PEGGY GREB (K10317-1)

Calcium-Rich Potatoes

It's in Their Genes

At the University of Wisconsin-Madison Department of Horticulture, geneticist John Bamberg (left) and physiologist Jiwan Palta examine the wild potato species *S. microdontum,* which has genes for high tuber calcium.

Baked potatoes, mashed potatoes, scalloped potatoes, potato salad, hash browns, french fries, potato chips . . . .

According to the U.S. Department of Agriculture's Economic Research Service, potatoes are America's most popular vegetable. The typical American consumes more than 140 pounds of them every year. That's 50 pounds more than the per-capita consumption of tomatoes—the potato's closest competitor. Unfortunately, potatoes can suffer from a variety of ailments that either render them unfit for sale or reduce their market value.

Says Jiwan Palta—a physiologist with the Department of Horticulture at the University of Wisconsin-Madison (UW)—some of these problems can be helped by adding calcium. Specifically, increased concentrations of calcium in potato tissue have been shown to reduce the severity of tuber defects such as internal brown spot and hollow heart. Increased levels of tuber calcium have also been correlated with improvements in tuber yield, grade, and storage quality.

John Bamberg—a geneticist who manages ARS' U.S. Potato Genebank in Sturgeon Bay, Wisconsin—says that *Solanum tuberosum* is the only cultivated potato species. But, he adds, about 200 wild, tuber-producing potato species exist. Knowing how beneficial calcium is to potatoes—and to the people eating them—Bamberg and Palta decided to work together to find which of these wild potato species are best at accumulating this important mineral.

The Root of the Problem

"Potato tubers are naturally deficient in calcium," says Palta. "They grow underground—usually in sandy, irrigated soil—and have about one-fifth the calcium found in the aboveground stem of the plant."

Palta explains that the plant's main root system draws water and a water-soluble form of calcium from the soil and sends them where they're needed most—the plant stem and leaves. Because the potato tuber is surrounded by moist soil, it transpires less and accumulates much less calcium.

Several years ago, Palta and his UW collaborators discovered that tubers have their own root systems, which supply water and nutrients directly to tubers. They then demonstrated that tubers could accumulate much more calcium if they were "spoon-fed" the mineral during bulking—their major growth and nutrient uptake phase. This research has caused a small revolution in the potato-growing industry.

Potato farmers who once fertilized the soil early in the growing season with calcium-rich lime and gypsum have modified their habits. They still fertilize with nitrogen-, phosphorus-, and potassium-rich products early in the season, but many now add water-soluble calcium, such as calcium nitrate, Nitro Plus, or N Plus, to their irrigation lines later, when tuber bulking occurs. This nutrient-rich water is drawn into the tuber by the stolon roots.

"Applying 100 to 200 pounds of water-soluble calcium per acre during bulk-

Tubers of wild species (right) are small and otherwise unfit for the table, but such plants often have genes for traits like high tuber calcium that could make important contributions to the quality of commercial cultivars (left).

ing vastly improves tuber quality," says Palta. "In general, we've found that the average calcium concentration in tubers increases 50 to 100 percent, and the incidence of internal defects dramatically declines.

"We have also found that with increased calcium concentration, tubers bruise less during harvest, transport, and storage. And, potato plants are less affected by heat stress when calcium is added to the soil during the stress period," Palta adds.

Screening Potatoes for Mineral Accumulation

Though Palta knew that a potato's calcium level could be increased, he didn't know whether certain species were better than others at accumulating the mineral. That's when he started collaborating with Bamberg at the U.S. Potato Genebank. Together, the scientists screened 21 potato species for their ability to accumulate tuber calcium when a control level of calcium was available and when higher levels were supplied.

Bamberg says, "We identified two wild species that are excellent calcium accumulators: *S. gourlayi* and *S. microdontum.*" *S. gourlayi* ranked first for calcium accumulation in the control environment, accumulating more than double that of *S. tuberosum.* It ranked second in additional accumulation in the treatment environment, accumulating three times more than *S. tuberosum.* And while *S. microdontum* exhibited only average calcium accumulation in the control environment, it had the highest calcium increase when grown in the high-calcium environment.

"Both these wild species are in the same taxonomic series as cultivated potato species, so they can be crossed with *S. tuberosum,"* says Bamberg.

After making their initial findings, Bamberg and Palta began screening potato plants for extremes of calcium-accumulation capacity. They moved from screening among species to screening among populations within a species to screening among genotypes within a population. As a result, they were able to identify potato germplasm with very high and very low calcium-accumulation capacity.

Their next step? To begin transferring the genes for super-high tuber calcium accumulation from the wild species to the cultivar breeding pool. Geneticist Bob Hanneman and technician Andy Hamernik, with the ARS Vegetable Crops Research Unit in Madison, will be able to help them do this. Their work includes making raw germplasm useful for breeding new cultivars. Hanneman says, "We serve as a bridge between the genebank and the user community. We put beneficial wild species into forms that breeders can use more readily."

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John Bamberg examines the stem and root system of a cultivated potato plant.

The Genebank's Continuing Mission

Bamberg's and Palta's research is just one example of how ARS scientists and their university collaborators are looking to enrich different types of produce with calcium and other essential minerals. It shows how scientists at the U.S. Potato Genebank fulfill their mission of studying traits that may be useful for breeding.

Says Bamberg, "The wild, weedy relatives of potato in the genebank collection are not suited for growing or eating in their natural state. But, as exemplified by tuber calcium, some wild potato species carry specific traits of great potential value to the potato industry."

With the help of other specialists, U.S. Potato Genebank scientists work to make these traits known and available to potato researchers and breeders worldwide.—By **Amy Spillman,** ARS.

This research is part of Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the World Wide Web at www.nps.ars.usda.gov.

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Note to Readers: Dr. Robert E. Hanneman, Jr., died while this article was in press. He worked for ARS for more than 30 years and was head of the U.S. Potato Genebank for 15. ★