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Search for Super Corn Seeks to Limit Nitrogen Use, Pollution (1)
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(Updates with today’s corn prices in 27th paragraph.)

By Jon Birger

April 15 (Bloomberg) -- Marc Albertsen, the bespectacled, 62-year-old research director at Pioneer Hi-Bred, DuPont Co.’s seed-development unit, was catching up on paperwork one morning in July 2007 when he got a call from an assistant, Sharon Cerwick.

“Marc,” Cerwick said, “you’d better come out here and see this.”

Cerwick had been in the field inspecting rows of experimental corn planted next to Pioneer’s headquarters in Johnston, Iowa. The corn had been genetically engineered by Albertsen and his colleagues in hopes of achieving a new trait:
more efficient use of nitrogen. That’s at the top of the corn growers’ wish list because the cost of ammonium nitrate fertilizer has soared 130 percent to $450 a ton since 2002.
Albertsen and other seed scientists have been trying to build nitrogen-efficient stalks for at least five years, but their super corn is still five to 10 years away.

“You’re talking about our holy grail,” said Pamela Johnson, a National Corn Growers Association board member with 1,200 acres in Floyd, Iowa.

In the field, Albertsen discovered one row of corn whose leaves were afflicted by a V-shaped yellowing, the telltale sign of nitrogen deficiency. The other row -- the plants that had been engineered for nitrogen efficiency -- was green and thriving. Both had been planted in severely nitrogen-deficient soil, but the genetically engineered plants seemed unaffected.

Need for Nitrogen

The malnourished seedlings reminded Albertsen of the past: sickly cornstalks he had seen as a boy on his family farm near Danbury, Iowa. The healthy ones, growing in the same tired soil, spoke of the future. He immediately phoned his team in Woodland, California, where Pioneer was running an identical trial in central California farmland, and asked them to check their seedlings.

“Even today, it gives me goose bumps,” he said. “Their field checks came back with the same results.”

Other than water and sunlight, there’s nothing more important to growing corn -- the most-valuable U.S. crop, worth
$66.7 billion in 2010 -- than nitrogen. Generous applications of nitrogen fertilizer are essential to the 180-to-200-bushel-an- acre yields that have become commonplace in big farm states such as Iowa and Illinois, double what farmers were producing 35 years ago, according to the U.S. Department of Agriculture.
Wheat and rice growers around the world have seen yields plateau. Corn is the only major crop for which per-acre production continues to rise.

Environmental Damage

Such extraordinary productivity comes with an economic and environmental price. Nitrogen fertilizer is the biggest or second-biggest expense for most American farmers, said Rod Williamson, director of research at the Iowa Corn Growers Association. At an average cost of 60 cents a pound, the 150 pounds of nitrogen that farmers spread over each of the nearly 90 million acres of U.S. cornfields add up to a bill of around $8 billion a year.

Harder to quantify but no less costly is the damage fertilizer runoff does to aquatic life. More than half of the fertilizer American farmers apply to corn gets wasted. Some of it leaches into aquifers, polluting local drinking water. More of it ends up in rainwater runoff, flowing into the creeks and streams that feed the Chesapeake Bay, the Mississippi River, and other ecosystems.

Algae Blooms

The Mississippi runoff winds up in the Gulf of Mexico, where it spawns deadly algae blooms that steal oxygen from fish and plants. The Gulf is now home to the second-largest ocean dead zone, according to a 2010 study prepared by the Environmental Protection Agency and the USDA, and scientists are still debating which has been more damaging -- last year’s BP Plc oil spill or the ongoing nitrogen pollution from U.S. agriculture.

That isn’t the only environmental problem caused by nitrogen-heavy corn production. Another is climate change. Nitrogen fertilizer is produced from air, water and natural gas in a process that releases 3.6 tons of carbon dioxide per ton of fertilizer, according to an analysis by Yara International ASA, an Oslo-based chemical company. When the fertilizer breaks down in the soil, it releases nitrous oxide, a greenhouse gas that the EPA says is 310 times more effective at trapping heat in the atmosphere than carbon dioxide.

Ethanol Perception

Forty percent of the U.S. corn crop is now used to produce some 13 billion gallons of ethanol per year, according to the U.S. Energy Information Administration. As a result of the greenhouse gas produced during the corn/ethanol life cycle, academics such as Princeton University’s Timothy Searchinger and Duke University’s Robert Jackson now say that ethanol has a carbon footprint at least as large as gasoline’s. Many growers and ethanol advocates dispute that, but Johnson, the Iowa farmer and NCGA board member, believes U.S. corn producers must address these concerns to maintain support for ethanol.

“Reducing our use of nitrogen fertilizer is one of the ways we fight the perception that ethanol is a bad thing,” Johnson said.

All of which explains why DuPont is one of five major agribusinesses racing to develop nitrogen-efficient corn. If the fossil-fuel industry has as its mission the development of low- carbon “clean coal,” you might call this the quest for clean corn.

$1.5 Billion Market

The research and development divisions at Pioneer and its competitors -- Bayer AG's CropScience unit, Dow Chemical Co.'s Dow AgroSciences unit, Monsanto Co. and Syngenta AG -- want to be first to market with a nitrogen-efficient corn seed that might use up to 30 percent less fertilizer per bushel. Analysts say the U.S. market for corn with such a trait could be worth nearly $700 million a year. Globally, the market opportunity could be as high as $1.5 billion, said Kevin McCarthy, an analyst for Bank of America Merrill Lynch.

"It's without a doubt the single most important trait under development," said Mark Gulley, an agricultural chemicals analyst at Soleil Securities in New York.

While the potential payoff is enormous, so too is the scientific challenge. Until now, the biggest advances in genetically modified crops have involved transplanting a single new gene (called a "transgene") into corn DNA, which gives the plant a valuable new trait, such as resistance to the dreaded corn-borer bug. Unfortunately, there's no single-gene solution for nitrogen efficiency.

"There may be 100 important genes that control nitrogen use, whereas with an insect-resistance trait, it's only one," said Fred Below, a professor of plant physiology at the University of Illinois at Urbana-Champaign.

Nitrogen Efficiency Quest

That's because nitrogen utilization is not a single process, but rather multiple ones that start with roots' uptake of nitrogen from the soil, continue with the movement of nitrogen through the stalk, and culminate with use of nitrogen during photosynthesis to grow ears and kernels.

Multiple genes control each process, and it is this complexity that has made the quest for nitrogen efficiency one of small and incremental victories -- which brings us back to Albertsen's eureka moment in 2007.

As it turned out, the trial was not a complete success: The experimental seeds wound up yielding subpar amounts of corn when planted in nitrogen-rich soil. This only mildly discouraged Albertsen.

"It told me two things," he said. "One was that maybe we could make this project work -- something that wasn't certain when we embarked on it. And secondly, it endorsed our way of thinking about the genes that control uptake of nitrogen from the soil and how that nitrogen is transported and assimilated by the plant." Up until then, he hadn't been sure that genetically engineering a corn plant for nitrogen efficiency was possible.

Fertilizer Essentials

A tall, balding scientist with the soul of a farmer, Albertsen had been dreaming of nitrogen-efficient corn since he joined Pioneer 30 years ago. Iowa may be known for its rich farmland, but Albertsen grew up on a western Iowa farm with lousy soil.

"Fertilizer was always a big deal for us," he said. Ill- timed rains could wash away thousands of dollars worth of the stuff, putting a severe dent in his family's income. "Certain images -- like that V-shaped necrosis -- just got emblazoned in my mind."

Albertsen's farm upbringing is typical for scientists involved in seed research. Monsanto Chief Technology Officer Robb Fraley grew up on a farm in rural Illinois. Tom Wiltrout, who heads the global seeds

division for Dow AgroSciences, got his early farm education on his grandparents' 80-acre parcel in northern Indiana. All talk about using science to combat the caprice of Mother Nature and make farming less risky for folks like their parents and grandparents.

People to Feed

Their other goal: help feed a growing world population and slow rising food costs now contributing to unrest in the Middle East and other parts of the world. Corn futures have more than doubled, to $7.5925 a bushel, in the past year.

"World population is going to grow from 7 billion to 9 billion over the next 30 years, which will require a doubling of grain production," Fraley said. "That's a pretty big task."

Historically, the availability of nitrogen has had a decisive impact on how much food farmers could produce. While nitrogen is abundant in the atmosphere, making up 80 percent of the air we breathe, nitrogen gas cannot be absorbed by corn, rice, wheat and other grains.

Legumes such as soybeans and peanuts can use atmospheric nitrogen; their root systems host "nitrogen-fixing" bacteria that help the plant convert nitrogen gas into ammonia. While some academics are working to create a nitrogen-fixing corn hybrid that would get all the nitrogen it needs from the air, the private sector seems reluctant to invest in such speculative research.

'Change the World'

"I'm a believer that we will be able to fix nitrogen in corn some day and that it's going to change the world," said Nicholas Duck, head of corn and soybean research for Bayer CropScience. "That said, I think we are a long, long way from being able to understand how to do that."

Natural sources of nitrogen available to early farmers, such as animal manure or plant decay, tended to be limited, putting a cap on what farms could produce. Then, in 1900, a German chemist named Fritz Haber made a discovery that would win him a Nobel Prize.

Haber found a way to make synthetic nitrogen fertilizer by pressure-cooking nitrogen and hydrogen into the plant food now known as ammonium nitrate. His discovery gave birth not just to modern agriculture but also to the modern world. (Haber is also known for supervising Germany's poison-gas program during World War I.) Crop yields skyrocketed as farmers applied nitrates to their crops. More food allowed world population to soar from 1.6 billion people in 1900 to 6.6 billion today.

Corn Genome

The corn genome was decoded and sequenced in 2009 with the help of $29.5 million in funding from the National Science Foundation. Although seed scientists still have much to learn about how genes interact, they now understand which corn chromosomes control which functions of the plant. Attempts to genetically engineer corn for nitrogen efficiency involve identifying genes from other plants, other corn species, or even from bacteria that are thought to contribute to more efficient utilization of nitrogen. Those genes are then cloned and inserted into corn DNA with the help of a machine known as a "gene gun," which fires microscopic gene-covered pellets into the cells.

Pioneer originated the use of gene guns on corn in the 1980s, but newer technologies have accelerated the discovery process. Gene guns are imprecise; scientists cannot control exactly where the transgenes get inserted within the corn genome.

DNA Sequencing

To achieve a desired trait, researchers used to have to repeat the process hundreds, if not thousands, of times, then grow each of the newly created embryos to maturity to see which of their gene modifications were successful. Today's seed scientists use DNA sequencing and other advanced genomic technologies -- tools originally developed for medical research and drug development -- to identify which transgenes hit the mark. Only embryos that possess the most promising genetic profiles are grown to maturity.

All the companies involved in this research are pursuing similar strategies, and all say it will probably be the end of the decade before a corn seed genetically modified for nitrogen efficiency receives USDA approval. Syngenta and Dow, however, think they could have an interim product ready in half that time.

While seeds that contain transgenes must go through an exhaustive approval process, seeds developed through breeding are not similarly regulated.

Precision Breeding

Once upon a time, breeding was a low-tech endeavor. Not anymore. As with transgene research, the new embryos are all subjected to DNA sequencing, which allows scientists to identify hybrids with desirable chromosomes long before the seedlings ever sprout. Syngenta calls this precision breeding or marker- assisted breeding, and it is transforming the food industry. If you've noticed an improvement lately in your supermarket produce
-- perhaps your watermelons are sweeter and crunchier -- this is not necessarily Mother Nature. It could be a direct product of precision breeding.

As it turns out, the big beneficiary of the 1990s genomics revolution has not been medicine but farming.

"We have identified a lot of human disease genes, but so far that has not yet paid off in cures," said Michiel van Lookeren Campagne, the head of biotechnology R&D at Syngenta.
"What we are seeing is a substantial economic impact in agriculture through better breeding."

New Products

This year, both Syngenta and Pioneer began marketing drought-resistant corn hybrids created via precision breeding.
Since the seeds aren't genetically modified, they didn't need USDA approval. Syngenta says its hybrid reduces yield loss in dry fields by as much as 15 percent. Pioneer asserts a 5 percent advantage. Now, Syngenta and Dow are applying the same strategies to nitrogen. Their level of success may determine whether corn and ethanol production are seen as food and energy solutions or environmental villains.

California has enacted a low-carbon fuel standard that limits the growth of the ethanol market. Environmental concerns are being used to lobby Congress and the EPA against wider introduction of E15 gasoline,

which contains 15 percent ethanol, versus the 10 percent commonly sold now. Walt Wendland, the chief executive officer of two ethanol plants in Iowa -- Golden Grain Energy and Homeland Energy Solutions -- said that without widespread adoption of E15, the industry can't sell all the ethanol it's on pace to produce. "What are we supposed to do with all those gallons we can't even blend?"

Easing Ethanol Footprint

Both Wendland and the NCGA's Johnson are counting on nitrogen-efficient corn to blunt some of the attacks. Duke's Jackson, author of a study that criticizes ethanol's carbon footprint and questions the wisdom of ethanol subsidies, said nitrogen-efficient corn would be a positive step.

"I'm not sure it would be a game changer, but it would certainly be a major advance," Jackson said. "It would be helpful for greenhouse gas emissions, for water quality, and for farmers in the economic sense."

Still, it's not clear that farmers would actually use less nitrogen even if presented with more efficient seeds. Matt Liebman, an agronomy professor at Iowa State University, contends that the reason corn utilizes nitrogen inefficiently has as much to do with farm practice as plant physiology.

"Farmers tend to apply fertilizer when it's easiest, not when it's best," Liebman said.

Before Planting

Most farmers apply it in the fall after harvest or in the spring before planting. That's easier, since there are no plants to get in the way, but there's also no root system to hold the fertilizer in place, making the fertilizer more susceptible to runoff. "The best time to use fertilizer would be in June,"
Liebman said. Most farmers won't take their tractors onto their fields then.

Nitrogen-efficient corn seeds would give farmers a choice:
Apply 20 percent to 30 percent less fertilizer and enjoy the same crop yields, or apply the same amount of fertilizer and get enhanced yields. Most farmers are likely to choose the latter option, since the desire to grow more is practically hard-wired into their DNA.

"The three most important traits in agriculture are yield, yield and more yield," Syngenta's van Lookeren Campagne said.

Fraley concedes that the primary goal of Monsanto's nitrogen research is not to reduce fertilizer use but to boost production to 300 bushels an acre by 2030 -- nearly double the current U.S. average. "The real goal is to drive yields," he said.

Clean corn, in other words, may not turn out to be radically cleaner after all.

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--Editors: Eric Pooley, Steve Stroth

To contact the reporter on this story:
Jon Birger in New York at +1-212-318-2000.

To contact the editor responsible for this story:
Eric Pooley at +1-212-617-2874 or
epooley2@bloomberg.net