miracle, myth…or marketing

Baking soda

will fungi fail and roses rejoice?

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I grew up in a household where baking sod—a.k.a. sodium bicarbonate—was used for all kinds of purposes besides baking. It was great for brushing your teeth, deodorizing the fridge, and mixing with vinegar to make bottle rockets. A somewhat less spectacular outdoor use for baking soda is as a fungicide. Rose aficionados, in particular, swear by its ability to kill the fungi responsible for black spot disease *(Diplocarpon rosae)*. Let's explore the research behind this belief.

A. Does baking soda kill fungi?

In a word—no. Researchers in the early 1930s discovered that sodium bicarbonate (SBC) solutions created pH conditions hostile to the growth of blue and green citrus molds (*Penicillium* spp.). The spores of these and many other fungal species germinate best under acidic conditions, and SBC solutions are significantly more alkaline. Though early researchers thought baking soda was fungicidal (fungi were killed), later studies determined that it is fungistatic (fungi are prevented from growing but are not killed) even when used at high concentrations.

From a practical standpoint, this means that fungal (and bacterial) spores will not germinate as long as the pH of their surrounding environment is sufficiently alkaline. If and when the environment becomes more acidic, spore germination can resume.

One key to successfully using baking soda as a fungicide, therefore, is to apply it under controlled conditions, such as those used to store produce. Once removed from the parent plant, fruits and vegetables can be rapidly colonized by various bacteria and fungi. Though such diseases may be prevented or treated by application of traditional pesticides, interest in organically acceptable treatments is increasing and in this regard, SBC has had some demonstrated success *(Table 1)*.

B. To protect fruits and vegetables

There is considerable literature on this topic, much of it devoted to controlling citrus fruit mold. You've probably seen blue or green citrus molds on oranges whose rinds have been damaged. The acidic nature of citrus (and most other fruits) creates a perfect pH environment for fungal spore germination.

The thick, protective nature of citrus rind allows you to take some pretty drastic measures to control disease. Boiling baths of SBC solutions are routinely used to kill fungi and prevent future spore germination without damaging the fruit inside. SBC can also be applied to fruits with thinner skins, but generally at a lower concentration to prevent damage. Trials have found two to three percent SBC to have some effectiveness in controlling post harvest diseases of a veritable farmer's market of fruits and vegetables *(Table 2)*.

However, other researchers found sodium bicarbonate effects either inconsistent or less beneficial than other treatments, including borax, potassium, potassium sorbate, sodium carbonate, and conventional fungicides. Since sodium bicarbonate alone is not consistent in its ability to fight fungi, researchers have combined SBC with other disease control measures, such as using it to increase the efficacy of newer, reduced-risk fungicides.

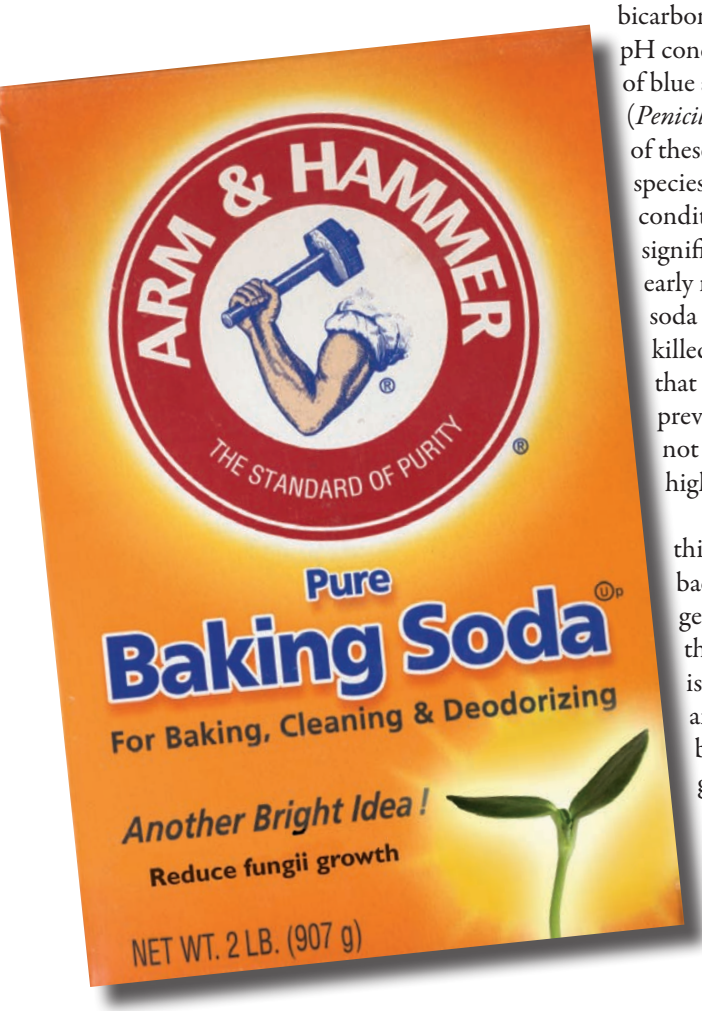

Table 1

General effectiveness of sodium bicarbonate (SBC) in disease control.

SBC formulation	Usage	Efficacy	Notes
SBC alone	Postharvest disease	-/+	Increased disease control with increased temperature and/or SBC concentration
SBC + wax	Postharvest disease	+	Works with smooth-skinned produce
SBC + chemical fungicide	Postharvest disease	+	Especially good with newer, reduced risk fungicides
SBC + microbial antagonist	Postharvest disease	+	Nearly always effective
SBC alone	Foliar (powdery mildew)	-/+	Highly dependent on disease pressure, environmental conditions; can be phytotoxic
SBC + oil	Foliar (powdery mildew)	+	Effective even with mildew epidemics
SBC (any formulation)	Foliar (other than powdery mildew)	-/+	Little research; primarily ineffective; some positive outcomes

Table 2

Summarized results of SBC application for postharvest disease control.

Disease organism	Efficacy
Alternaria spp.	Good to marginal
Aspergillus spp.	Good to poor
Botrytis spp.	Good to poor
Colletotrichum spp.	Good to poor
Fusarium spp.	Good
Geotrichum spp.	Marginal
Gliocladium spp.	Good
Helminthosporium spp.	Marginal
Monilinia spp.	Good to poor
Penicillium spp.	Good to poor
Phomopsis spp.	Marginal
Rhizopus spp.	Good to marginal
Sclerotium spp.	Good
Thielaviopsis spp.	Poor

Table 3

Postharvest application of antagonistic microbes.

Disease organism	Efficacy
Alternaria spp.	Good
Botrytis spp.	Good
Colletotrichum spp.	Good to poor
Monilinia spp.	Good
Penicillium spp.	Good
Pythium spp.	Good
Rhizopus spp.	Good

Postharvest disease

The most promising research toward postharvest disease control appears to be using SBC in combination with microbial antagonists, primarily yeasts, which colonize the fruit and prevent growth of disease organisms *(Table 3)*. SBC does not affect the growth of these microbes, which are themselves harmless to the fruit. In many studies, the treatment is synergistic, meaning that the combination of SBC and yeast is more effective than the additive effects of each treatment alone. It's likely that SBC inhibits the spread of the disease organisms, and the available surface of the fruit is then colonized by harmless microbes.

C. Using baking soda on leaf diseases

By far the most studied application of sodium bicarbonate has been as a deterrent to several genera of foliar powdery mildew. Low levels of SBC (0.5-2%) were found to reduce germination and growth of several mildew species in the lab. In greenhouses, where powdery mildews are prevalent on plants of agricultural and ornamental importance, weak solutions of SBC (0.5-1.0%) have been used successfully without causing significant phytotoxicity. In field research, however, SBC has provided fewer consistent results, with good, marginal, or poor control of powdery mildew species reported equally on crops *(Table 4)*. No patterns emerge either among crops tested or mildew species controlled, most likely due to environmental variability in field conditions.

Other treatments have been more successful in powdery mildew control, including horticultural oils, potassium bicarbonate, potassium phosphate, sulfur, milk, and even water sprays. Probably the most field success has been found in combining SBC with horticultural oils, including mineral and vegetable oils *(see the Fall 2008* MasterGardener *magazine).* The mixtures are so effective that they've been successful even on serious powdery mildew epidemics.

D. Drawbacks of baking soda

Because the disease-fighting properties of sodium bicarbonate have been studied for many decades, several practical drawbacks have been identified. While dilute solutions of SBC have been strongly inhibitory to fungal spore germination in lab, this phenomenon does not translate to the greenhouse, nursery, or landscape. Repeatedly, studies have found that significantly higher concentrations of SBC are required to have any effect in these practical settings. Particularly difficult to control are diseases on stems (where the solution runs off) and the lower surfaces of leaves (which are difficult to spray). Furthermore, SBC is a water-soluble compound, and any efficacy it may have is washed away with the next rainfall.

While SBC efficacy increases with concentration, so do the phytotoxic effects, presumably due to sodium content. Stored

Table 4

Summarized results of SBC application for foliar disease control.

Disease organism	Efficacy
Alternaria spp.	Good to marginal
Aspergillus spp.	Poor
Botryosphaeria spp.	Good
Botrytis spp.	Good to poor
Claviceps spp.	Marginal
Coniella spp.	Good
Erysiphe spp.	Good to marginal
Escherichia spp.	Poor
Fusarium spp.	Good to poor
Guignardia spp.	Good
Leandria spp.	Poor

Disease organism	Efficacy
Leveillula spp.	Good to poor
Oidium spp.	Good to poor
Ovulariopsis spp.	Good
Peronospora spp.	Good
Phyllachora spp.	Good
Plasmopara spp.	Poor
Puccinia spp.	Good to marginal
Spilocea spp.	Poor
Sphaerotheca spp.	Good to poor
Uncinula spp.	Good to poor
Venturia spp.	Marginal

fruits can experience weight loss and undesirable aesthetic alterations such as changes in color or presence of SBC residues with as little as 2 percent SBC. Phytotoxicity is even more problematic on foliage, where even a 1 percent SBC solution can cause severe foliar damage, including interveinal chlorosis.

E. This is all really fascinating, but what about rose diseases?

There are several articles in the scientific literature that explore the efficacy of baking soda in treating rose diseases. Five studied the effect of sodium bicarbonate on powdery mildew. Though sodium bicarbonate reduced the mildew *(Sphaerotheca pannosa* var. rosae) attack in all five studies, suppression was short-term, not as effective as potassium bicarbonate, potassium phosphate, phosphate salts, or wine vinegar, and in one case was phytotoxic even in a dilute (1%) solution.

Better results are found when sodium bicarbonate is combined with horticultural oil. Two groups of researchers sprayed roses in the landscape with solutions of sodium bicarbonate mixed with horticultural oil for treatment of black spot *(Diplocarpon rosae).* Both groups report the treatment to be effective in reducing, but not eliminating, powdery mildew, especially when disease pressure was low. The importance of an organic mulch to suppress disease inoculum (and thus depress disease pressure) was emphasized by one article. It is important to note that in both cases it was mixtures of sodium bicarbonate and horticultural oil applied, not simply baking soda.

Unfortunately, neither of these articles is mentioned in the on-line resource "Using Baking Soda as a Fungicide." Most of the claims presented in this article come from non-scientific resources, as do the recommendations. One assertion—that "a 0.5% solution [of baking soda] was most effective in preventing blackspot"—directly contradicts the published work of the researcher who is supposedly quoted! Yet this on-line article is cited thousands of times on the Internet as proof that baking soda will prevent black spot on roses.

F. How about using baking soda to control other fungal diseases?

There are a handful of articles testing the value of SBC on ornamental plants other than roses in field situations. Unfortunately, the results are not encouraging. SBC did not reduce powdery mildew on lilacs, marigolds, or rosemary and in the latter case caused severe foliar damage. Neither was it effective in treating white rust in field-grown chrysanthemums. Only when combined with horticultural oil was SBC useful in treating powdery mildew in Euonymus. Baking soda itself is not likely to control fungal disease in your garden or landscape, but very easily could cause leaf damage if used at a higher concentration. Low concentrations of SBC, combined with a horticultural oil, may have some effectiveness on mild cases of powdery mildew.

The most promising strategy I've seen for controlling fungal diseases—the use of microbial antagonists in combination with SBC—has only been developed for post harvest disease control. So far, there are no similar, published efforts for addressing foliar diseases.

G. Then what's the best strategy for reducing black spot and other foliar disease in the landscape?

As with most landscape problems, there is no "miracle cure" for rose black spot. There are, however, some simple, straightforward precautions you can take in treating fungal diseases in your landscape and garden:

Always remember "right plant, right place." When we moved to our current house, there were three rose bushes in the back yard (north-facing) that perpetually had blighted buds caused by *Botrytis cinerea.* Moving these bushes to the sunny front yard completely solved the problem.

Coarse organic mulch has been shown to decrease incidence of rose black spot. When I reviewed the literature on landscape mulches, I found this same conclusion held true for other foliar diseases: coarse organic mulches can combat spread of diseases through physical, chemical, and biological means. So rather than using landscape fabric—or worse, leaving your soil bare—cover it with a thick layer of mulch, such as wood chips.

Baking soda and other reduced-risk pesticides work best if used when disease levels are low. Treat the problem right after symptoms appear; don't wait until you have a fungal free-for-all. And keep roses and other susceptible plants well hydrated in the summer. This improves their overall resistance to stress. ■