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The Myth of the Magic Bullet

"Success in the lab guarantees success in the field"

The Myth

Managing landscapes sustainably requires, among other things, reducing the use of harmful chemicals in the form of fertilizers and pesticides. This has led to a surge in environmentally-friendly products on the market that purportedly work as well or better than traditional pesticides. One of these products is harpin, a protein isolated from the bacterium (*Erwinia amylovora*) responsible for fire blight on fruit trees. This compound can induce the biochemical pathways responsible for disease resistance in laboratory plant systems through a process called systemic acquired resistance (SAR). Since I have received several inquires regarding the efficacy of this product on landscape plants, I obtained a packet of the promotional materials for harpin marketed by Eden Bioscience under the Messenger® brand name.

The packet includes technical bulletins, a reprint of the *Science* journal article that first reported the existence of harpin, experimental data developed by the company, testimonials from gardeners, a CD entitled "The Science Behind Messenger® Home and Garden", an endorsement from the American Rose Society, and a free sample of the product. The EPA fact sheet on harpin confirms the low environmental risk and states that harpin protects "many crops, including vegetables, traditional agronomic crops and ornamentals" against certain viral diseases, soil-borne pathogens and pests. Furthermore, the fact sheet continues, harpin "reduces infestations of selected insects and enhances plant growth, general vigor, and yield" of these same plants. EPA also bestowed their Presidential Green Chemistry Challenge award on this product in 2000. It sounds like the "magic bullet" that landscape managers have been seeking.

The Reality

My first reaction upon reading the EPA fact sheet was that there must be a solid body of scientific research to support the application of this material to the many plant species alluded to in the EPA fact sheet. Upon contacting EPA regulators, I was surprised to learn that efficacy data are not required for pesticide regulation: the concerns instead are focused on environmental and human safety. While these are important criteria, it means that the EPA depends on product manufacturers to supply objective and accurate information regarding the effectiveness of its product.

What are the specific manufacturer claims for harpin efficacy on garden and landscape plants?

Here are direct quotes from the sales literature provided with Messenger®:

- "A 'vaccination' that naturally supercharges every plant in your garden."
- "Messenger® treated plants are healthier, more vigorous, better able to resist stresses from adverse weather or pests, and are more productive."
- "Flowers, vegetables, shrubs, trees and even grass treated with Messenger® turn up their natural growth and defense mechanisms empowering the plant to take up more nutrients, grow quicker and larger and have a stronger resistance to stress and disease."

There are many other absolute statements in the sales literature, which, when considered along with the Science reprint and EPA award would lead any rational reader to assume that these statements had been scientifically validated. Since the informational packet contained no peer-reviewed studies documenting

the success of harpin field applications, I turned to the scientific literature databases to answer my questions.

How does harpin work?

This protein is thought to have its initial effect on the cell walls of the host plant. The most effective way to induce the response is through tissue infiltration into the intercellular spaces (spaces between individual cells within a leaf or other tissue). Then, as the discoverers of harpin explain, "harpin elicits the [response] in many plants including tobacco, pepper, sunflower, tomato cabbage, *Arabidopsis*, cucumber, geranium, watermelon and lettuce." This methodology works well with soft leaf tissues in a laboratory environment, but tissue infiltration is not a realistic application for whole plant work, especially in field situations.

Field application of harpin is subject to other practical problems as well. Harpin cannot be mixed with chlorinated water, so users must have a source of deionized water. Secondly, users must be able to predict disease incidence or arrival of pest insects, since plants require 5-7 days to become resistant after application of harpin. To overcome this problem, the manufacturers suggest applying the material every 2-3 weeks while the plants are growing – but at a suggested retail price of about $20 per application, this can become a very expensive proposition. Third, some university researchers have suggested that climatic conditions will affect field success, where areas with longer growing seasons or higher levels of sunlight might exhibit greater success than cooler, shadier regions.

What is the current science behind harpin?

Laboratory work: Less than a dozen crop species have been studied thus far for harpin activity, and nearly all of those studies have focused on cell culture or plant tissue responses. Experimental models such as these are useful for laboratory experimentation, but they have limited application to whole plant systems, especially those in uncontrolled environments. The results from such studies may not accurately predict what will happen in the field using the same species, and should not be used as indicators of effectiveness on other species. Therefore, the numerous papers that have focused on *Arabidopsis* and tobacco cell culture responses do not provide reliable information in predicting harpin activity in roses or any other landscape plant.

Greenhouse and field work: The scientific literature with direct connections to landscape application of harpin is limited to a handful of articles and includes primarily annual crop species (such as cotton, tomato, and cucumber) and fruit trees (apple and citrus). The results here were not positive: for example, harpin application did not reduce tomato bacterial spot, control citrus canker, or increase cotton crop production. I found no peer-reviewed literature that reported consistent control of any pathogen on any crop, or dependable evidence of improved growth and/or yield. There are no laboratory or field studies on any woody landscape species.

Technical reports from university research, though not as thoroughly vetted as published articles, still can provide useful and generally objective information. Here are some excerpts from reports I was able to access over the Internet:

Cornell University: "Overall, Messenger® did not increase [sweet corn] plant productivity or yield." "In the last 2 years of testing, Messenger® has given only marginal control [of tree fruits]." "No differences in yield or quality were observed by application of Messenger® [on peppers]."

Iowa State University: "None of the treatments significantly [including Messenger®] reduced disease incidence [on strawberry] or improved yield in these trials. The biological control treatments even had lower yield than the unsprayed controls in the gray mold trials."
Kansas State University: "It does not appear that…Messenger® had any effect on wheat growth, development, disease tolerance, or grain yield."
Michigan State University: "…all the fungicide treatments (with the exception of Messenger®…)…significantly limited foliar blights [of celery]."
Texas A&M: "No significant differences were observed among yields [of peanuts]."
University of Georgia: "Tests in Georgia have shown no benefit in disease control."
University of Kentucky: "Harpin…has not performed well in replicated tests." "**…**no change in blue mold activity with increasing rate of Messenger® – strong evidence of the lack of efficacy of this product."
University of Tennessee: "Regular sprays of Messenger®…did not significantly affect seedling disease incidence, early growth, or yield of fall spinach."
Washington State University: "Messenger® did not control *Alternaria* leaf spot [in cabbage] relative to plants receiving no fungicide sprays." Furthermore, treated plants **"**showed premature senescence and abscission of the older leaves**."** In another study, Messenger® appeared to have a positive effect on cherry and pear fruit size, but "results in apple were mixed." A third study on disease control in wine grapes states that Messenger® is "generally considered ineffective."

It is troubling that the EPA took none of the negative or inconclusive scientific data into account prior to releasing their fact sheet, which illustrates the conflict of interest inherent in allowing product manufacturers to submit efficacy information without external validation. As retired University of Kentucky Extension Pathologist Dr. William Nesmith states, "The EPA assumes that the market place and lawyers will resolve issues related to poor efficacy. I urge growers to always ask for experimental data when considering disease control decisions." I would further suggest that you ask for scientifically vetted experimental data. If they are not available, take all "magic bullet" claims with a grain of salt.

The Bottom Line

- Controlled laboratory experiments do not necessarily translate to greenhouse or field success.
- It is unrealistic to assume that annual plant species can be used as a predictive model for the management of woody species.
- Consider the practical and financial drawbacks of any management practice before purchasing a new product.
- Don't succumb to advertising hype – ask for objective and balanced opinions.

For more information, please visit Dr. Chalker-Scott's web page at http://www.theinformedgardener.com.