Dispatches

Potato innovation has stagnated for decades. Sexual reproduction might get it unstuck.

Halving the number of potato chromosomes could open the way to many more new varieties with useful traits.

by **Peter Imle** December 18, 2020


Minnesota
Seed Potatoes
Certified

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This story is one of a series about how hidden innovations produce the foods we eat at the prices we pay. It has been edited for length and clarity. As told to Krithika Varagur.

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The vast majority of the potato varieties grown today date back 50 to 100 years, which says a lot about the potato industry and the difficulty of breeding new varieties. Here, we strictly grow red potatoes, mostly for the East Coast and Florida restaurant markets. The number one thing that sells a red potato is a nice bright red skin color, without any blemishes.

We're a seed potato farm, meaning we don't buy material from outside our farm. We start out with very small sprouts, which we grow in test tubes before we transfer them to a greenhouse, where they'll develop into plants that will create small tubers. Because that whole system is sealed, the potato tubers don't carry any soil- or insect-vectored diseases. This also gives us the opportunity to collect new experimental varieties through that same system, side by side with our traditional stuff, so we're evaluating new material every year. We do our own variety trials and experiment with new varieties in-house.

Personally, I'm always evaluating for that even redder potato. I really thought we were very close with two experimental lines that we were working with the last three or four years, but last spring we went to plant them and the material had acquired a fair amount of seed rot over the course of the winter. Our end users were really complimentary of the variety, but unfortunately, it looks as though I can't store it.

The biggest roadblock to breeding better potato varieties is that commercial potatoes are tetraploid, meaning that they have four sets of chromosomes. (A lot of other major crops, such as tomatoes and corn, are diploid, with two sets of chromosomes.) The reason this matters is that when you cross any two tetraploid potatoes, there is so much genetic variance in the offspring that unhelpful mutations can kind of hide. So traditional potato breeding programs, which work through trial and error, discard a huge amount, about 90%, of their offspring. It's not a really efficient process.

Fifty years ago, when just about every land-grant university in the country had a potato breeding program, people were making significantly more crosses and evaluating significantly more material. Now that you're down to just a handful of potato breeders left in the country, not enough crosses are being made and not enough material is being evaluated for that method to be successful, in my opinion. The Department of Agriculture recently funded a big grant for several breeders to come together and try to move commercial potato breeding from tetraploid to diploid. (I'm one of the advisors on that grant.)

There are several kinds of naturally occurring diploid potatoes. But it just so happens that over time, the most productive lines in North America were tetraploid ones, and those are most of what we still consume today. But the diploid lines that exist in nature are the starting point for this research. Moving potato breeding to diploid specimens would drastically decrease the time needed to create new potato varieties. Crossing diploids means that defective genes would have less room to hide, so to speak. Their offspring are much more predictable, so we could really select for desirable traits. And we could also plant them as true seeds, rather than as tissue cultures. Tetraploids are reproduced asexually, with replanted tubers, whereas diploids can be reproduced sexually, with pollinated seeds, and seeds are much easier to scale up for a new breed.

Many major crops such as corn already use hybrid diploid breeding, and we know a lot about

This is all on a long time horizon; I'm hoping to see this happen at some point in my career. It would have a big impact on seed potatoes, which currently take about five or six years until they become commercial lines. If it is successful, it would make available a lot of the genomic tools that other crops have been using for a long time to try and do more targeted breeding. I'm not talking about transgenics or CRISPR or anything like that, but the basic molecular tools used by most other crops today, like marker-assisted selection, which involves using genetic markers to identify particular locations in the potato genome that may be correlated to specific traits, and then using those to quickly identify parents and/or progeny that have these traits. (This is much faster than growing out multiple generations of material just to identify whether the traits are present or not.) Basically, we're trying to move potato breeding into the 21st century. We're stuck in the past because of our reliance on complicated tetraploid lines and the decline of our agricultural research programs. We're not trying to change the basic flavor or texture of potatoes. But these new genomic techniques, which *would* change the basic nature of potato breeding, will be necessary to meet the rising demand for varieties that are more efficient at water use, use less fertilizer, are more disease resistant, need fewer pesticides, and can be stored at cooler temperatures.

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