosphate as the source of phosphorus (left); the same nutrient solution with potassium phosphite as the source of phosphorus (right).
Phosphoric Acid vs Phosphorous Acid

- "Both phosphoric acid (H₃PO₄) and phosphorous acid (H₃PO₃) are agrochemicals essential for crop production."
- Under normal plant growth conditions, both disassociate and exist as corresponding anions, phosphate and phosphite.
- A clear distinction exists between the two agrochemical compounds:
  - Phosphate is a nutrient source of P essential for plants, and
  - Phosphite is an EPA registered agricultural bio fungicide

From: Are Phosphorous and Phosphoric Acids Equal Phosphorous Sources for Plant Growth?
By Brunings, et. al., Univ. of Florida website: https://edis.ifas.ufl.edu/hs254
Section 3: ProPhyt®

A systemic fungicide for the control of several foliar and soil-borne diseases of field crops, grapes, herbs, fruits, pecans and vegetables
ProPhyt is a POTASSIUM PHOSPHITE fungicide. What sets it apart from others is the ratio of both mono and di potassium phosphite in the formulation.

Registered by EPA as a BIO-Fungicide.

ProPhyt is a systemic fungicide, which can be taken up through the foliage or via the soil.

Within the plant ProPhyt has bi-mobile systemicity. That is, it can move both upward in the xylem and downward via the phloem.

ProPhyt is a protectant, not a curative product.
Potassium Phosphite (ProPhyt):

- Potassium is the least phytotoxic of the salts used in production of phosphorous acid (especially sodium salts in products like Phostrol and Nutriphite)
- High water solubility
- Low salt index
- pH 6.0 – 6.5
- Good crop tolerance
ProPhyt®
Potassium Phosphite – Product Safety

- EPA Designation – Exempt from tolerances
  - Tolerances are maximum legally permissible levels of pesticide residues, including active and inert
- Caution Label
- Carcinogen – Not Likely
- Cholinesterase Inhibitor - No
- Ground Water Contaminant – Potential

“Acute Toxicological Data for potassium phosphite:
Oral Toxicity : LD50 (rat) >5000 mg/kg
Dermal Toxicity : LD50 (rat) >4000 mg/kg
Inhalation Toxicity : LC50 (rat) >5.05 mg/l
Eye Irritation : Mild irritant
Skin Irritation : Not irritant
Dermal Sensitization : Not a sensitizer

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Benefits of ProPhyt®

- 0 day PHI and 4 hour REI. Rapidly absorbed into the plant.
- Dual mode of Action. Good choice as partner for resistance management
- No PHI concerns (no residue issues)
- Effective under heavy disease pressure vs. other phosphite products
- Fits well into IPM
- Typical rate is 2-4 pints per acre on 7-14 day schedule
Stability in Spray Tank: ProPhyt is stable in aqueous solution for long periods of time.

Tank Mixing Concerns (Compatibility): It is generally compatible with most pesticides and fertilizers except those containing soluble copper salts or oxidizing agents such as nitrates.

- In combination.....tank mix flexibility, often see improved performance with combos
  - Can be mixed with Copper fungicides like Kocide
  - Generally safe when applied with most adjuvants

Compatibility with Biologicals: Non-toxic to predatory mites
Crops/Diseases on ProPhyt® Label

Tree Fruit & Nuts:
- Avocado, Citrus, Pecan, Pome Fruit (Apple, Pear), Stone Fruit (Peaches, Nectarines), Walnuts, Almonds

Control of various diseases caused by Phytophthora, Cladosporium, Alternaria, Botryosphaeria, etc.

Fruit Crops:
- Grapes, Pineapple
- Blueberries, Caneberries (Blackberries, Raspberries), Cranberries, Strawberries

Control of various diseases caused by Phytophthora, Pythium, Alternaria, Plasmopara, Guignardia, etc.

Vegetables:
- Asparagus, Brassica Vegetables (Broccoli, Cauliflower, etc.), Bulb Veggies (Onions, etc.), Cucurbit Vegetables (Cucumber, Melon, Pumpkin, Squash), Fruiting Vegetables (Tomato, Tomatillo), Leafy Veggies (Lettuce, Spinach), Legume Vegetables, Snap Beans, Peppers

Control of various diseases caused by Phytophthora, Bremia, Pseudoperonospora, Peronospora, etc.

Field Crops:
- Corn, Peanuts, Sorghum, Potatoes

Other Crops:
- Herbs & Spices (Basil, Thyme, etc.), Hops, Conifers

Control of various diseases caused by Phytophthora, Alternaria, Botryosphaeria, etc.
Section 4: Examples of Performance on Different Crops
ProPhyt on Lettuce
Combinations with Protectants

Lettuce Downy Mildew
Univ. of FL, 2010

Note: Another study by Keinath, et. al., 2007 discussed the activity of ProPhyt when combined with other chemistries and biopesticides.
ProPhyt on Strawberry
Control of Root Necrosis (Colletotrichum acutatum)
University of Florida, 2015-16

Mkt weight lb/Ac

Helena ProPhyt 2 pt dip f.b. 2...
Topsin 4.5FL 20 fl oz
Actinovate 12 oz
Regalia 2 qt dip f.b. 2 qt
Oxidate 2.02 qt
Fontelis 24 fl oz
Non-treated control
Abound 8 fl oz
Serenade Soil 4 qt
Switch 62.5WG 8 oz
TerraGrow 10 oz
Actinovate 24 oz
Roval 2 pt

35% Additional yield

L. Cordova, J. Mertely, and N.A. Peres
University of Florida,
Wrap-up

- Phosphate is a nutrient source of P, essential for plants, and **Phosphite is an EPA registered agricultural biofungicide**

- ProPhyt is a potassium phosphite biofungicide with 2 modes of action (direct fungal activity and triggers plant defense mechanisms)

- ProPhyt is a broad-spectrum, systemic crop protection product with excellent disease control properties
References


