FORUM

Using Superplants To Clean Up Our Environment

Phytoremediation is an innovative use of green plants to clean up our environment. The term comes from the Greek word for plants ("phyto-") that can detoxify, or remediate, soil or water contaminated with heavy metals or excess minerals.

Think of the industrial wastes, toxins, and byproducts that emerge from our daily activities—everything from sewage sludge from cities to toxic heavy metals from mines or factories to chemicals from agriculture. Produced and used in moderation and disposed of properly, these compounds aren't a threat to human health or the environment.

What should we do, however, when these materials accumulate in inappropriate places to levels that can be harmful? Cleaning them up is a job for superplants!

In this issue, you'll read about the work of Agricultural Research Service plant physiologist Leon V. Kochian and his associates at the ARS Plant, Soil, and Nutrition Laboratory in Ithaca, New York (p. 4). This laboratory was established in 1940 with the mission of studying the relationship between the soil-plant system and the nutritional quality of plant foods.

In keeping with its original mission, the laboratory has also hosted research that mapped the ability of soils to provide essential nutrients such as selenium and zinc to our foods. The soil maps are now standard references that the food industry uses to guide its actions.

Over the last 10 years, though, Kochian has shifted gears a bit. He's been studying the details of the processes by which plants take up mineral nutrients—zinc, iron, manganese—from the soil. One plant, alpine pennycress *(Thlaspi caerulescens)* was chosen for intensive study because it accumulates tremendous excesses of some of these elements—as much as 1,000 times more than normal. This behavior has been tracked to an alteration in nutrient uptake and transport.

Normally, the activity of so-called "transporter" proteins responsible for micronutrient uptake slows and eventually turns off as the plant accumulates significant levels. In this plant, however, there is no such regulation, so it keeps taking in more. Kochian is identifying the genes involved in the hyperaccumulation and hopes to transfer them to larger, more suitable plants.

ARS agronomist Rufus L. Chaney, a phytoremediation pioneer who published the first paper on the subject in 1980, is also working with alpine pennycress and hopes to develop a commercial variety of it. He has found it to be especially good at removing zinc and cadmium from soil (p. 6). Cadmium is a heavy metal that is usually released by industries in conjunction with zinc. Chaney has one pennycress that takes in 10 times more soil cadmium than any other known soil-cleaning plant.

Other ARS scientists nationwide are applying the concept of phytoremediation to many different research problems. Michael P. Russelle in St. Paul, Minnesota, has developed a novel alfalfa that rapidly absorbs large amounts of nitrogen—in its nitrate form—from soil and water. He used the plant to successfully clean up a North Dakota site where derailed tank cars spilled massive quantities of liquid nitrogen fertilizer.

The plants' ability to tolerate what they've taken in is equally important. That's the focus of research by David W. Ow at Albany, California. In hunting for genes that are key to increased tolerance, Ow has worked with Indian brown mustard *(Brassica juncea)* plants provided by ARS colleague Gary S. Bañuelos at Fresno, California.

Ow's team first moved mustard genes into a simple-structured yeast, *Schizosaccharomyces pombe*, so they could be more easily copied and examined for function. Now the scientists are in the process of moving each of about 50 genes into another model plant, thale cress *(Arabidopsis thaliana)*, for more detailed studies of their function in plants. They have found that some genes boost the test plants' ability to withstand high levels of metals.

Bañuelos is working with central California farmers whose soils and recycled irrigation water are overloaded with selenium or boron—two salty contaminants that are all too common on the west side of the state's famous central valley. His experiments over the past 12 years have shown that plants in the *Brassica* family, like mustard and canola, thrive on the selenium-laden soils and water.

Bañuelos recently helped coordinate production in California of another *Brassica* not usually thought of as a phytoremediator—broccoli. The harvested broccoli was shipped to ARS nutritionist John W. Finley at Grand Forks, North Dakota, for analysis to see whether it can be used in a study of this veggie's health-imparting benefits (p. 12).

Although the concept of phytoremediation is simplicity itself, this research is slow, complicated, and painstaking. But compared to the very disruptive and expensive process of soil removal and physical extraction of contaminants, phytoremediation may be the best alternative.

If successful, it will provide a low-cost "green" technology for soil cleanup that can be easily used anywhere without special training or equipment. An added benefit of phytoremediation is that the plants—after pulling the contaminant from the soil—also serve as ready-made storage containers for the contaminant during shipment and subsequent treatment.

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