

What Can Phosphonates Do For You?

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chemical classes.

By A. R. Chase



Downy mildew on rose. (Photos courtesy of A.R. Chase)

The United States was introduced to phosphonates in the 1980s when Rhone Poulenc introduced Aliette 80WP. In the summer of 1987, Rhone Poulenc (now Bayer Environmental Sciences) brought researchers from all over the world to share their research experiences with fosetyl aluminum (the active ingredient of Aliette). In the previous year, I had been testing the effect of Aliette on bacterial diseases of ornamentals. Aliette was also being tested in the field for fire blight control on apples. After working on Aliette since 1980 for Pythium and Phytophthora, I was very interested in the fact that it showed some control of bacterial leaf spots caused by *Pseudomonas* and *Xanthomonas*. I actually did not start looking at Aliette or any other phosphonate for downy mildew control until I returned to California in 1994.

It has been commonly held that Aliette and the phosphonates work on oomycete fungi,

including downy mildews (like *Peronospora*), *Phytophthora* and *Pythium*. Nearly all of the phosphonate research that has been reported in the past 20 years involves *Phytophthora* as the primary target. Aliette shows curative activity on *Phytophthora* on citrus for up to eight weeks, and stem injections on avocado show decreased disease for up to two years. In some cases, soil treatments of citrus trees with Aliette are more effective than foliar sprays, showing higher amounts of potassium phosphonate (the active chemical) in plants up to eight weeks after treatment. A 13-day kick-back for grapevine downy mildew has also been demonstrated, meaning that 13 days after infection, Aliette can be applied and still eradicate the infection. The long-term presence of potassium phosphonate in woody tissue has been demonstrated in many crops.

A review of the literature shows that oomycetes are not the only targets for phosphonates. They have been reported to control apple scab

(*Venturia*), *Phomopsis* dieback on grapevines, *Monilinia* (in petri dishes), *Colletotrichum* leaf spot (Anthracnose) on beans, alfalfa mosaic virus on beans, *Rhizoctonia* damping-off on wheat, *Uromyces* rust on bean and *Fusarium* wilt on some crops but not others. Control of *Sclerotinia* (dollar spot) on turf was very good with one phosphonate and actually better than an industry standard given in the same trial. Against bacterial shot hole on plums, caused by *Xanthomonas campestris* pv., a phosphonate was as effective as an industry standard and actually safer than the standard and copper.

When I started giving talks in California, I was often asked whether or not the alternatives were as effective as Aliette. At the same time, we started working in the area of downy mildew control so this was a natural target for testing products like Alude, Fosphite and Vital that have fungicide labels and others like pHortress and Nutri Grow PK that have fertilizer labels. Figure 1, left, shows some phosphonates and their active ingre-

Aliette 80WP

Bayer Environmental Science
www.bayercropscience.com

Alude

Cleary Chemical Corp.
www.clearychemical.com

BAS500

BASF Corp.
www.basf.com

Camelot

Whitmire Micro-Gen
www.wmmg.com

Compass O

Olympic Horticultural Products
www.olympichort.com

Cygnus

The Scotts Co.
www.scotts.com

BioPhos

Ag-Bio
www.agbio-inc.com

Fosphite

J.H. Biotech
www.jhbiotech.com

Heritage

Syngenta Professional Products
www.syngentaprofessionalproducts.com

Kocide TNO

Griffin LLC
www.dupont.com

Mimik

ORCAL

Nutri Grow PK

Cleary Chemical Corp.
www.clearychemical.com

pHortress

Western Farm Service
www.westernfarmservice.com

Phyton 27

Phyton Corp.
www.phytoncorp.com

Pipron

SePRO Corp.
www.sepro.com

Silwet

GE Silicones
www.ge.com

Stature DM

SePRO Corp.
www.sepro.com

Subdue MAXX

Syngenta Professional Products
www.syngentaprofessionalproducts.com

Systhane

Dow AgroSciences
www.dowagro.com

Vital

SePRO Corp.
www.sepro.com

dients that we have tested in the past five years.

Figure 2, left, summarizes our results with these products over the past five years. The rates per 100 gal. are given in ounces. Most applications were sprays for foliar diseases and drenches for root diseases. The results are given as N=none, S=some, G=good, VG=very good and E=excellent. Some of the trials were done on more than one crop type and pathogen. For instance, Pythium on callas and snapdragons gave different results. Also, Phytophthora aerial blight versus root rot gave different results. But they could not be predicted. The downy work was not variable, even though many different hosts were tested (pansy, snapdragon, stock, statice, salvia and rose were included in at least one trial). Trials on azalea and frasier fir showed better control with Aliette than either Biophos or Vital. Overall, phosphonates work very well on the oomycetes but also give good control of bacterial leaf spots and good to excellent control of powdery mildew. We have achieved no meaningful control of Alternaria leaf spot or Botrytis blight.

DOWNY MILDEW CONTROL

In one of our most recent downy mildew trials, we tested the ability of a wide variety of products to eradicate both downy mildew and Botrytis blight on greenhouse potted roses. After two sprays on a 10-day interval we rated each disease (see Figure 3, below). This trial showed poor results with downy mildew eradication by the strobilurins (Heritage, BAS500, Compass O and Cygnus). This is probably due to the low use rates I chose to include. The phosphonates included in this trial were Mimik and Aliette. Mimik (two forms tested) is being developed by ORCAL, showing that the improved form gave the best control of downy mildew on roses and was statistically the same as Stature DM. Aliette also gave very good control of downy mildew and some control of Botrytis blight (not statistically significant).

We also just finished a trial on prevention of downy mildew on stock (*Matthiola incanae*). We performed a single trial a few years ago on an experimental product using it as a drench to prevent pansy downy mildew. It worked, much to my surprise. In the stock trial I included all of the systemic products that had shown good results when used as foliar sprays. These included the experimental product from the pansy trial (fenamidone at 14 oz. per 100 gal. — Bayer), Aliette 80WDG (16 oz.), Stature DM (9.6 oz.), Heritage (2 oz.), Subdue MAXX (1 oz.) and Mimik. We drenched these products every 14 days, for a total of four times. The results were clear cut with 100 percent prevention by the two phosphonates (Aliette and Mimik) and no significant control with Subdue MAXX, Heritage or fenamidone.

These trials indicate that phosphonates, other than Aliette, do work very well on downy mildew whether they are applied prior to infection or



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after sporulation has occurred. The best control will nearly always be achieved when products are applied preventively as a spray but use of a curative or a drench really improves the usefulness of phosphonates for downy mildew on ornamentals.

A year or so ago, I was told by a California cut flower grower that they used phosphonates for powdery mildew control. After I tried to correct them to "downy" mildew, they reiterated that it was powdery mildew. Well, almost cured of the gut response that the



Powdery mildew on rosemary.

Figure 1. Phosphonate products and their ingredients. **POWDERY**

Product	Description
Aliette	80% Fosetyl aluminum
Alude	45.8 % Mono and di potassium salts of phosphorous acids, 5.17 lb. per gal.
BioPhos	Phosphate and potassium salts
Fosphite	Same as Alude, 6.22 lb. per gal.
Mimik	7% nitrogen (urea), 28% mono and di potassium salts of phosphorous acid, 17% K ₂ O, 11.62 lb. per gal.
Nutri Grow PK	25% phosphoric acid, 26% soluble potash
pHortress	37% phosphoric acid, 25% soluble potash, 0.2% manganese
Vital	50% mono and di potassium phosphite

MILDEW CONTROL

Figure 2. Efficacy of phosphonates in trials at Chase Research Gardens.

Product	Alternaria	Bacteria	Botrytis	Downy mildew	Phytophthora	Powdery mildew	Pythium
Aliette	Worse(16)	VG(16)	S/N(16)	VGE(16)	VGE(16)	S-G(16)	VGE(16)
Alude		G(64)		E(64)	S/E(32,64)	G-VGE(64)	S/N(64)
BioPhos				VGE(128)	VG(128) N(128,256)		
Fosphite			N(24,48)	G(24,48)		G(64), VG(24)	
Mimik	N(64)	S-G(64)	N(16, 64) S(64)	E(64)		VGE(16,64)	
Nutri Grow PK				VGE(128)	E(64)		VG(128)
pHortress				VGE(64)		S-VGE(64)	
Vital		VG(32)		VGE(64, 96)	E(96)	G-E(64)	N(96)
Average	None	Good	Slight	Very good	Very good	Good	Very good

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Figure 3. Effect of strobilurins and phosphonates on rose downy mildew and Botrytis blight (mean percentage of surface area with sporulation). Numbers in the same column followed by the same letter are not significantly different.

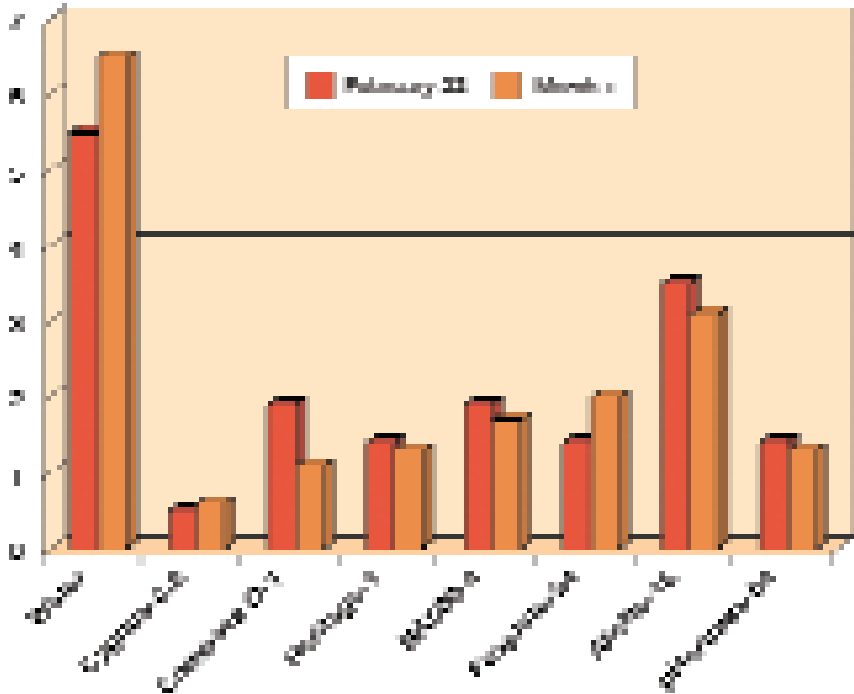
Treatment	Rate per 100 gal.	Percent Downy Mildew	Percent Botrytis
Water	N/A	54.2 bc	29.2 ab
Heritage	1 oz.	68.2 c	20.0 ab
BAS500	2 oz.	56.7 bc	40.0 b
Compass O	1 oz.	35.4 ab	31.7 ab
Cygnus	3.2 oz.	28.2 ab	21.2 ab
Cyazofamid/Silwet	2.1 oz./ 2 oz.	31.4 ab	12.9 a
Cyazofamid/Silwet	2.75 oz./ 2 oz.	17.9 a	19.6 ab
Cyazofamid/Silwet	3.5 oz./ 2 oz.	10.0 a	20.0 ab
Mimik original	64 oz.	23.6 ab	13.7 ab
Mimik improved	64 oz.	4.2 a	13.7 ab
Stature DM	6.4 oz.	17.7 a	14.2 ab
Aliette 80WDG	32 oz.	11.7 a	5.4 a

grower was wrong, we set about to check this out. We have performed three trials on powdery mildew eradication since that meeting.

The first trial attempted eradication of powdery mildew on greenhouse potted roses. Two applications were made on a weekly interval. The water-treated controls had 74 percent of their leaves with powdery mildew, while Aliette-treated plants (16

oz. per 100 gal.) had only 63 percent, Fosphite (64 oz.) had 55 percent, and pHortress (64 oz.) had 60 percent compared to an industry standard Pipron (8 oz.), which had 53 percent. In this case, the degree of eradication was low but significant and equal to the industry standard. The next trial we performed was on gerber daisy with a powdery mildew infection. We also made the applications twice on a weekly inter-

Figure 4.



val, comparing Vital and Alude at 64 oz. per 100 gal. to Systhane at 2 oz. per 100 gal. The water-sprayed control increased in severity about 80 percent over the one-week test while the Systhane plants showed no increase in powdery mildew. The plants sprayed with Vital had no increase, and those sprayed with Alude showed only a 20-percent increase.

The final trial was performed

on rosemary with slight powdery mildew when we started spraying on a weekly interval. We tested four phosphonates as well as four strobilurins. The specifics (products and rates) and two sets of disease data are shown in Figure 4, page 37. The best control was achieved with Cygnus, but all of the phosphonates were statistically as effective as the best fungicides in the trial (strobil-

continued on page 72

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"Phosphonates" continued from page 38

Figure 5.

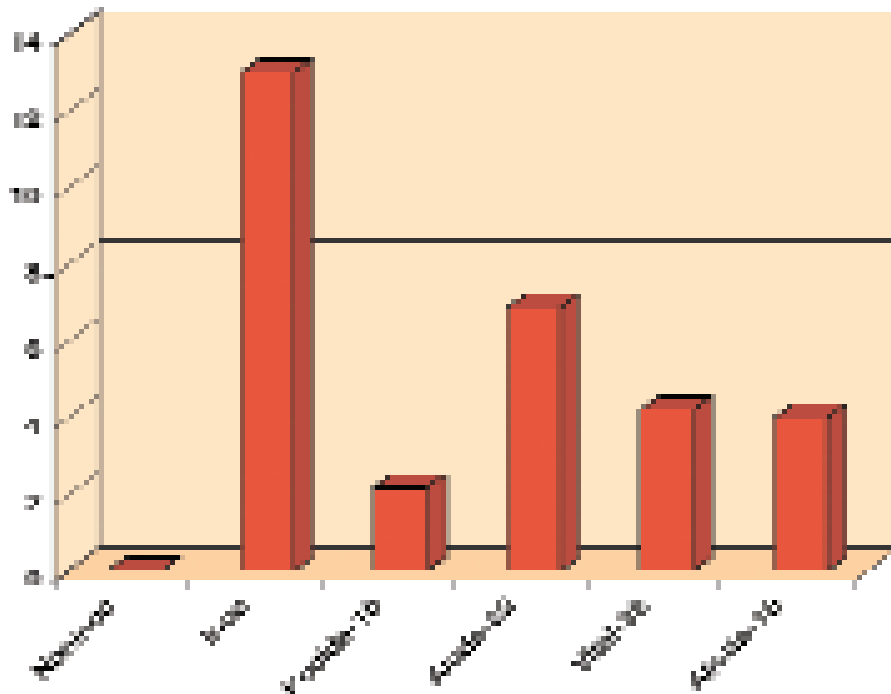


Figure 6. Spray solution pH for various concentrations of some phosphonates.

Phosphonate	16 oz.	32 oz.	64 oz.	80 oz.	96 oz.
Aliette	4.84	4.41	N/A	3.88	N/A
Alude	N/A	6.19	6.06	N/A	5.98
Biophos	N/A	6.87	6.83	N/A	6.78
Fosphite	6.42	6.33	6.22	N/A	N/A
Mimik	N/A	5.99	5.76	N/A	5.66
pHortress	N/A	5.85	5.60	N/A	5.54
Vital	N/A	6.31	6.23	N/A	6.17

urins). Not only do phosphonates control powdery mildew on some ornamentals they can also be used as a curative treatment with similar results as industry standards like strobilurins, sterol inhibitors and Pipron.

BACTERIAL LEAF SPOT CONTROL

I spent part of seven years and a lot of Rhone Poulenc's grant money trying to figure out how to use Aliette for bacterial disease control while I was a professor at the University of Florida. The first question we tried to answer was whether or not the phosphonates, other than Aliette, could control bacterial leaf spots on ornamentals. The first test was sprayed four times on a 10-day interval starting before they were inoculated. The severity of *Xanthomonas* on stock (*matthiola*) evaluated some phosphonates (see Figure 5, page 38). Some control was achieved with all treatments, but

the best control was seen when plants were treated with Kocide TNO, though the phosphonates were statistically equivalent.

The second trial with *Xanthomonas* blight on ranunculus compared Mimik (64 oz. per 100 gal.) to Camelot (20 oz.) and Phyton 27 (20 oz.). Plants were sprayed four times on a weekly interval starting before they were inoculated. Both Camelot and Phyton 27 gave good control, with Mimik supplying slightly less control. All three were significantly better than the inoculated control but not different than each other and not as good as the non-inoculated control. In summary, the phosphonates do give similar control to Aliette on some bacterial leaf spots.

Florida growers had discovered that 1 percent vinegar could control some bacterial leaf spots (e.g., *Xanthomonas* leaf spot on English ivy). Knowing that an Aliette spray was very acidic (pH of 3.5-4 in our water at the



Top: *Xanthomonas* blight on stock (*matthiola*). Bottom: *Xanthomonas* leaf spot on ranunculus.

research center) I compared efficacy of Aliette to 1 percent vinegar and copper. All three were effective on *Xanthomonas* diseases. Although the alternatives to Aliette are often referred to as phos acids, they are not very acidic (see Figure 6, page 38).

The rates we checked for solution pH were those given on the product labels. The pH in our well water registered 7.78. The pH readings lead me to question whether or not we could safely tank mix a copper with any of them. This would be an ideal tank mix to minimize resistance development if we could apply it without copper damage. Low pH increases the availability of copper, making tank mixes with Aliette impossible on most herbaceous plants. We performed one

trial on two sensitive bedding plants (impatiens and wax begonia). The phosphonates were all tank mixed with 20 oz. per 100 gal. of Phyton 27 and applied a single time to drip. Phytotoxicity was evaluated after three days and again after one week.

The combination of Aliette and Phyton 27 did result in significant copper burn as did the combination of Fosphite or pHortress and Phyton 27. Phyton 27 alone was completely safe on these plants. This cannot be explained by the pH of the solution alone since the Fosphite combination had a higher pH than others that were safe. The other treatments did not show any phytotoxicity in this trial. Our previous trials have shown some phytotoxicity from phosphonates on sensitive bed-

ding plants. Apparently, some phosphonates can be tank mixed with Phyton 27 safely. Testing the safety of the phosphonate alone is recommended on bedding plants and other herbaceous crops at a young stage. It remains to be seen in future testing if the tank mix is

Figure 7. Phytotoxicity of copper tank mixes with phosphonates on two bedding plants. Damage was rated on the following scale: 1 = none, 2 = slight burning, 3 = moderate, 4 = severe, 5 = plant dead.

Phosphonate	Rate per 100 gal.	pH test solution	Wax begonia	Impatiens
Water	N/A	7.91	1	1
Phyton 27	25 oz.	6.20	1	1
Aliette/P27	64/25 oz.	4.06	3	2
Alude/P27	64/25 oz.	5.88	1	1
Biophos/P27	64/25 oz.	6.65	2	2
Fosphite/P27	64/25 oz.	6.15	3	2
Mimik/P27	64/25 oz.	5.57	1	1
pHortress/P27	64/25 oz.	5.35	2	2
Vital/P27	64/25 oz.	6.11	2.5	20

efficacious for bacterial diseases.

CONCLUSIONS

Phosphonates continue to be developed and will be used by ornamental producers for years to come. They are unique in their ability to reduce some diseases by direct action as well as indirect action as a systemic acquired resistance (SAR) initiator. They are very effective for oomycete diseases like Phytophthora aerial blight, Pythium root rot and downy mildew. They also work very well on powdery mildew and almost as good as copper on some bacterial leaf spots. In the future, we will try to define other targets for phosphonates, including rust, Anthracnose and other leaf spots.

One final word of caution — be sure to read the labels of each pesticide carefully and follow the directions for legal and safe use. The label is the law! GPN

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