Is Monsanto's patented Roundup Ready gene responsible for a flattening of U.S. soybean yields that has cost farmers an estimated $1.28 billion?
Presentation at 2004 Midwest Soybean Conference explores the numbers...and the potential causes behind them.

By Dan Sullivan

September 28, 2004: Flat soybean yields since the mid '90s, followed by a drastic drop in 2003, have many farmers wringing their hands and some agronomists searching for answers.

The flat yields since 1995 have cost conventional U.S. soybean farmers an estimated $1.28 billion, according to a report entitled "Stagnating National Bean Yields" The report—presented at the 2004 Midwest Soybean Conference in Des Moines, Iowa, last August—first described historical yield trends, then went on to explore potential causes for the downward spiral, including erratic weather patterns, increased marginal acreage under production, and genetic changes.

From 1972 to 1993, according to the report, soybean yields increased .45 percent each year. Those yields peaked in 1994, then went flat until 2003, when they dropped by 5.88 bu./acre.

"We went to seed companies and they confirmed that yields have leveled off," said Ron Eliason, who headed up a consortium of farmers funding the study. "We asked 'Is this a trend you see?' And they said 'yes.' For most of these people, this was anecdotal. The statistics...sort of got their attention."

The report also looked at severe weather patterns—including early season dry spells and heavy August rain—as a possible cause for the drop in yields. But the statistical data showed that there was not enough variation from other years to account for such a radical shift. "In other words, our conclusion was that there's something going on in soybeans that is not explained by the weather," Eliason said.

The report went on to speculate that conventional soybeans may have performed better in 2003 than some genetically modified (GM) hybrids. "There are some things that happened since 1995 that would lead you to look into that area," Eliason told New Farm during a telephone interview. "I don't want to get into that controversy…but anytime you get into genetically engineering a plant, that takes energy."

What's the connection?

In 1996, Monsanto introduced its Roundup Ready gene into the soybean market, patenting a genetically engineered plant that was resistant to the company's own Roundup Ready herbicide (glyphosate). That year, 7 percent of all soybeans planted on U.S. soil were Roundup Ready. By 2004, that figure had risen to 85 percent.

The promises of Roundup Ready soybeans—for which farmers are required to sign elaborate contracts, pay licensing fees and a premium for the technology, and face stiff penalties for saving seed—included better weed control with lower pesticide use, less labor in the fields, and improved yields.

Those claims have fallen short. While weed control has been improved with less labor, new glyphosate-resistant 'super weeds' are now developing as a result of overuse of the herbicide (studies have shown that farmers growing Roundup Ready soy use 2 to 5 times more herbicide than farmers growing other varieties). Perhaps most critical to farmers, yields have gone down.

While flat or even lower yields from one year to the next do not necessarily mean a smaller paycheck for the farmer—that's determined by market forces—if farmers are paying a premium for a technology that promises higher yields while it actually reduces them, that could have a significant bearing on their bottom line.

The report at the Midwest Soybean Conference also considered as possible causes for crop losses a new aphid problem and the fact that soybean plantings on marginal lands have increased by 12 million acres since 1996 (some researchers say soybeans do not belong in such areas because they are erosive).

Soybeans do tend to perform better than some other crops on marginal lands, said Paul Hepperly, research director at The Rodale Institute, where experiments comparing soybean yields in conventional and organic systems have been under way for more than two decades.

As for the aphid problem, Hepperly pointed out that when a Roundup Ready soybean plant is sprayed with glyphosate it turns yellow, then gains back its green color as the plant recovers. Aphids are typically attracted to yellow plants, he said. "Aphids never before used to be a problem on soybeans," Hepperly said. "Are these aphids to some extent a consequence of the changes that affected the metabolism of the plants?

"Roundup inhibits the pathway that produces 35 percent of the metabolites. When they're blocking the normal interaction of that pathway, they're playing with things that affect the immune system of that plant."

And that could make those plants less resistant to pest and disease problems, Hepperly said. Technologies such as Roundup Ready are typically developed in best-case-scenario environments that bolster performance but seldom reflect real-farm pressures, he said, pointing out that the problems now developing with Roundup Ready soy are mostly related to stress factors in an uncontrolled environment.

Hepperly questioned whether the new pest, root rot susceptibility the other problems now plaguing soybean farmer might be related to a new production system skewed toward what's easiest to produce, not necessarily what's most productive.

And he's not alone.

"There have been myriad factors at work," said Mike Duffy, Ph.D., an Extension economist at Iowa State University. "To lay it all at the doorstep of Roundup Ready is probably a stretch. I think that could be part of it.

"Early studies showed a yield drag associated with Roundup Ready; that, I think, has been largely overcome. Then we kind of almost moved into this 'pest du jour' phase, with aphids, root rot, white mold, sudden death—you name it, something was coming along.

"I've kind of got a gut feeling that we were putting research dollars into looking more at genes and not as much at yields. As a result, I think we may have seen some slippage in that way. To say it's all Roundup Ready's fault, I don't think that would be right. But to say that's part of it, I would have to agree with that."

Research connecting Roundup Ready soybeans to pest and production problems has plagued Monsanto almost since the company introduced the technology:

Lower yields may be just the tip of the iceberg

By Dan Sullivan

Unintended consequences of genetic engineering such as lower yields, woody stems, disease susceptibility, invasive super weeds, genetic pollution and a host of unknowns have led many scientists, consumer groups, and environmentalists to question the wisdom of unleashing such technologies before they have been proven safe.

Those sounding the alarm assert that proper scientific precautions were sidestepped by biotech companies eager to get their products to market, arm in arm with industry-tied government regulators. Now, they say, the consequences of this rush to market are unfolding.

Predictions about the adverse effects of Roundup Ready and other genetic technology play out daily in the media. This summer, Arkansas Extension agents added ragweed to the list of invasive weed species developing a tolerance to glyphosate—leading to more, not less, use of herbicides. And for the first time, the USDA has ordered a full-blown environmental impact statement on a genetic technology—
Roundup tolerant creeping bentgrass destined for golf courses and residential lawns—after research showed that pollen from the genetically engineered grass can travel at least 13 miles. (U.S. Forest Service officials were quoted in the The New York Times as saying genetically engineered creeping bentgrass "has the potential to adversely impact all 175 national forests and grasslands.")

While Roundup Ready corn is a reality, most U.S.-grown genetically modified corn is engineered to produce the bacteria Bacillus thuringiensis (Bt). Bt produces crystals and spores that paralyze the digestive tract of certain insect larvae, specifically the European corn borer. Organic farmers and gardeners have historically (and discriminately) applied Bt powder when pests are at their larval stage.

Bt modified corn presents several concerns. Like the

• Fusarium fungi are not uncommon in soybeans, and population levels typically fluctuate. But University of Missouri researchers conducting experiments between 1997 and 2001 found that Roundup Ready soybean fields sprayed with glyphosate had abnormally increased levels of the fungi, a condition that can lead to a host of problems for the plants, including sudden death syndrome (SDS) and other root rots. (Since that study, research in Canada has also connected glyphosate use to fusarium head blight in wheat.)

• Research at the University of Georgia in 1999 showed that Roundup Ready soybeans exhibited an unintended 20 percent increase in lignin, making them overly woody and causing stem splitting (particularly in high heat), resulting in crop losses in the South of up to 40 percent.

• And, following two years of field research, University of Nebraska researchers concluded in 2000 that Roundup Ready soybeans were yielding 6 percent less than their closest relatives (hybridized plants that were exactly the same, minus the Roundup Ready gene)

Roundup Ready gene, there's no telling what impact the constant presence of Bt will have over time on mycorrhizae, rhizobia, and other soil and root microorganisms key to building healthy soil and to delivering proper nutrition to plants. No one disputes that Bt running through the entire plant for its whole life cycle, then being absorbed back into the earth as the plant decays will eventually lead to more rapid resistance by the pests it now controls. And the potential consequences to humans of eating Bt corn—like so many variables surrounding genetic engineering—are unknown (45 percent of all corn planted in the U.S. in 2004 was genetically engineered).

In 2002, British scientists at the University of Newcastle discovered DNA material from genetically engineered plants in human gut bacteria. Asides from the dangers the Roundup Ready and Bt genes may themselves present to human health, many of the GE crops also contain antibiotic-resistant marker genes. Some scientist fear a buildup of such materials would eventually sabotage a person's ability to fight off infection.

Last year, Norwegian scientist Terje Traavik, Ph.D., linked flowering Bt corn to a wave of illnesses in the southern Philippines. Criticized for going public with his findings before they had been peer reviewed, Traavik now claims he's found human antibodies to the Bt toxin in blood samples taken from people who had complained of illness the year before.

In August, a federal judge ordered the USDA to disclose where four companies are performing open field testing in Hawaii on crops genetically engineered to produce pharmaceuticals, after community members on the island of Moloka'i complained of similar—though inexplicable—allergic reactions. (Experimental crops from so-called 'biopharms' in the Midwest have already accidentally been mixed with other stored grains destined for human consumption.)

Pollen drift from genetically engineered crops continues to contaminate neighboring conventional and organic crops, leading to rejection of those crops on domestic and foreign markets.

and 11 percent less than high-yielding conventional varieties. Agronomist Roger Elmore, Ph.D., and his colleagues calculated those losses equal to about 3 bushels per acre.

Not all at the 2004 Midwest Soybean Conference spelled gloom and doom for conventional soybeans. Scott Abney, Ph.D., a plant pathologist from Purdue University and also a speaker at the conference, held out hope of getting the yields back on track through cooperative breeding programs that boost plant qualities such as disease and drought resistance as well as "overall agronomic performance." Jim Specht, another University of Nebraska agronomist, presented research that showed that the corn-to-soybean ratio (roughly 3.2 to 1) had remained generally constant from 1972 to 2003 (noting the anomaly years of 1994 and 2003).

And genetic pollution by engineered crops—as demonstrated by contaminated native corn in Mexico and native sunflowers in the U.S.—threatens the integrity, perhaps the very existence, of these species.

"The [introduced] gene action eliminates the normal evolution of genetic expression," said Paul Hepperly, a plant breeder and research director at The Rodale Institute. Evidence suggests that these natives will favor the new gene and select away from other mechanisms, he said.

"You no longer have the ability to select for natural resistance in native crops, which is where people have traditionally gone when there's been a problem."

Representatives at Monsanto did not return phone calls for this report.