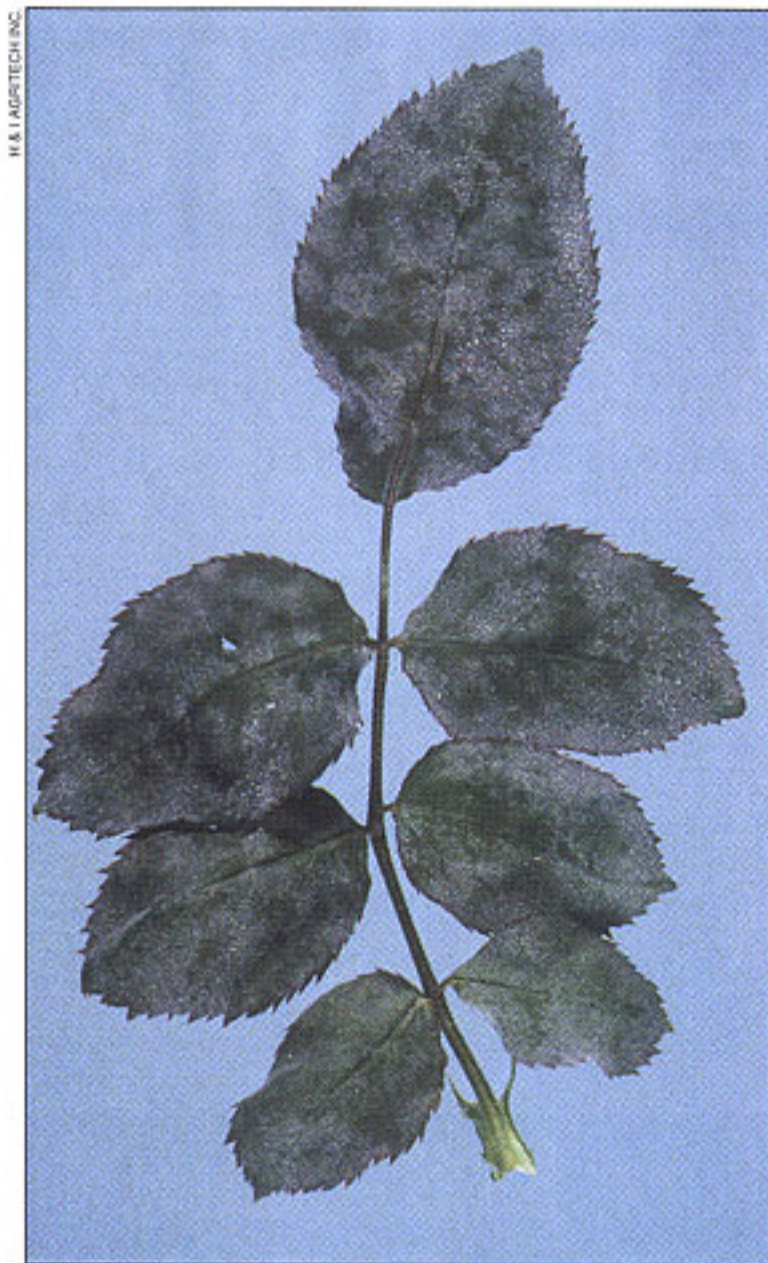


Fungicides for the FUTURE

Biocompatible formulations containing bicarbonates offer an effective, environmentally safe alternative to current fungicides.

By Dr. Kenneth Horst



Effect of Potassium Bicarbonate Formulations on Powdery Mildew Spores

| Formulation | Total No. of Spores Collected Before Treatment | Total No. of Viable Spores After Treatment | Total % of Viable Spores |
|-------------|--|--|--------------------------|
| D | 1,224 | 0 | 0 |
| Armicarb | 1,263 | 0 | 0 |
| E | 1,724 | 0 | 0 |
| F | 1,070 | 6 | 0.6 |
| G | 1,196 | 4 | 0.3 |
| Water | 2,249 | 730 | 32.5 |

Since the late 1940s, agricultural chemicals have served as the principle means of plant-disease control. The pesticide market today is quite large. Fungicide sales alone amount to \$500 million per year in the US and \$4 billion per year worldwide. Yet, due to increasing public concerns over the safety of pesticide use, the Environmental Protection Agency has begun limiting the number of pesticides registered for legal use.

Over the last 10 years, 35 percent of registered pesticides have been recalled, reviewed and withdrawn from the market. Just last year, the EPA canceled 1,215 pesticide registrations, and that trend is expected to continue as the ramifications of using these products become more readily apparent. As the need for safer pest-control methods increases, researchers have begun looking to biocompatible fungicides, which are those that exhibit low mammalian and environmental toxicities.

Two biocompatible candidates, bicarbonate salts and horticultural oils, have been shown to control activity against specific pathogenic fungi. At Cornell University, Ithaca, NY, we wanted to determine the effectiveness of both candidates, singly and in combination, in controlling powdery mildew on roses. This condition, which is caused by the fungus *Sphaerotheca pannosa* var. *rosae*, is the most widespread and destructive disease of roses in the world.

We chose four *Rosa* cultivars for the study: 'Kardinal', 'Osiana', 'Samantha' and 'Melody'. More than 1,000 plants were studied and all showed signs of powdery mildew. Several plants of each species were sprayed with one of the following treatments: potassium bicarbonate combined with the horticultural oil Sunspray UFO, sodium bicarbonate combined with Sunspray UFO, potassium bicarbonate alone, sodium bicarbonate alone, Sunspray UFO alone and ammonium bicarbonate. Control plants were treated only with water. Treatments were applied

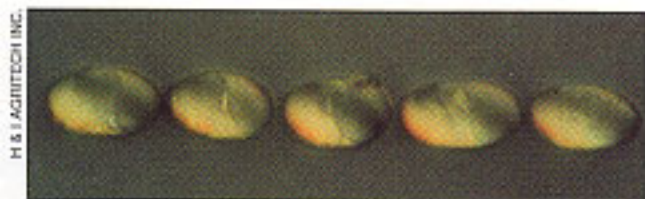
Powdery Mildew Control and Phytotoxicity of Potassium Bicarbonate Formulations

| Species | Formulation | Result |
|--|---------------------|---|
| <i>Acer rubrum</i> | H | Good control, no phytotoxicity |
| <i>A. rubrum</i> | I | Excellent control, stunted leaves |
| <i>Centaurea montana</i> | J | Excellent control, no phytotoxicity |
| <i>Chrysanthemum</i> × <i>morifolium</i> | K | Excellent control, no phytotoxicity |
| <i>Euphorbia pulcherrima</i> | K | Good control, young-leaf distortion |
| <i>Heliopsis scabra</i> | J | Excellent control, no phytotoxicity |
| <i>Melissa officinalis</i> | J | Excellent control, no phytotoxicity |
| <i>Phlox</i> | J | Fair to good control, young-leaf distortion |
| <i>Pulmonaria</i> | J | Excellent control, possibility of wrinkling |
| <i>Quercus</i> spp. | I | Good control, leaf distortion |
| <i>Quercus</i> spp. | I (diluted formula) | Good control, no phytotoxicity |
| <i>Quercus</i> spp. | L | Good control, no phytotoxicity |
| <i>Rhododendron</i> | I | Excellent control, no phytotoxicity |
| <i>Verbena</i> | J | Good control, no phytotoxicity |
| <i>Zinnia</i> | K | Good control, no phytotoxicity |

Selected Potassium Bicarbonate Powdery Mildew Ratings (Mean Percentage of Lesions per Plant)

| Variety | Formulation | 3 Sprays | 4 Sprays | 5 Sprays |
|------------------------|-------------|----------|----------|----------|
| <i>Rosa</i> 'Kardinal' | A | 0.01 | 0.07 | 0.48 |
| | B | 0.09 | 0.00 | 0.02 |
| | C | 0.06 | 0.10 | 0.11 |
| | Water | 2.19 | 2.74 | 3.36 |
| <i>R.</i> 'Osiana' | A | 0.38 | 0.06 | 0.60 |
| | B | 0.22 | 0.02 | 0.23 |
| | C | 0.30 | 0.11 | 0.33 |
| | Water | 2.90 | 3.06 | 3.92 |
| <i>R.</i> 'Samantha' | A | 0.97 | 0.97 | 1.69 |
| | B | 0.40 | 0.28 | 0.61 |
| | C | 0.51 | 0.36 | 0.98 |
| | Water | 2.57 | 3.14 | 4.03 |
| <i>R.</i> 'Melody' | A | 0.83 | 0.46 | 0.74 |
| | B | 0.35 | 0.04 | 0.30 |
| | C | 0.32 | 0.40 | 0.59 |
| | Water | 4.07 | 4.53 | 4.45 |

Opposite: The untreated rose leaves (left) display symptoms of powdery mildew, but after treatment with potassium bicarbonate, the symptoms disappear (right).



Magnified healthy powdery mildew spores (top) die after treatment with potassium bicarbonate (bottom).

weekly, and the plants were inspected and rated for signs of mildew each week for a period of six weeks.

And the Winner is ...

Our studies revealed that bicarbonate and horticultural oil combinations are effective in controlling powdery mildew on all cultivars. Apparently, the spreader-sticker quality of Sunspray UFO enables the bicarbonates to be more easily applied and to stay on the plant. When it comes to choosing among bicarbonates, however, the combination of potassium bicarbonate and Sunspray UFO was proved more effective than the combination of sodium bicarbonate and Sunspray UFO. The next most effective treatments were potassium bicarbonate alone, followed by sodium bicarbonate alone, Sunspray UFO alone, ammonium bicarbonate and water.

Although Sunspray UFO provides an effective sticking property, repeatedly using it at its label-recommended dosage can cause serious phytotoxicity to roses. Therefore, we assessed the spreader-sticker effectiveness and phytotoxicity of alternative additives. We tested 350 possible biocompatible additives and found 10 to 12 to be efficacious in controlling the disease in a rapid detached leaf assay. Our next step was to field test the effectiveness of these 10 to 12 bicarbonate formulations on powdery mildew. Each formulation contained potassium bicarbonate and one of the biocompatible additives.

The formulations that provided the best powdery mildew control are shown in the table on page 59. The roses are listed in order of increasing susceptibility to mildew. Those formulations demonstrating an impressive capability for killing powdery-mildew spores are shown in another table on page 59. In addition, no phytotoxicity was exhibited for any of the formulations tested.

Based on these results, the best formulation from the trials was registered with the EPA under the name Armicarb. It will be available in early 1997 for commercial use as a powdery mildew control for horticultural plants.

In trials at Cornell University, Armicarb has performed well on the rose varieties as compared to traditional mildewcides. It has been effective in controlling powdery mildew on other species as well, as shown in another table on page 59. Armicarb is also cost-effective; its cost per 100-gallon application is less than or equal to five of the six powdery mildew-control products currently on the market.

Research results indicate that bicarbonates are effective biocompatible fungicides. The EPA's designation of bicarbonates as "generally regarded as safe" (GRAS) confirms their ecological safety. In fact, the EPA granted Armicarb's registration less than six months after submission. Its label provides the proper concentrations to be used and the precautions to be exercised.

People often wonder if store-bought baking soda (sodium bicarbonate) will provide the same adequate disease control

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as Armicarb if sprayed on plants along with an oil or soap. The answer is no, because Armicarb's active ingredient is *potassium* bicarbonate. Armicarb also has an excellent spreader-sticker additive built into the formulation.

H & I Agritech Inc., also in Ithaca, is continuing to work on biocompatible bicarbonates and other biocompatible chemicals. A whole new family of environmentally safe disease- and pest-control tools for consumer and commercial use is anticipated from these efforts. Our experiments also revealed that ammonium bicarbonate formulations are effective in controlling soil-borne pathogens such as dollar spot (caused by *Sclerotinia homeocarpa*) and Pythium blight (caused by *Pythium*). Ammonium bicarbonate's control of these diseases was not only comparable to Terraclor and Truban, but its use enhanced specimen growth. Perhaps, in time, safer chemicals will be available for all plant ailments.

Dr. Kenneth Horst is a professor of plant pathology at Cornell University, Ithaca, NY, and is president of H & I Agritech Inc., also in Ithaca. He specializes in ornamental plants and has written two books on the diseases that attack them.