North Carolina State University, Raleigh, N.C.

A Seasoned Discovery Helps Keep Crops Fresh and 'Unweathered'

Invinsa helps crops manage heat and drought stress.

AgroFresh Inc.

Contrary to the image of scientists having sudden, stunning insights that abruptly change the world, most scientific advances occur in progressive steps over time, one stage building on another through years of systematic research.

A case in point: A synthetic compound called 1-methylcyclopropene (1-MCP). As SmartFresh, it helps keep apples, kiwis and other fruits fresh and crisp for consumers to purchase and eat long after they've been harvested. As EthylBloc, it's used by flower wholesalers to prolong freshness in their floral products.

Developed by biochemist Edward Sisler, Ph.D., and horticulturalist Sylvia Blankenship, Ph.D., at North Carolina State University (NC State), 1-MCP's discovery followed dogged work in the 1980s-1990s on the role of the organic compound ethylene in plant growth.

In 2011, advances by other scientists are adding a new role to 1-MCP's capabilities: Helping an array of growing crops remain productive through the stress of drought or extreme heat. Sprayed on plants facing a stretch of hostile conditions, the new Invinsa technology helps them weather the unfriendly conditions by preventing their normal response — wilting and shutting down.

It has the potential to help boost food production around the world — whether by rice farmers in Asia or corn growers in Iowa — improving crop yields in third-world countries where food supplies can be marginal and helping blunt price spikes for consumers in affluent societies.

Further, government tests on 1-MCP in the United States and other countries have found it safe for consumption and without impact on the environment.

Blankenship, now a professor of horticulture and an associate dean at NC State's College of Agriculture and Life Sciences, hasn't been involved in the latest developments. But she's pleased to see her foundational work still moving forward.

"I think it's wonderful," she says. "To know your work continues to evolve and to make a difference is a great feeling."

Finding SmartFresh

Both Sisler and Blankenship spent their careers studying the physiology and biochemistry of ethylene. The vapor-borne plant hormone plays multiple roles in plants' lives, from stimulating shoot growth, root formation and flower opening to triggering flower and leaf decay and fruit ripening. For Sisler, an early research goal was to find a way to speed up tobacco leaves' color changes in curing sheds.

A focus was ethylene's interaction with receptors on plants. It was a complicated process that included discovery of one substance (diazocyclopentadiene or DACP) that did inhibit ethylene. Although they patented it in 1993, DACP proved impractical for several reasons, including flammability.

"Eventually, we identified components of DACP that proved to be potent ethylene inhibitors," Blankenship says. "1-MCP was synthesized. It was remarkable in its ability to retard ripening. You could put an apple on a counter for a month and pick it up and eat it and it would be fresh. It worked on fruit, cut flowers, tomatoes."

Blankenship compares a plant's ethylene receptors to a lock — ethylene is the key that opens the lock and tells the plant to begin shutting down and the fruit to begin ripening.

"1-MCP is also a key, but not exactly the right key," she says. "You can insert it into the lock but can't turn it. Once it's there, it blocks the ethylene from acting."

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Once Sisler and Blankenship had their key, the next step was almost as formidable as the research. "Ed and I are classic scientists," Blankenship says. "We didn't know what to do next. In those days, you got on the university website, found a form for reporting patentable discoveries and sent it in. Then someone in the technology transfer office called and explained what you could and could not do."

"After the university secured patent protection in 1996," notes Kelly Sexton, Ph.D., assistant director for outreach and new ventures in NC State's Office of Technology Transfer, "the challenge was to get the technology commercialized. The Office of Technology Transfer and the inventors approached a number of food companies they thought might be interested, but without success.

"Finally, they decided to approach businesses in the flower industry. A small, family-owned company, Floralife responded." Sexton notes that both Floralife's tweak of 1-MCP into a floral product and its subsequent life as a fruit preservative were covered by NC State's patents. And although Sisler and Blankenship had no part in the latest product development work on Invinsa, NC State's patents for their foundational work apply to that as well.

Sisler's and Blankenship's original research was supported with research funding from the U.S. Department of Agriculture and the North Carolina Agricultural Research Service. After Floralife became involved, corporate funding underwrote further developments.

"By extending freshness, this compound gives growers, packers and wholesalers much more flexibility in taking their products to market, increases yields and reduces losses to waste," Lopez says. "Most of all it gives consumers access to crisp, fresh fruit almost year-round. When SmartFresh is used in combination with other storage technologies — such as controlled atmosphere — you get the best piece of fruit you can buy in the store."

At Floralife, chemist Jim Daly formulated it into a powder that could be mixed with water — when 1-MCP was then released into the air, it slowed the aging of the flowers. The product became a staple for the wholesalers who bring those flowers to market.

Since edible products weren't involved, there were only minimal regulatory requirements to be dealt with. But as Floralife scientists worked on their new technology, they recognized its potential for food preservation. In the late 1990s the small family-owned business approached the global technology company Rohm and Haas, which organized trials on apples. In 1999 it founded AgroFresh Inc. to commercialize the product they called SmartFresh. In 2009, Rohm and Haas — and AgroFresh — were purchased by the Dow Chemical Co. as wholly owned subsidiaries.

Worldwide Usage

"Today, SmartFresh is used around the world, from Europe to South Africa, New Zealand and China," notes Gerry Lopez, AgroFresh's vice president and director for agronomic crops. "SmartFresh is used to slow the ripening of about 50 percent of all apples harvested in the United States."

Apples are SmartFresh's No. 1 product, but it's also applied to fruits like pears, kiwis, plums and avocados. It's been tried for crops like tomatoes, as well, but since fresh tomatoes are available year-round, the economics are different. The product best serves single-harvest crops.

SmartFresh is a treatment that the fruit is exposed to, applied in enclosed spaces such as cold rooms. Simply introduced into the atmosphere within the enclosed space, it's absorbed by the fruits from the air.

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The Invinsa Factor

Still, in its 10-year life as a product, SmartFresh has been used only on fruit already harvested. AgroFresh's staff wondered if there was a way to extend its benefits to living plants — which would require applying it in the open air. In 2008, the company entered into a partnership with agricultural giant Syngenta to develop Invinsa. Scientists at nine universities throughout the United States and in Argentina contributed to research on forms — primarily sprays — that could be used outdoors.

"We started with flowers because we knew the kind of biological responses to look for," Lopez says. "Once we knew meaningful results were possible, we tried it on field crops — corn, soybeans, rice, wheat, cotton. Cotton responds extremely well. One benefit that emerged was its ability to help crops avoid their normal stress response."

Essentially, when besieged by drought or hot spells, growing plants respond by shutting down — allowing their flowers to wilt and their leaves to curl — and generating seeds to reproduce themselves. By blocking their ethylene receptors with Invinsa, the farmer has a way to prevent the stress response.

"Generally," Lopez says, "Invinsa increases plants' photosynthetic activity during stress and increases plant robustness. For corn, as an example, it produces larger ears with better kernel fill at the end of the ear. For cotton, it fosters early boll retention and limits ethylene boll abortion due to insect damage." The multiple-university studies have demonstrated that an Invinsa crop's yield will increase 5 to 15 percent compared to the normal yield in a stressed crop. Lopez expects the new product to reach market within the next several years.

But he adds a caveat: "This technology has a specific role. It's effective in defeating transient stress but it won't resolve the hazards of prolonged stress. If the farmer knows the drought or extreme heat is going to break in seven to 10 days, Invinsa will help bridge the crisis and provide a better yield at the end of the year."

Invinsa's first target market is likely to be rice crops in Asia, Lopez suggests — the stress of hot climates is more predictable than in more temperate climates. One challenge is the need to develop a range of appropriate delivery techniques — in the United States it might be applied to corn as a spray from a trailer pulled by a tractor and to rice by aerial spraying. In Asia, it's most likely to be administered by hand, suggesting multiple applications in a granular form.

"This is a superb example of the way that science continually builds upon itself," Lopez suggests. "It started with the laboratory research development of 1-MCP. It was a wonderful discovery. Scientists around the world have written hundreds of papers on its potential uses.

"EthylBloc and SmartFresh have had enormous impacts on people's quality of life. We think Invinsa has the potential to help support a sustainable food supply for a burgeoning world population."

— Ralph N. Fuller