Roland Piquepaille's Technology Trends

Transgenic Mustard Cleans Up Soils

http://www.primidi.com/2005/02/15.html

I'm often impressed by some scientists' ideas. But today, I'm a little bit worried, as researchers have genetically modified a common plant, the Indian mustard, to absorb more selenium, a toxic heavy metal found in soils polluted by irrigation wastewater. The transgenic plants were four times more efficient at swallowing selenium than natural ones in a contaminated area of California's Central Valley, according to articles from ***Nature*** and ***Wired News***. These field tests are only experiments, but the researchers also want to add genes to other plants to remove different toxic materials from soils, such as mercury. What would happen if such transgenic plants filled with dangerous chemicals start to crossbreed with natural ones? Or if an insect eats these plants before being eaten itself in the natural food chain, leading to some selenium in our food? Read more and tell me what you think...

Let's start with the good news from the *Nature* article.

Genetically modified Indian mustard plants have successfully cleaned up excessive selenium in a California field. This is the first field trial for a pollution-busting transgenic plant, and it proves that the technology can work outside the laboratory, say the researchers who carried out the test.

Farmland in certain parts of California is heavily irrigated, and the water dissolves selenium in shale found in the region. As the water evaporates on the surface soil, selenium is concentrated to levels that are toxic to plants. But Indian mustard (*Brassica juncea*) has a natural resistance to the element, and absorbs it as it takes in water through its roots.

Here is a picture of natural Indian mustard plants growing in Kansas (Credit: **Kansas Wildflowers And Grasses**).

To increase the level of absorption of selenium by the Indian mustard plants, the researchers, led by **Norman Terry**, a plant biologist at the University of California, Berkeley, added extra genes to the plant. And here are the first field test results.

The researchers created three different strains of the transgenic mustard plants, each producing different enzymes to soak up selenium, and tested them in selenium-contaminated soils alongside wild-type Indian mustard. [And] hey found that the transgenic plants could accumulate up to 4.3 times as much selenium as conventional, wild-type Indian mustard.

The transgenic plants showed up to 80% of the growth expected in uncontaminated soil, whereas the wild-type plants had their growth halved by the selenium. They were harvested after 45 days in the field, but the researchers expect that longer growth periods could remove more selenium, and estimate that the most effective plants removed about 4.4% of the element in the top 25 centimetres of soil.

The process known as phytoremediation, which uses natural plants to remove toxic materials from soil, is not new, and is cheaper than traditional methods, which imply to remove polluted soil some place before burying it elsewhere. But it takes a long time, so adding genes to speed the process is an attractive solution. But what about the long term ecological impact?

The possibility of the transgenic plants crossbreeding with food crops is a worry, admits Clayton Rugh, a plant biologist at Michigan State University in East Lansing. "If you're going to engineer a plant to take up high quantities of metals, you must ensure it doesn't get into food crops," he says. "They would have to be carefully contained with measures above and beyond those for genetically modified food crops," he says.

Another source mentioned by *Wired News* also admits there are some dangers.

"We don't know enough about the unintended effects of genetic engineering," said Gurian-Sherman, senior scientist with the Center for Food Safety. The toxicity of plants can change, or a modified plant could interbreed with wild plants, he said. "What happens when an insect eats one of these plants, and then something else eats that insect?

On the contrary, Terry doesn't seem concerned by the consequences of such experiments. Read carefully this quote from *Nature*.

In a useful spin-off, the Indian mustard plants could eventually be used as feed for cattle with insufficient selenium in their diet, says Terry. The team is now trying to boost the plants' power even more. "We'd like to see increases in accumulation of 10 to 100 times that possible with wild-type plants," says Terry.

"This research is a great start."

Let me summarize this. First, you add genes to a plant which will then easily absorb dangerous and toxic chemicals. Then you use these plants to feed cows. But why on earth a cow would need to ingest more selenium? And are you sure that you want this selenium in your plate?

I'm not an expert in this field, but these experiments look quite dangerous to me in the long term, especially if they become widespread.

By the way, the research work has been published by *Environmental Science & Technology* on February 1, 2005. Here is a link to **the abstract** of the paper called "Field Trial of Transgenic Indian Mustard Plants Shows Enhanced Phytoremediation of Selenium-Contaminated Sediment."

Can we benefit from this or not? Please post your comments and tell me what you think.

Sources: Mark Peplow, Nature, February 11, 2005; Stephen Leahy, Wired News, February 12, 2005; and various websites

(Continued on next page)

ScienceDaily
Your source for the latest research news

Web address:
http://www.sciencedaily.com/releases/2005/02/050205102915.htm

Transgenic Plants Remove More Selenium From Contaminated Soil Than Wild-type Plants, New Field Tests Show

ScienceDaily (Feb. 9, 2005) — BERKELEY – In the first field trial of plants genetically tweaked to absorb more contaminants, researchers found that the transgenic plants handily beat out their wild-type counterparts. The results raised hopes that the plants might become a viable alternative for cleaning up polluted soil.

Gary Bañuelos, soil scientist with the USDA Agricultural Research Service, inspects the leaves of a transgenic Indian mustard plant used to remove selenium from contaminated soil. (Credit: Photo by Stella Zambrzuski, USDA ARS)

The new research findings, published today (Tuesday, Feb. 1) in the journal Environmental Science and Technology, show that three transgenic lines of the Indian mustard plant, Brassica juncea, absorbed two to four times more selenium from contaminated soil than the genetically unaltered, wild-type plants.

Researchers from the University of California, Berkeley, and the Agricultural Research Service (ARS) of the U.S. Department of Agriculture teamed up for the six-week trial to see if they could replicate in field conditions the results of prior studies in laboratory greenhouses. Those previous tests showed that transgenic plants performed up to three times as well as wild plants in cleaning up selenium-polluted soil.

"Field conditions involve a million different variables, from weather to soil conditions, so results can be radically different than those in the lab," said Norman Terry, professor of plant and microbial biology at UC Berkeley's College of Natural Resources and co-lead author of the study. "It turns out that our field test results were better than those from the greenhouse, and that was a surprise."

In California, as much as 100,000 cubic meters of sediment contaminated with selenium, salt and boron remain in the San Luis Drain, a concrete-lined canal originally intended to channel irrigation wastewater from Central Valley farms to the Sacramento River Delta near Antioch. Selenium is considered an essential trace mineral for both humans and animals, but it becomes toxic at high doses. The dangers of selenium toxicity came to light in the 1980s when biologists discovered that irrigation drain water held at the Kesterson Reservoir in the San Joaquin Valley was causing serious deformities in birds.

The researchers say cleaning up the sediment in the San Luis Drain could cost millions of dollars using conventional methods, including soil washing, excavation and reburial. In contrast, they say that using plants to remove contaminants -- a process called phytoremediation -- provides one of the most cost-effective methods of cleaning polluted soil available.

"Phytoremediation can help clean up the selenium, but the thing that's holding people up from using plants more widely is that, by and large, they work slowly," said Terry. "So what we want to do is take a plant like Indian mustard, because it can grow quickly -- up to six to seven feet tall -- and it is tolerant to many toxic conditions. It's a good plant for remediation, but we want to see if it's possible to increase its ability to absorb selenium and other pollutants ten-, one hundred-, or even one thousand- fold. This field test is the proof-of-concept showing that we are heading in the right direction."

Researchers like using the Indian mustard plant because it is very efficient at absorbing selenate, the bioavailable form of selenium in the soil. The plant is tricked into absorbing selenate because it is chemically similar to sulfate, an essential nutrient for the plant.

Gary S. Bañuelos, a soil scientist with the USDA's ARS and co-lead author of the paper, directed the field tests, which were carried out in Fresno County.

The three types of transgenic plants and the wild-type control plants were transplanted into four 33-by-1 meter field plots, two that contained contaminated sediment from the San Luis Drain and two that contained clean soil.

One line of Indian mustard plants was engineered to produce more of the enzyme adenosine triphosphate sulfurylase (APS). The enzyme is key to the plant's ability to convert selenate into a non-toxic form of selenium, allowing the plant to accumulate more of the contaminant without incurring harm. In the field trial, the APS plant line absorbed 4.3 times more selenium than the wild-type plants.

The other two transgenic lines were engineered to produce more of the enzymes gamma-glutamyl cysteine synthetase (ECS) and glutathione synthetase (GS), both of which play key roles in the production of glutathione. Glutathione, part of the plant's antioxidant system, may be buffering the impact of the contaminants, said the researchers.

The ECS and GS lines absorbed 2.8 times and 2.3 times more selenium respectively than the wild plants. Moreover, the GS plants seemed particularly tolerant of the contaminated soil, growing 80 percent as well as the GS plants planted in clean soil.

Because USDA regulators are scrupulous about experiments involving genetically modified plants in the field, the researchers took great care to minimize the transfer of genes through pollen.

"Before we started the study, we took aerial surveys to ensure that no other mustard-related plant species were being grown in the vicinity," said Bañuelos.

He noted that every morning trained workers swept through the fields to literally nip any flowers in the bud, and that netting and buried chicken wire were used to keep wildlife away from the plants.

"One of the challenges in developing transgenic plants for remediation is engineering them in such a way that the risk of gene transfer is reduced or eliminated," said Bañuelos.

Terry said that techniques now being developed by plant geneticists -- such as modifying chloroplast DNA rather than nuclear DNA -- will eventually reduce the need for such constant monitoring. Since chloroplast DNA is maternally inherited, there is little risk of pollen transfer, said Terry.

Terry said it's worth pursuing methods of improving phytoremediation because there are benefits unique to plants.

"A particularly promising aspect about mustard plants is that they can metabolize selenium into a gas called dimethyl selenide," said Terry. "This is something we've been working to enhance in our lab. Getting inorganic selenium into gas form will allow it to just dissipate harmlessly into the atmosphere. No other form of remediation can do that."

And what happens to the plants after they've soaked up their share of selenium? The researchers say that the plants can be harvested, dried and carefully added to animal feed or used as a soil amendment in areas where selenium is in short supply.

"There are many areas where selenium is deficient, so farmers actually pay for animal feed that is supplemented with selenium," said Terry. "Farmers would love to have this source of selenium."

Other co-authors of the study include Danika L. LeDuc, a post-doctoral researcher at UC Berkeley's Department of Plant and Microbial Biology, Elizabeth A.H. Pilon-Smits, associate professor of biology at Colorado State University, and Bruce E. Mackey, a biostatistician at the USDA's ARS.

The study was funded by the Electric Power Research Institute and the Agriculture Research Initiative of California State University.

Adapted from materials provided by University Of California, Berkeley.

Need to cite this story in your essay, paper, or report? Use one of the following formats:

- (•) APA
- ( ) MLA

University Of California, Berkeley (2005, February 9). Transgenic Plants Remove More Selenium From Contaminated Soil Than Wild-type Plants, New Field Tests Show. *ScienceDaily*. Retrieved July 4, 2008, from http://www.sciencedaily.com/releases/2005/02/050205102915.htm