The University of Alabama

FreezePruf Offers Protection for Crops Threatened by Falling Temperatures

When freezing temperatures hit Florida with unexpected strength in early 2010, they wiped out 30 percent of some growers' citrus crops, killed 70 percent of tomatoes in southwest Florida and wreaked havoc on crops ranging from sweet corn to green beans. Losses were estimated in hundreds of millions of dollars, according to the *Wall Street Journal*.

The impact was felt well beyond the growers themselves. One northeastern supermarket group reported a 40 percent increase in wholesale prices for tomatoes, lettuce and other produce.

If the risk of a killing freeze is growers' collective nightmare, biologist David Francko, Ph.D., has a solution — an antifreeze for plants that can keep oranges, tomatoes and other vulnerable crops growing past killing frosts and well into the fall.

"FreezePruf helps plants survive a freeze," says Francko, a professor of biological sciences at The University of Alabama (UA). "Applied at least 12 hours ahead of a projected freeze, FreezePruf can help crops avoid the blossom loss and fruit rot normally associated with freezing temperatures."

So far, the FreezePruf spray appears to be effective on nearly every kind of plant, from fruit trees to vegetable plants to ornamental flowers and shrubs. Francko and his team are working to extend the list.

"With almost 300,000 species of plants in the world," he says, "there's bound to be at least one it won't work on. But I haven't found it yet." In fact, the list of applicable plants is growing not just from his research but also from customer input.

"A real surprise was a call I got from the owner of a small vineyard in Virginia," Francko says. "We hadn't worked on grapes, so they weren't on our list of applicable plants, but the client said he used it on his Chardonnay grapes before an unexpected frost and they came through just fine."

As Francko sees it, FreezePruf is valuable for both commercial growers and home gardeners. With it, flowering and setting of fruit can be extended by as much as three weeks on either end of the season. Cold tolerance of foliage can be increased by as much as 9 degrees Fahrenheit, depending on the type of plant. He compares it to moving a growing zone 200 miles south.

He is quick to point out, however, that the product does not make plants invincible. "Expectations have to be reasonable. FreezePruf can protect tomato plants at 31 to 32 degrees, but it won't protect them for extended periods at 25 degrees," emphasizes Francko. "It likely won't save 100 percent of an orange grower's crop during a truly deep freeze, but it may save 50 percent of the crop

Laura Shill, University Relations, The University of Alabama

FreezePruf, developed by Professor David Francko (right), will help gardeners and commercial growers alike to survive frosts and extend their seasons. GroTech President Mark Russell (left) is working with Francko to take the product to market.

rather than the 5 percent that might survive untreated."

Transition Zones

Francko began working on cold-hardiness issues while on the faculty at Miami University in Ohio in the late 1990s. He continued the research at UA, where he relocated in 2006. He also serves as dean of the UA Graduate School and associate provost for the university.

"Southern Ohio is something of a transitional growing zone, and we were wondering whether some southern ornamental plants could succeed there," Francko says. His team at Miami included geneticists Kenneth Wilson, Ph.D., Quinn Li, Ph.D., and postdoctoral associate and co-inventor Maria Alejandra Equiza. Focusing on plants like palms and crape myrtles, Wilson and Li found that they relied on the same genes and pathway systems as cold-hardy varieties.

"That suggested that we might be able to genetically engineer plants," Francko says, "but I also wondered if there was something we could do with existing plants. I started looking for a mechanical approach."

At Miami, the work was supported by university funds and a grant from the Ohio Plant Biotechnology Consortium. A significant part of the work was done at Miami, and he couldn't have developed the technology without its support, Francko notes.

"Dave wanted to bring the project with him to Alabama so we worked out a compensation arrangement with Miami," notes Richard Swatloski, Ph.D., a licensing associate in UA's Office for Technology Transfer. "His UA work has been supported with university funds — and without any corporate support. Dave was concerned that the technology not be tied to a large manufacturer, where it might end up a minor side-product."

"If things like 'polyethylene glycol' and 'surfactants' sound unappealingly chemical," notes Swatloski, "they're all currently present in many consumer products and incorporated in many edible products. All of FreezePruf's components are agents already widely used in foods and to grow fruits. It's absolutely green — safe to eat and biodegradable."

Simulating Drought Stress

At Miami, Francko's search for a "mechanical approach" led him to think about "drought stress," the phenomenon plants rely on to avoid damage from low moisture levels and that can also make plants more cold hardy. A big issue in simulating drought stress was making sure that, as cells shrink in reaction to water stress, they do so uniformly, retaining their integrity and their ability to function.

It took him six months to find the right combination of agents. The key was polyethylene glycol (PEG), a common polyether compound that has applications ranging from lubricants in eye drops to pollutant removal in power plants. Its ability to prevent warping or shrinking in wooden objects by replacing the water in the wood has been utilized to preserve sunken wooden ships when they are raised.

"PEG drives the whole process, but FreezePruf is a combination of agents that work together, each with a specific role," Francko says. One, a surfactant, helps the agents quickly pass through the surfaces of leaves, flowers and fruit. Another, an antidessicant, reduces water loss from plant structures once the surface is dry.

Two cryoprotectants insulate against freezing temperatures. High-molecular-weight PEG stays largely outside the cells, pulling water from within them to lower the freezing points in both cell interiors and extracellular spaces. A second, low-molecular-weight compound partitions between the interior and exterior cell spaces, contributing to lower freezing points.

The high-weight PEG also interacts with cell membranes and walls to increase their resistance to ice crystal damage,

increasing plants' cold hardiness. And a silicate compound binds to cell walls to strengthen against ice crystal damage.

Going to Market

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Using existing ingredients also meant the product could bypass federal approval, although it still faced challenges.

"With its makeup of existing, approved ingredients, FreezePruf didn't require federal review," says Swatloski. "On the other hand, that meant we've had to get state-by-state approvals for it. We've worked our way through most of them.

"We applied for a patent on FreezePruf in 2007 and licensed the technology to a small company called GroTech-SM in 2008."

In fact, Oregon-based GroTech-SM has exactly one employee and one product — FreezePruf. Founder and President Mark Russell has worked for more than a decade as an independent consultant focused on commercial agriculture, dealing with issues ranging from crop development to product promotion to market expansion. He founded GroTech-SM — SM stands for sales and marketing — as a potential venue for his work in 2007.

He saw a UA news release about FreezePruf and called Francko to pursue the possibility of representing it in the Northwest. When he was told that the university was first looking for a company to help with commercialization, he explained instead that he thought he could take the new product to market.

"We thought we could make FreezePruf available at the retail level fairly quickly," Russell says. "We contracted with Liquid Fence to manufacture and distribute it, and it began appearing on shelves in the late summer of 2009."

Based in Brodheadsville, Penn., the Liquid Fence Co. specializes in gardening and farm materials such as deer and rabbit repellants, insect repellants for animals, and gardening accessories. It sells its products through retail distribution and by mail order, bottling FreezePruf in quart and gallon to multigallon quantities. At present, the majority of FreezePruf sales are at the retail level through independent garden centers, Russell says.

"Our agreement gives Liquid Fence the rights to package and sell at the retail level nationally," Russell notes, "but we hold the trademark and the rights to produce for the commercial market separately. I'm currently negotiating with several companies for commercial-level production and distribution."

It is, he notes, a relatively easy product to produce but an expensive one to ship. He expects to have several regional manufacturers producing FreezePruf PRO for the 2011 season.

A Ripe Future

"FreezePruf can be a valuable tool for commercial growers, whether for fruit trees, vines or vegetable crops," Russell says. "The challenge for the commercial market is that growers will test a product for two or three years before committing to it on a large scale. But I'm confident that will happen.

"This technology has the potential to help home gardeners get more from their plants, both vegetables and ornamentals. But in my mind it holds tremendous economic benefits for commercial growers in avoiding crop damage and financial losses due to freezes. And that will help all of us in terms of the prices we pay at the supermarket."

— Ralph N. Fuller