Can Plant BREEDING Go Open SOURCE?

by Erik Ness

Irwin Goldman with Badger Flame beet. Photo courtesy of the Open Source Seed Initiative.
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Elderberry Hill Farm, a small CSA just across the lake from campus. They were harvesting carrots: orange, yellow, and purple; skinny and fat; stubby and elongated.

With a care and precision not normally associated with carrot harvest, they logged the numbered tags for each small row, selected about a dozen of the better specimens, and bagged them for further study back in the lab. As they worked, they bantered about breeding technology, how long grad school takes, food politics, and the ethics of genetic engineering.

This carrot project led by Claire Luby (pictured on the cover of this issue) has radical intent. The season before the UW-Madison grad student had collected seeds for every commercially available carrot cultivar she could find in the U.S.—142 in all. She’d sorted them and run a series of cross pollinations. Now they were harvesting the fruit of that cross. It’s standard practice among plant breeders to mix populations this way just to see what happens—to explore what’s hiding in the DNA. And that’s a part of her mission.

But Luby is also trying to stake out some intellectual property for future carrot breeders. In the last year alone, 15 patents have been filed for carrot varieties, primarily by one company. Some academic plant breeders are increasingly concerned by the economic concentration of seed companies and the concurrent growth of plant patents. What kind of operating room does that leave for academics and farmers?

There’s not an abundance of data, but in the European Union in 2011, the top five seed companies applied for 91% of intellectual property rights. Luby’s graduate project is to map this patent thicket to determine the current operating room in carrot breeding. But she’s also planting a flag. “What we’d like to do is then release some of these populations under the Open Source Seed Initiative (OSSI) so that the diversity remains available to use for breeding,” she explains.

On a warm and sunny day last fall, a handful of horticultural students from the University of Wisconsin–Madison (UW-Madison) descended on

The OSSI is a small but growing organization of breeders concerned about these entangling webs of intellectual property restrictions. Since the 1980s, UW-Madison rural sociologist Jack Kloppenburg has been arguing that economic consolidation of seed companies and the global proliferation of intellectual property restrictions is endangering the tradition of plant breeding, and with it, potentially, our food supply.

The OSSI hopes to build an open-source culture for plant germplasm to mirror the system first pioneered by software developers in the 1990s. These activists promoted universal access to technology through a special license: Developers can use this licensed code so long as they allow others to work with it under the same terms.

The OSSI has discarded the license idea in part because of differences between patent and copyright law and because it’s too complicated to implement. Instead, they’ve settled on a pledge: breeders make their seeds available without restrictions on use and ask the recipients of those seeds to make the same commitment. “Our ambitions are to actually build a separate pool of germplasm that
is ethically based,” Kloppenburg explains. It’s governed as a public trust resource and not by fiduciary responsibilities to shareholders.

Despite the soaring fortunes of various food movements, he sees an uphill battle. “Few people understand what plant breeding is,” he says. A seed is a seed is a seed, and most people don’t see the decades—even centuries and millennia—of culture and care that created it.

The Race to Control Plant Genetics

Helping plot Luby’s rebellion—by way of overseeing her Ph.D.—is UW-Madison horticulture chair Irwin Goldman (pictured on previous page). A noted breeder of beets, onions, and carrots, Goldman is a later convert to the open-source cause. At first, Kloppenburg’s predictions fell on deaf ears (his book, First the Seed, was published back in 1988). He was talking economics; breeders just wanted to breed.

On his computer, Goldman calls up an organizational chart of the global seed industry and points to the giants. By 2011, more than 75% of the global seed production was controlled by just 10 corporations. Monsanto, DuPont Pioneer, and Syngenta controlled a little more than half.

Patent law is a combination of legislation and court cases. In the current environment, companies and universities are escalating their efforts to control plant genetics via the law. But there is a loud international critique. "The claims in a patent are largely what the lawyers can get from the U.S. Patent and Trademark Office (USPTO),” Goldman explains, a de facto negotiation that can last years. "Just because the patent is issued doesn’t mean it’s right,” he says.

And patents are just one tool. Agricultural seeds now often come with bag tags—simply using them activates a license forbidding seed saving or research. And where research institutions used to share germplasm freely, these exchanges are now almost universally governed by material transfer agreements.

Goldman’s epiphany came when he was doing time as a dean at the UW College of Agricultural and Life Sciences, and a prominent biotech company submitted a new service agreement. Among other things, it prohibited: extracting DNA from any company lines, sequencing the DNA, and growing the seeds out in experiments. The meaning to Goldman: “You are not allowed to study anything we produce.”

“You don’t own the seed anymore,” Goldman says. “You are renting it.” That’s particularly true of commodity crops like corn and soybeans. He contends that for a young plant breeder starting out now, corn is so encumbered with intellectual property claims that it would be virtually impossible to start a breeding program. “I don’t think there is enough available for them to really make a go of it,” he says. “So much is tied down.”

But what’s truly driving some breeders to distraction is the patenting of plant traits that many people believe have not been invented, but simply exist deep within the DNA. Unlike the plant variety protection...
certificates in use since 1970, these newer “utility” patents prohibit research and seed saving.

For a few years now, Goldman has been following with interest a pending application for a red carrot by Seminis (a division of Monsanto). “Red carrot has existed for thousands of years in China and Japan,” he objects. “It’s naturally occurring. And I’ve been breeding it too.”

There is a bit of irony here: Goldman was part of a UW-Madison team that spent more than 20 years perfecting a beet with five times the natural level of pigment—and patented it. If Seminis is granted its carrot patent, what exactly might it contain? The first claim of the patent was simply a carrot red with lycopene—beta carotene can make a carrot red as well. The third claim of the patent is: “an average lycopene content that is at least about 110%, 115%, 120%, or 130% of the average lycopene content of carrot variety Nutri-red.” In other words, the carrot is red with lycopene—but not amazingly more red—than an existing variety.

Goldman sees an incremental gain, not anything really novel. And so far, the USPTO agrees; after more than eight years, the patent still hasn’t been granted. Maybe that means the system works. But the uncertainty has a chilling effect on further research, Goldman says, not least because only a handful of people worldwide can even understand the patents. And few have the resources for such a protracted negotiation.

Goldman’s been tinkering with carrot genetics for his entire professional career, and he can’t understand how anyone could “claim” these genes. Carrot was domesticated in Afghanistan 7,000 years ago. The predominant orange color emerged in Northern Europe in the 16th and 17th century. “I could tie up genes that had been selected by farmers millennia ago? I’d rather just do my part in stewarding that genetic material to the next hands.”

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—Irwin Goldman

Intellectual Property and Innovation

The complicated relationship between intellectual property and plant breeding can be seen on almost any agricultural landscape, but the view is particularly good from the Honeycrisp orchards of the University of Minnesota (UM). One of the most successful apple breeds of the last 50 years, it was developed by UM horticulturalists David Bedford and James Luby. (James Luby happens also to be Claire’s father.)

Compared with annual crops, breeding tree fruit has a very long horizon. The Honeycrisp project started even before Luby picked it up around 1979. It was another 12 years before they received their patent.

The Honeycrisp has done well for the university—the U.S. patent is expired, but it’s still earning in countries with longer patent terms: $13,006,658 in total royalty income as of August. Under University of Minnesota Regents Policy, a third of that goes to the inventors, and a quarter has been returned to Luby’s department, where it has gone straight back to the breeding program.

Before Luby arrived, plant breeding was supported by a combination of state budget allocations and federal land grant money. Mid-century, there were some 20 public breeding programs at academic institutions across the apple-growing regions of the country. Their breeding advances were offered as a public service.

This public support was in decline by the time Luby began his career; only a dozen breeding programs remained. Recession and political shifts in the 1980s led to further changes in government priorities. The U.S. has lost more than a third of its public plant-breeding programs in the last two decades. Today only three public apple-breeding programs survive.

In this environment, the Honeycrisp revenue helped keep the breeding going. “It

Revenue from the Honeycrisp apple helped keep the breeding program at the University of Minnesota going in the face of declining public dollars. Photo courtesy of Flickr/WyldWoods (WW.N).
provides a monopoly in return for innovation,” says Luby.

The decline in public money for plant breeding, in other words, is intertwined with intellectual property issues. “Plant breeders and seed companies are constantly looking for and investing in new technologies to develop the next innovative product,” says Thomas McBride, Monsanto’s Deputy General Counsel for Intellectual Property and Licensing, in a statement provided to CSA News magazine. “The ability to obtain intellectual property rights on these innovations provides companies a means to continue to invest in further research and development for the next generation of new and improved seed and agricultural products.”

An open-source approach is an artifact of less technological past, McBride argues. “Today, global food security needs, and a need to bring solutions to farmers’ fields quickly and efficiently, demand catalysts to accelerate innovation. The rights provided by a patent are one such catalyst to foster and encourage ongoing innovation.”

“I don’t buy the argument that intellectual property in our industry is stymieing people coming into it,” adds Andrew W. LaVigne of the American Seed Trade Association. “Plant breeding is evolving, and the seed industry is evolving with it.”

But LaVigne does share concerns that academic plant-breeding programs remain robust enough to train future generations. Not every breeding program has a Honeycrisp, but they produce value beyond the occasional market breakthrough. Luby and every breeder interviewed for this article voiced concern about the funding decline for academic plant breeding.

And while James Luby doesn’t necessarily support OSSI’s agenda across the board, the father/daughter discussions have more common ground than you might imagine. As he learns some of the intricacies of the intellectual property arguments, he’s been surprised by some of the traits awarded patent status. “It’s pretty amazing to me,” he says. “I don’t think the solutions are simple. I think we both recognize that somebody’s gotta pay the bill.”

A Return to the Seed-Saving Habits of Our Ancestors?

Despite the extraordinary accomplishments of academically trained plant breeders in both public and private sector, some of the most important breeding happened long before anyone even knew what a gene was.

Selective breeding probably began about 12,000 years ago, with people gathering fruits and seeds and bringing them to one place. The initial selection was probably unconscious, yet over time, a handful of key traits would emerge and drive domestication: non-shattering, dormancy, non-toxicity, and low bitterness. These attributes lower a plant’s fitness in nature but increase its desirability in domestication. And for all of our major food crops, these traits were already well established by the time of modern industrial society.

Few farmers grow their own seed today, but just 150 years ago, seed saving and rudimentary breeding were an essential tool in every farmer’s box. “On the most basic level, it’s an interaction between a plant and an animal,” explains Frank Morton, a self-described accidental lettuce breeder.

In 1983, Morton was a twenty-something farmer growing greens for the Portland, OR restaurant market when he grew his first cross. He had done some botanizing in college but never studied plant breeding. When he saw a red oak leaf lettuce in a flat of green oak leaf, he knew it was an accidental cross with a red romaine.

“It was intuitively clear what I should do next, which is to save the seed from the ones that I liked,” he says. “And that’s how I became a plant breeder.”

Now he has hundreds of varieties, with names like Total Clown.
and Red to the Heart. In 1994, he began selling seeds through Wild Garden Seeds. He’s particularly excited about his efforts to grow a dark red iceberg.

But a few years ago, his son called him over to the computer to show him a patent for red lettuce. “I’ve been working on that since 2005,” he said, outraged. And as he read more and more patents, he was astonished to find claims for green, curly leaves, and resistance to aphids. “They did not invent the trait. The plant invented the trait. It’s a discovery. It is not an invention.”

“Once these lettuce patents started rolling out, it was clear that you could not be a lettuce breeder if all of these patents are true,” he says. “All I am doing is taking these heirloom lettuces and crossing them and letting that internal coloration build.”

In 2010, Morton met Kloppenburg and was invited to one of the inaugural OSSI events. Since then, he has pledged more than two dozen varieties, mostly greens, to the OSSI seed pool. He believes a new breed of farmers will take up the seed-saving habits of our ancestors, and he’s eager to make a stand for farmers’ rights. “You watch. The next generation is going to be completely different.”

Will a Pledge Pay the Bills?

Not everyone is so optimistic. William Tracy is a UW-Madison corn breeder who shared many of OSSI’s core concerns and joined in early meetings. Tracy backed away when the group chose its current honor-system pledge over a more aggressive license.

“I was looking for something that would actually enable plant breeders to move forward, yet freely share their germplasm,” Tracy says. A pledge didn’t do enough to ensure fair compensation. “Plant breeding requires an infrastructure, and sometimes a substantial one,” he says. “I have to have tractors and planters and people to pollinate. That costs money.”

As a dominant agricultural commodity, corn is a far cry from carrots. While you could fit the world’s carrot breeders in a small classroom, the large majority of U.S. plant breeders work in corn—more than work in the next four largest crops. And the immense value of corn as a commodity has led to an almost complete private sector takeover. There are only 4 public corn breeders left in the country, operating on the margins of the Corn Belt. It’s generally accepted that they cannot compete with the commercial hybrids in the heartland.

Transgenics and legal actions against seed saving garner most of the public attention in corn breeding, but the real difference-making investment is in extensive field trials and sophisticated statistical analysis, argues Ed Buckler, USDA-ARS maize geneticist at Cornell. With millions of potential crosses, a random approach to breeding would take too long. Seed companies invest heavily in proprietary

Bill Tracy and Tessa Peters examining plants in a corn field. Photo by Chris Zimmerman.
software to analyze their massive field trial database, stacking the odds for each new generation. Ultimately, it’s a testament to what breeding can accomplish when it’s fully funded.

Recall Irwin Goldman’s contention that there is not enough freedom to operate for corn breeders? That a freshly minted breeder wouldn’t be able to cut through the patent thicket to establish a breeding program?

Tracy disagrees, and ironically it’s because some of the early corn patents now expiring. He believes a very competitive corn breeding line could be established from commercial hybrids just coming off patent. “OSSI has all the room it needs to operate,” agrees Buckler. “It can start with 20 year old germplasm and run. I think you can do quite well.”

Navigating the Best Way Forward to Help Solve Future Challenges

Cross-pollination. Planting a seed. People may not know much about plant breeding, but the cultural power of these ideas is unmistakable and deeply ingrained.

And that is perhaps the most compelling element of OSSI’s idea: that the ancient art that enabled civilization itself and gave rise to some of our deepest metaphors for creativity can no longer work unrestrained. Every gene is an idea. Could you imagine telling a political scientist they couldn’t work with The Federalist Papers?

While there is doubt that the OSSI model can provide a workable alternative, it has captured the spirit of an emerging critique. Calls for intellectual property reform come from all quarters of the economy and from everywhere in the world.

“Seed has been stolen forever,” Goldman says, with less alarm than you might imagine. “It’s just how it has always gone. As legal and corporate frameworks have been built up around that, people haven’t stopped stealing each other’s seeds. People steal our stuff all the time. Part of the open-source idea for me was thinking about the fact that I kind of want people to steal my seeds. Not that I want to lose value, but I want the seeds to be used. I want them to be incorporated into other people’s genetics. I think it’s good for food.”

“Our agricultural production system is all about reducing biodiversity,” he says. Get rid of the weeds, the insects, and every other species besides the one we’re harvesting.

On top of this monoculture, reducing seed diversity is potentially disastrous. “Whether it’s for disease resistance or whether it’s for productivity we’re going to have to exchange seeds with each other,” he says. “Diversity in the seed system would be a much healthier thing for humanity. These things are meant to be commingled.”

Agriculture faces serious challenges in the coming decades. We’ll need to feed more people with less land. Competition for water is expected to increase. Climate change may destabilize entire climatic regimes.

Plant breeding will be a critical tool for addressing each of these tests. Genetic engineering is likely to play a role as well, but this cleverness lacks the native genius of plant breeding. We know we want a plant that yields more or conserves water, but we don’t necessarily know how to get there. Corn breeders didn’t know that upright leaves and small tassels were the key to increasing yield. That’s what nature told us as we selected for dense planting and high yield.

“The genetics are going to tell you what works, by applying that selection pressure in whatever environment you want to grow the plant in,” says Claire Luby. “It adds a sense of place back to plant breeding.”

From where she sits, the more room that plant breeders have to operate, the greater the chance we’ll find something that is going to work. “You want as many people breeding as you can.”

E. Ness, contributing writer to CSA News magazine

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