

A DAY WITHOUT GENETICALLY ALTERED ORANGE JUICE

Florida's \$9 billion citrus industry is at risk from an insect-borne bacterial disease with no known cure. Many scientists argue the only solution is genetic engineering.



REUTERS/JOE SKIPPER

BY TOM BROWN
FORT PIERCE, FLA., DEC 3

FOR MANY AMERICANS, few things seem more wholesome than a glass of fresh-squeezed Florida orange juice, the

original "natural food." As former beauty queen Anita Bryant chirped more than four decades ago, in what remains a fondly remembered tagline: "A day without orange juice is like a day without sunshine." She wasn't talking about green oranges

or genetically altered ones, but that was then.

We live in a "world of nasty bacteria now," says Calvin Arnold, a scientist with the U.S. Department of Agriculture. An insect-borne bacterial disease that is ravaging Florida's



FIGHTING BACK: Dr. Calvin Arnold, a scientist with the U.S. Department of Agriculture, speaks during an interview with Reuters in his office in Fort Pierce, Florida September 26, 2010. REUTERS/JOE SKIPPER

citrus crop means the juice squeezed from the Sunshine State's fruit may soon come from trees that have had their genetic makeup modified.

The blight, commonly known as "greening," is the world's most destructive citrus disease.

GMO juice would likely be reviled by critics of the biotech industry as "Frankenfood." But Arnold and other experts say there simply may be no other choice in the battle against greening.

"It's the most serious disease threat that the Florida citrus industry has ever faced," said Arnold, a 67-year-old official with the USDA's Agricultural Research Service.

As the director of the U.S. Horticultural Research Laboratory in Fort Pierce, in the prime Indian River region of Florida's citrus belt, Arnold is on the frontlines of what he and others describe as an all-out push by the biotech industry, and geneticists in particular, to develop an effective weapon against greening.

Most scientists who have studied the problem seem to agree that genetic modification, and the cultivation of trees resistant to the bacteria that causes "greening" disease, currently hold out the only real long-term hope of fighting it.

CITRUS GREENING

Spread by tiny insect called psyllids, this bacterial blight is the world's most destructive citrus disease. Once a tree is infected, there is no cure

DISTRIBUTION

■ Asian citrus psyllid

■ Asian citrus psyllid with Asian form of greening disease

THE DISEASE

- ▶ Also known as Huanglongbing (HLB) or "yellow dragon disease"
- ▶ Thought to have originated in China in the early 1900s
- ▶ Causes tree leaves to yellow, fruit to become bitter and deformed, and eventually death of the tree

THE INSECT

4mm
Actual size

Asian citrus psyllid

Photo: Michael Rogers / Citrus Research and Education Center, University of Florida
Sources: University of California, University of Florida

That was the conclusion of a report sponsored by the Florida Department of Citrus and U.S. National Academy of Sciences in March, which highlighted the need for urgency to save Florida's \$9 billion citrus industry.

There are significant risks of failure, though, even as more money is poured into research. Much of the U.S. funding has come from Florida growers themselves, who have earmarked \$15 million for the fiscal year ending in June 2011 on 120 different projects aimed at coming up with a solution to greening.

For all their promise, since genetically modified crops made their commercial debut in the United States about 15 years ago, the biotech industry has so far had only limited success in using genetics to develop resistance to bacterial diseases.

If the new-age crop developers fall short now, it could dent some of their long-standing claims about ensuring global food security and making pesky farm pests a thing of the past.

According to Arnold, it could also mean that the large-scale citrus industry that exists in Florida today, which accounts for two-thirds of U.S. citrus fruit production, could be gone in as little as seven to eight years.

NO CURE, INDUSTRY SHRINKING

ALSO KNOWN AS Huanglongbing (HLB), or "yellow dragon disease," greening was identified in China more than a century ago and has no known cure.

It has existed in Asia and Africa for decades and cut a path of destruction across groves in Brazil and Florida -- the world's two largest orange juice producers -- since it was



SOMETHING AMISS: Larry Hardie, a grove manager for Barnes Citrus, Inc. holds malformed star ruby grapefruit affected by 'greening' in Vero Beach, Florida Dec. 1, 2010. **REUTERS/JOE SKIPPER**

BLOG

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detected in Brazil in 2004.

Ravaging Florida since 2005, the disease is spread by a tiny insect called a psyllid that thrives on young citrus leaves. The pathogen affects the flow of nutrients in citrus trees, giving them yellow shoots and blotchy or mottled leaves and reducing their amount of fruit, which tends to be abnormally small or lopsided and badly flavored.

The first symptoms of infection may not appear for six to 18 months but the disease, which often makes fruit stay green or prevents it from turning orange, can then spread quite quickly throughout an orchard.

As it does so -- and greening has now infected all of Florida's citrus growing counties -- crop yields drop, the severity increases, and orchard production can become unsustainable economically within seven to 10 years after planting.

"GREENING IS SPREADING VERY FAST AND WILL HAVE WIDESPREAD TREE DAMAGES."

"Greening is spread very fast and will have widespread tree damages," said Arnold. "It's a big loss when you lose an acre of mature trees," he said, noting that a grower's initial investment was about \$8,000 an acre.

Arnold, a native Floridian who speaks with a distinct southern drawl rarely heard across the state these days, remembers when Florida had about 900,000 acres (364,200 hectares) planted with citrus.

Florida's total citrus acreage declined to a new historic low of slightly more than 554,000 acres (224,200 hectares) in an annual USDA census released in September, and commercial orange acreage fell to its lowest level in 24 years. The first citrus census was done in the mid-1960s.

Total citrus acreage has been dropping since 1998, as the industry consolidated and farmers sold off land to real estate developers.



MOTTLED LEAVES: Larry Hardie, a grove manager for Barnes Citrus, Inc. holds the leaves from a star ruby grapefruit tree affected by greening in a grove in Vero Beach, Florida Dec. 1, 2010. **REUTERS/JOE SKIPPER**

“AS THE ACREAGE GOES DOWN, LOWER AND LOWER, THERE’S CONCERN ABOUT REACHING A THRESHOLD WHERE THE INFRASTRUCTURE WILL COLLAPSE.”

BIG BUSINESS: A worker sprays a grove of star ruby grapefruit in Vero Beach, Florida Dec. 1, 2010. REUTERS/JOE SKIPPER



But greening has been a major factor in more recent declines and a corresponding drop in production.

If acreage drops too much below current levels, there are fears that citrus processing plants and packing houses in the state will simply shut down, since there won't be enough fruit to stay in business.

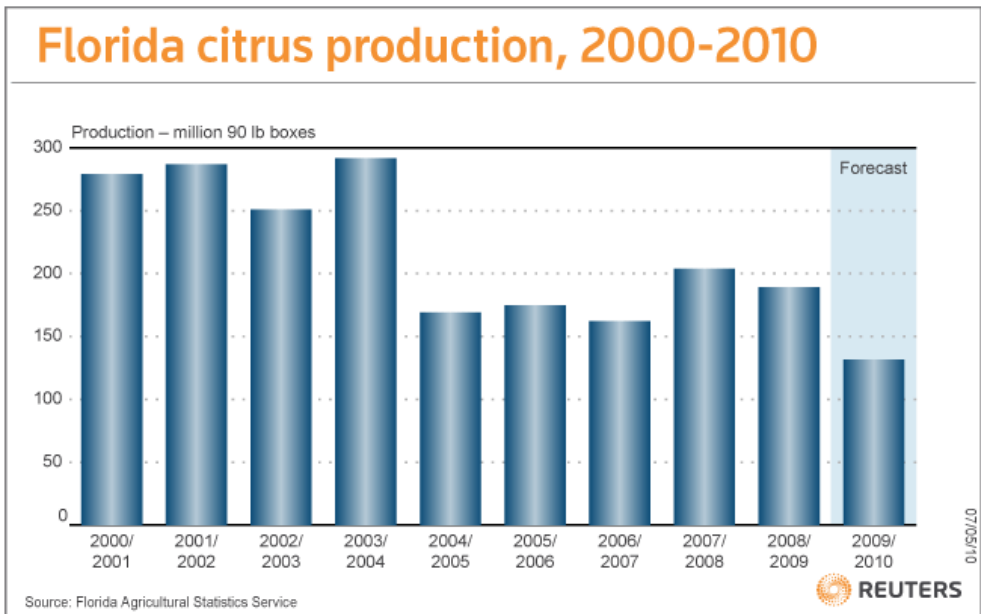
“As the acreage goes down, lower and lower, there’s concern about reaching a threshold where the infrastructure will collapse,” Arnold said.

KEEPING THE INDUSTRY ALIVE

SHORT-TERM SOLUTIONS to greening, including increased reliance on pesticides to kill psyllids and removing infected trees, can help keep Florida’s citrus industry alive.

Insecticide use has probably doubled over the last five years, said Tom Jerkins, whose company, Blue Goose Growers, manages some of the biggest groves across Florida.

The report sponsored by the National Academy of Sciences warned that massive use of insecticides to suppress the citrus



psyllid population carries the risk of the insect developing resistance to the chemicals, however, along with the threat of groundwater contamination and a decrease in the number of beneficial insects.

It has been more than half a century since the Great Leap Forward in China under Chairman Mao, when a failed experiment in pest eradication included issuing everyone in China a flyswatter.

The fly problem persisted, even though millions of the insects were killed. But the benefits of close coordination, if not the collectivized agriculture that inspired Mao, seemed lost on Florida's citrus producers until quite recently.

Finally recognizing the need to work together, the growers have organized into so-called "citrus health management associations" throughout the state.

Jerkins, who also heads Florida's Citrus Research and Development Foundation, said this means farmers now all disperse pesticides at about the same time. That leads to more powerful insect suppression by avoiding a "checkerboard effect" where bugs in a grove where chemicals are dispersed can find safe haven in a grove just next door.

"It makes the broader treatment more effective but it also allows growers to coordinate the type of pesticides used, so there's less chance the psyllid will develop resistance if we overuse one kind of pesticide," Jerkins said.

Such methods, along with enhanced tree nutrition and visual identification and prompt removal of infected trees, are helping to control the disease.

But there is also a need for a broader crackdown on abandoned groves with trees still harboring the disease. And with the number of infected trees in Florida continuing to rise, many experts believe production will not be sustainable over the long term.

The bacterium that causes citrus greening is so lethal that the U.S. government classified it among potential bioterror tools known as "select agents" until about two years ago, severely limiting the scientific community's ability to conduct research into the organism.

Research has expanded rapidly since the pathogen was declassified, according to Arnold, and one of his researchers in Fort Pierce led the team that completed the sequencing of the pathogen's genome about a year ago.

According to Arnold, two other researchers in Fort Pierce have been leading efforts to sequence the citrus psyllid, which are now near successful completion, and geneticists are also poised to announce the sequencing of two different varieties of citrus trees.

NEW DIAGNOSTIC TOOLS

FRED GMITTER, a University of Florida geneticist and plant breeder, led one of the tree genome sequencing projects. The other has been conducted under the auspices of

REUTERS TELEVISION



BATTLING BUGS: Dr. Wayne Hunter, a research entomologist with the U.S. Department of Agriculture, speaks during an interview with Reuters in his laboratory in Fort Pierce, Florida September 26, 2010. **REUTERS/JOE SKIPPER**

the International Citrus Genome Consortium, a group made up of scientists from China, Japan, France, Italy, Spain, Brazil and the United States.

Gmitter said the preliminary results of both genome sequencing projects were expected to be made public in January, providing "an extremely useful resource" and diagnostic tool for research into greening, disease resistance in general, and other issues of potential economic significance such as fruit quality and anti-oxidant content.

"To really understand all these things in full detail without having a genome sequence is



IMPERFECTIONS: Larry Hardie, a grove manager for Barnes Citrus, Inc. holds a malformed star ruby grapefruit in Vero Beach, Florida Dec. 1, 2010. **REUTERS/JOE SKIPPER**

impossible," Gmitter said, referring to how sequencing and pinpointing the genetic expression of greening could ultimately help breeders develop new varieties of trees fully resistant to the disease.

"We know some citrus types are much more tolerant of the pathogen than others. And so the question is, why is that? And so we can begin then to look at the genomes of these different types and make comparisons across a broad range of genes to try to understand exactly what it is that makes one of them extremely tolerant and the other one essentially dies when it becomes infected," he said.

Even without tools like genome maps, research has plowed ahead on many fronts including field trials of citrus trees genetically designed for disease resistance at Arnold's government-controlled lab in Fort Pierce and a separate, privately-owned facility operated



MIXED CROP: A grove worker picks red marsh seedless grapefruit in a grove in Vero Beach, Florida Dec. 1, 2010. **REUTERS/ JOE SKIPPER**

by Southern Gardens Citrus in Hendry County, Florida.

Southern Gardens is a unit of Florida-based U.S. Sugar Corp and it has been working, under field trial permits issued by the USDA's Biotechnology Bioregulatory Services arm, with researchers at Texas A&M University and a Florida company called Integrated Plant Genetics on the development of transgenic greening-resistant trees.

RETURN ON INVESTMENT

RICK KRESS, THE PRESIDENT of Southern Gardens, said the company has spent millions of dollars on its disease research so far. He said it was impossible to calculate the potential return on investment, but thwarting greening was of interest to citrus growers worldwide, not just in Florida.

Erik Mirkov, a professor of plant pathology at Texas A&M's Agrilife Research Center in Weslaco, Texas, has spearheaded some of the genetic modification work being done on behalf of Southern Gardens and said the payback could be huge, depending on patenting issues and global acceptance.

A disease-resistant tree cultivated in Florida could catch on quickly in an agricultural powerhouse like Brazil, for instance, where oranges are one of the country's biggest earners and researchers also see trees based on engineered citrus genotypes as the only

"IT COULD VERY WELL BE THAT THERE MAY BE SOME CULTIVARS OUT THERE THAT THE PSYLLID JUST DOES NOT LIKE TO FEED ON."

likely long-term solution to greening.

Mirkov's own work, which he said could lead to the first commercial plantings in as little as three years, involves inserting a few genes from a plant that he identified only as "commonly consumed around the world," into citrus trees to make them resistant to greening.

"You can do the math, it could potentially be huge," said Mirkov, referring to currently existing models for payment of non-transgenic citrus varieties. These commonly include an upfront fee of \$2 per tree, and a modest royalty fee on fruit yield.

"There's an example of a new release of mandarin type of orange from the University of California at Riverside called Tango and everyone in the world wants to grow that, because it's a really nice piece of fruit, no seeds, easy to peel. So yes, the return on investment can be extremely large," he said.

Orange trees typically start bearing fruit

three or four years after being planted. Because the genetically engineered trees are so new, none are believed to have reached the flowering or fruit-bearing stage thus far.

In a bid to curb overall costs, but also to accelerate research, Arnold said an agreement with the Fujian Academy of Agricultural Sciences in China was being used to conduct some of the more labor-intensive work into psyllids, citrus germplasms and disease resistance.

"The labor in China is reasonable and inexpensive, so we're taking advantage of that," Arnold said.

"They can hire a whole line of technicians, maybe 70 technicians and line them up, for the same amount of money that it would take us to hire three or four," he said.

Calling it "mass production of the research," he said the primary focus of the work in China was on trying to identify varieties of citrus trees with some sort of natural resistance either to psyllids or greening.

"It could very well be that there may be some cultivars out there that the psyllid just does not like to feed on," Arnold said. "We're trying to find out which ones they are."

Gmitter, the University of Florida geneticist and breeder, has been actively involved in citrus research in China, including the search for a tree with some sort of naturally occurring mutation to resist greening. He

said China, where a whole catalogue of HLB research is being conducted, had managed to keep its vast citrus growing areas highly productive, even in regions that have been heavily infested with HLB.

"In some places in China they essentially went to a scorched-earth policy and then came back in and replanted with healthy materials and implemented area-wide pest control strategies," Gmitter said.

He said China could become the world's leading orange juice producer in as little as 10 years, with or without GMO crops, thanks to advantages including lower land and labor costs.

"There are several large companies as well as a governmental interest in expanding their industrial production of sweet orange juice," Gmitter said. "Fifteen years ago they set out to do this in the world of apples and today the major source of apple juice concentrate worldwide is China."

GMO CROP CONTROVERSY

RESEARCH IS UNDER way in a number of areas, short of genetic modification, that could lead to more effective controls of the citrus psyllid population.

Wayne Hunter, an entomologist at Fort Pierce, spoke excitedly for instance about some of the promises held out by RNA interference (RNAi), a method of blocking gene function that could potentially be used to target something as specific as a psyllid's ability to grow wings and fly or to form the sheath that it uses to pierce and suck the oranges it feeds on. "This will totally change the way we approach things," said Hunter.

"It's already changed the way we look at medicine, it's changed the way we look at agriculture. This is probably going to be one of the biggest things that's comes along since the discovery of insecticides," he said.

Other possible psyllid controls include work on a compound in the foliage of guava trees that repels the bugs.

Lukasz Stelinski, a University of Florida entomologist who has led research into turning the guava tree chemicals into a controlled release spray to protect citrus groves, said logistical hurdles had proven difficult to overcome, however.

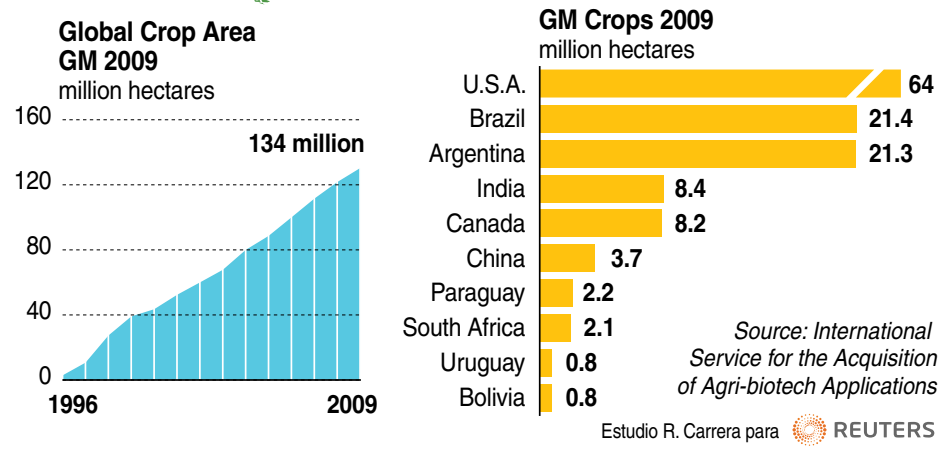
"I don't believe this is something close to being developed," he said.

It has been 16 years since the first commercialized GMO crop -- the Flavr Savr tomato -- was approved for sale in the United States. The tomato, which gave birth to biotech food, was designed to retain a

TRANSGENIC CROPS

The use of genetically modified crops has surged around the globe since the first commercialized crop, a tomato engineered with the flick of a gene to keep longer, made its debut in the United States in 1994

TOP 25 TRANSGENIC SEED USERS



fresh taste despite the rigors of shipping and handling. It was pulled from production amid controversy only a few years after making its debut.

GMO crops have won acceptance from many farmers and most scientists in the years since then, and a vast array of processed foods on the shelves of U.S. supermarkets now have some genetically engineered ingredients, thanks in large part to GMO corn, soybeans and sugarbeets.

GMO supporters say there is plenty of evidence that the crops are safe, but critics contend it is still unclear whether the technology has long-term adverse effects.

Though commonly found in processed foods, including baby formula, GMO crops currently are limited to just two whole fruits -- Hawaiian papaya and a variety of plums --

sold in U.S. stores.

That alone makes it likely that GMO oranges, if and when they get to the stage of having to meet regulatory approval, would draw intense scrutiny.

But Dean Gabriel, whose Alachua, Florida-based Integrated Plant Genetics is among the companies that hopes to see engineered oranges commercialized, said there is no reason to see them as a potential health threat.

"What we are actually doing is not that far off of traditional breeding. It's been made out to seem like, you know, we're making it radioactive or something. But it's really not that," he said.

"I'm totally convinced there is no other solution to this. There is no natural resistance to this particular pathogen," he added.

HIGH HOPES

ARNOLD ACKNOWLEDGED that genetic engineering had failed to deliver on some of the high hopes it raised initially.

"There's been limited success when using genetics to develop resistance to bacterial diseases," he said. "It's still a very new science and the actual impact, significant impact, in the economic, global market is still very, very limited," he said.

But he said the general public was likely to accept GMO juice, if the USDA and other regulators give it their official seal of approval.

"I think especially here in the U.S., they're understanding transgenics a lot better. Just like people go to Taco Bell, they know they're eating crops that have been produced transgenically," Arnold said.

"Some of the concern is dissipating because now that transgenic crops are widespread in our foodstream, within the U.S., we aren't seeing people dying right and left, so to speak. I think some people are understanding that there is a high level of safety there," he said.

Gmitter said GMO crops were a double-

edged sword, however, since they combine cutting-edge science with the potential profit-slashing consequences of marketplace rejection.

"One side of that cutting edge is that the world population to date still has not unanimously embraced genetic engineering technology," he said.

Tropicana Products, a unit of PepsiCo and the leading U.S. orange juice processor, declined to make a company official available for comment on the issue of genetically modified juice.

Coca-Cola Co, the world's No. 1 provider of juice and drinks and a leading player in the U.S. orange juice market through its Minute Maid brand, said it was actively involved in the search for "the best solutions to eliminate the threat of HLB."

Both Coca-Cola and PepsiCo have product lines that include vast quantities of high-fructose corn syrup as an ingredient. The sweetener is derived from genetically modified Bt corn, which is highly processed and unlike the sweet table corn that many people eat.

"Numerous health organizations, such

as the World Health Organization, the Food and Agriculture Organization of the United Nations, the U.S. Food and Drug Administration and the U.S. National Academy of Sciences, have determined that the use of biotechnology is safe," Coca-Cola said in a statement.

"While we acknowledge the benefits that biotechnology can provide to the environment and to addressing the growing pressure on the global food supply, we also respect local communities' preferences in the sourcing of food and beverage ingredients," the statement added.

Sitting behind his desk at the lab in Florida's citrus country, Arnold described the genetic work under way there as "heavy duty research" but said it was not something being done by "mad scientists."

"Nature's been transferring genes, breeders have been transferring genes, for many, many years. So if we do it properly there's no reason why transgenics can't be safe," he said.

(Editing by Claudia Parsons and Jim Impoco)

**PONDERING THE FUTURE:**

Larry Hardie (R), a grove manager for Barnes Citrus, Inc. and Wayne Collier, a grove consultant for G.L. Homes (L) speak as they look at a star ruby grapefruit grove affected by 'greening' in Vero Beach, Florida Dec. 1, 2010. **REUTERS/JOE SKIPPER**

COVER PHOTO: Citrus affected by 'greening', an insect-borne bacterial disease is shown in a laboratory at the U.S. Department of Agriculture's U.S. Horticultural Research Laboratory in Fort Pierce, Florida September 26, 2010. **REUTERS/JOE SKIPPER**

FOR MORE INFORMATION CONTACT:

JIM IMPOCO,
ENTERPRISE EDITOR, AMERICAS
+1 646 223 8923
jim.impoco@thomsonreuters.com

CLAUDIA PARSONS,
DEPUTY ENTERPRISE EDITOR
+1 646 223 6282
claudia.parsons@thomsonreuters.com

THOMAS BROWN
+1 305 810 2688
thomas.brown@thomsonreuters.com