It's in their genes...

Calcium Rich Spuds

By Amy Spillman
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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. ***(Photo by Peggy Greb)***

According to the USDA's Economic Research Service, potatoes are America's most popular vegetable. The typical American consumes more than 140 pounds of them every year. As growers know, the potatoes can suffer from a variety of ailments that either render them unfit for sale or reduce their market value.

Jiwan Palta, a physiologist with the Department of Horticulture at the University of Wisconsin-Madison (UW), says 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 linked with improvements in tuber yield grade, and storage quality.

John Bamberg, a geneticist who manages Agricultural Research Service's (ARS) U.S. Potato Genebank in Sturgeon Bay, Wis., 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, 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

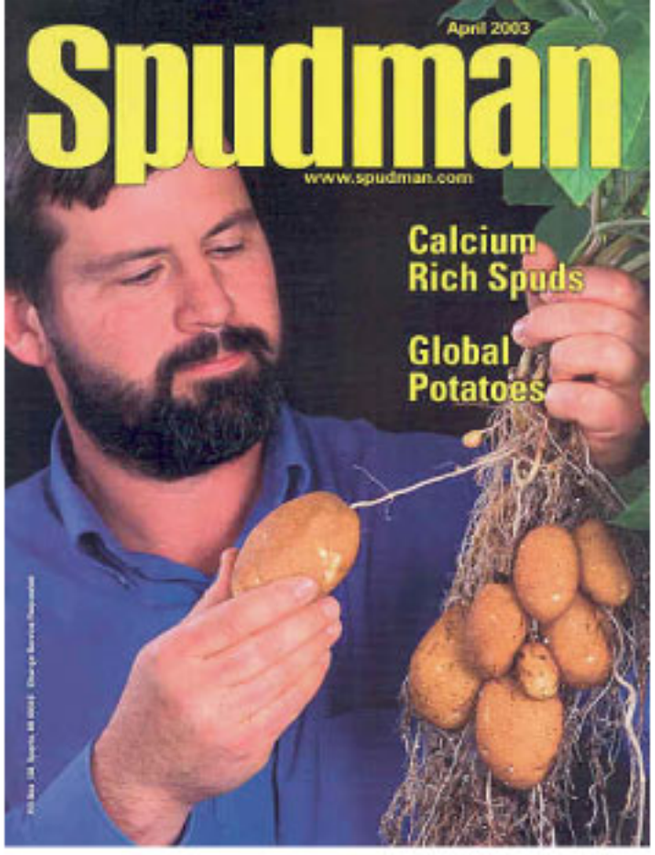
"Potato tubers are naturally deficient in calcium," says Palta. "They grow underground usually in sandy, irrigated soil, and have about one-fifth the calcium found in the above ground stem of the plant."

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.

Today, 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 bulking vastly improves tuber quality," says Palta. "In general, we've found that the average calcium concentration in tubers



Researchers are using the genetic traits of tubers from wild species to breed high calcium tubers. See story on page 20.

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

Though Palta knew that a potato's calcium level could be increased, he didn't know if 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.

"We identified two wild species that are excellent calcium accumulators: S. gourlayi and S. microdontum," Bamberg said.

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 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, Wis. will help them do this. Their work includes making raw germplasm useful for breeding new cultivars.

"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," Hanneman says.

The genebank's mission

Bamberg's and Palta's research is an example of how ARS scientists and their university collaborators are enriching different types of produce with calcium and other essential minerals.

"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," Bamberg said.

With the help of other specialists, U.S. Potato Genebank scientists make traits known and available to potato researchers and breeders worldwide. This research is part of Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the Web at www.nps.ars.usda.gov.