



Science
Societies

Brightening chefs' palettes with gorgeous dry beans

UC-Davis Releases Five Disease-Resistant Heirloom- Like Varieties

By DJ McCauley

| April 22, 2021



The stunning variety in color and patterns is on show in seven breeding lines trialed by the UC-Davis team, five of which were recently released as publicly available varieties. Clockwise from top left: UC Southwest Red, Good Daughter Stallard, UC Rio Zape, UC Southwest Gold, UC Four Corners Red, and UC Sunrise. UC Tiger's Eye is in the middle. Photo by Travis Parker.

- Heirloom beans are colorful, flavorful, and desirable, but they often lack key agronomic and disease-resistance traits.
- A team at University of California–Davis released five heirloom-like varieties of dry bean, published in the *Journal of Plant Registrations*.
- The beans not only taste great and meet the needs of organic growers but are resistant to bean common mosaic virus (BCMV) and have higher yields than their heirloom counterparts.

If chefs are painters, then these beans are fresh new tubes of oil paint.

“There’s a whole seed renaissance going on right now,” Mike Reeske says. “When I show chefs these beans, have them taste them, and tell them about their history, they go nuts.”

Reeske and his wife Chris own Rio Del Rey Farms, an organic operation in northern San Diego County, California. He’s always had a soft spot for heirloom bean varieties, with their meaty bite, colorful exteriors, and long history of cultivation in the Southwest, but they’re often tough to grow. Many have poor yields and are susceptible to a major

disease aphid and seed-transmitted disease: bean common mosaic virus (BCMV).

Enter Travis Parker. In 2013, when he started his project with Reeske, Parker was a graduate student at the University of California–Davis (UC–Davis) working under his adviser (and eminent bean breeder) Paul Gepts. Gepts is a distinguished professor, Fellow of ASA and CSSA, and recipient of the Meyer Medal. The stars aligned: with support from Lundberg Family Farms, a company that grows organic rice, and the Clif Bar Family Foundation, the team started an inspired bean breeding project.

Their goal was to meet the needs of organic farmers and bring them a niche product that not only enriches the soil while fetching premium market prices for its looks and culinary quality.

Since 2013, the UC–Davis team has been selecting parents from heirloom varieties, testing for resistance to BCMV, and trialing beans in field at multiple locations. Their efforts have led to the release of five new varieties of beans in the *Journal of Plant Registrations* (Table 1). These new varieties have all the culinary and aesthetic qualities of their heirloom parent, plus the agronomic and disease-resistance qualities of adapted lines. Parker and the UC–Davis team have made huge strides for breeding beans that chefs love and organic farmers would love to grow.



A UC-Davis field where the team conducts seed increases for new varieties to scale up seed lots. Photo by Travis Parker.

Table 1. Five new disease-resistant heirloom-like varieties released by the University of California–Davis (UC–Davis) in the *Journal of Plant Registrations*

UC-Davis variety	Heirloom parent	Looks/tastes like	Yield increase	Read about it at
UC Southwest Gold	Zuni Gold	Zuni Gold	60%	https://doi.org/10.1002/plr.2.20117
UC Rio Zape	Rio Zape	Rio Zape	19%	https://doi.org/10.1002/plr.2.20095
UC Sunrise	Zuni Gold	Zuni Gold	50%	https://doi.org/10.1002/plr.2.20096
UC Tiger’s Eye	Tiger’s Eye	Tiger’s Eye	28%	https://doi.org/10.1002/plr.2.20084
UC Southwest Red	Zuni Gold	Anasazi	53%	https://doi.org/10.1002/plr.2.20092

Picking Parents

Though common bean (*Phaseolus vulgaris* L.) is just one species, there is staggering diversity in the sizes, shapes, and coat colors of its seed. Early breeders domesticated the humble bean near its centers of origin in Mesoamerica and the southern Andes 7,000 years ago.

“Researchers at the turn of the century found Pueblo cave dwellings, and in one, there was a clay pot of Anasazi beans from at least 800 years ago,” Reeske says. “There’s people in the Four Corners area that still grow those kinds of beans as part of their cultural heritage.”

Though stories claiming to germinate 800-year-old seeds and harvest the beans are (most likely) tall tales, it's this cultural heritage that brings us such delightful seeds. The heirloom varieties we know—and many we've never heard of—are a product of seed saving, grown and passed down for generations without formal improvement.

Unlike commercial varieties of navy, pinto, and black beans, the Anasazi bean has poor agronomic qualities. But bean-savvy consumers enjoy it for its lovely colors and flavors and are often willing to pay a much higher price for it compared with the plain-Jane dry beans on grocery store shelves.

"People buy seed, then cook it, and you see the color pattern still," Gepts says. "You eat with your eyes as well as your tastebuds."

So the UC-Davis team put an "Anasazi-like" bean on their "to-breed" list. Likewise, the team earmarked varieties like Tiger's Eye (a deep gold background with a purplish stripe), Rio Zape (purple and black stripes), and Zuni Gold (mottled orange or gold and white) for improvement.

There were other parents, too—seeds with striking coat colors that didn't hold up to the multi-year, multi-location field trials that Parker and Gepts put their beans through before releasing them as varieties. Some are still in the pipeline for formal releases while others will be available as germplasm for parties interested in trying them out.

The UC-Davis team began trialing parent varieties in 2013 and 2014, evaluating this vast collection of heirloom and specialty bean types, seeing what was promising and what was not so promising.

In 2015, Charlie Brummer, a professor at UC-Davis and Fellow of CSSA, got a USDA-NIFA grant and support from the Organic Agriculture Research and Extension Initiative

to start a new project: Student Collaborative Organic Plant Breeding Education (SCOPE).

“SCOPE is a chance for students to get hands-on experience breeding that they might not get otherwise,” Brummer says. “They work with mentors and manage their own breeding projects.”

The 23-acre Student Farm in the heart of the UC-Davis campus was a natural home for SCOPE. There, Parker winnowed down selections and evaluated crosses for disease resistance between 2014 and 2018.

“Travis is a real testament to what we can do with the SCOPE project,” Brummer says.

“Travis put in a ton of work, a ton of effort, and now there are these varieties to release. We took varieties with significant weaknesses and made them better! It’s very fulfilling to produce something this desirable for a specific market.”

Bean Common Mosaic Virus

One of the team’s biggest goals was integrating resistance to BCMV. This disease is named for the symptoms it induces: patchwork mosaic patterns of “light green–yellow leaf tissue, dark green tissue, or both light and dark mosaics together on the trifoliate leaves,” according to the University of California Integrated Pest Management Program. Infected plants also show leaf puckering, blistering, curling, and rolling.

Aphids often transmit BCMV from infected plants to healthy plants as they feed.

Virions—infective viral particles—loosely stick to the aphid’s stylets, which are the mouthparts it uses to probe plant tissue. Though yield loss is only reduced a little when aphids infect growing or mature bean plants, the seed those plants produce carry the virus to the next generation, resulting in stunted, unproductive growth and yield losses of 75 to 100%.

For organic growers trying to carve out a niche market using heirloom bean varieties on a small amount of land, BCMV can be devastating.



Two bean plants show the phenotypic differences visible after inoculation with bean common mosaic virus (BCMV). One plant is resistant (left) and one susceptible. Photo by Travis Parker.

“I actually planted Tiger’s Eye in the past, during one of my trials in graduate school,” says ASA, CSSA, and SSSA member Brook Brouwer, a Washington State University extension agent who has researched

heirloom beans in western Washington. “It had BCMV–infected seed, and it just destroyed my trial. I’ve seen firsthand how destructive this virus can be.”

Fortunately, there’s a well-documented genetic source of resistance to BCMV: the dominant “*I* allele.” To create varieties with all the characteristics of heirloom beans, but with resistance and increased agronomic performance, Parker chose a “donor” parent from the UC–Davis collection to cross with the heirloom “recurrent” parent.

“In the F1 generation, the progeny are totally different compared to either parent—sometimes unrecognizable,” Parker says. “But cross-pollinate back to the heirloom variety once, and it becomes a little more like the recurrent parent. Backcross twice, you’re getting more similar, and beyond that, it’s at least seven-eighths heirloom. You’re pretty certain, at that point, that it’s really similar to the heirloom.”

As Parker backcrossed varieties, he was selecting for plants with seed coats that looked like that of the heirloom parent, better agronomic traits for production, and BCMV resistance.

The team used a two-pronged approach to evaluate for resistance. As soon as a plant germinated, the team inoculated the leaves using ground-up infected leaf tissue mixed with a buffer to keep the pH stabilized and a little bit of celite. The abrasive celite punctures tiny holes in the cuticle of the plant, giving the virus a means of entry. It's essentially the mineral equivalent of an aphid's stylets probing the plant. When the little plant grew a bit more, Parker would pluck off a leaflet, extract its DNA, and check to see if the marker for BCMV resistance was present.

Over the course of the growing season, they also evaluated the plants for phenotypic characteristics of resistance, rating the plants from totally susceptible to completely resistant.



Travis Parker, first author of the recent heirloom-like dry bean variety releases in the Journal of Plant Registrations. Photo by Bob

Johnson of AgAlert.

“Phenotypically, plants that are homozygous and heterozygous for BCMV resistance look the same,” Parker says. “Using marker-assisted selection was really useful to make sure we’re not moving forward with plants that are heterozygous. If we didn’t have this marker test, we’d have to do pretty extensive progeny testing for multiple lines of each of these [varieties], and even then, you’re never really sure.”

With the combination of in-field evaluations of virus resistance and benchtop evaluations of bean plant DNA, Parker made doubly sure his plants carry resistance. But the plants aren’t *just* resistant—the varieties are much more productive than their heirloom counterparts.

Breeding for Organic Management

Across the board, these heirloom-like dry bean varieties are a product of a project intended to serve the organic community. It’s only logical that the team used organically managed land to test their varieties.

Along with the organic practices at the UC–Davis Student Farm, the team also tested the beans in multi-year, multi-location trials at several organic farms across the state of California before releasing the best varieties in the *Journal of Plant Registrations*.

“This team was committed to organic breeding through the entire variety development,” Brouwer says. “Organic trials are ignored in breeding operations a lot of the time, so it’s fantastic to see a group that’s going for heirloom looks and flavor, with improved agronomics for organic farming.”

Three independent organic farms tested seed: Coke Farms, Fifth Crow Farms, and Rio Del Rey Farms. UC–Davis served as the northernmost site, with a location in Valley Center as the southernmost, just before the U.S.–Mexico border.

“There were some varieties I was really excited about that just weren’t cutting it,” Parker says. “We had to send these out in the field, in multiple locations, to make sure they were good enough to put the UC–Davis name on them.”

The varieties Parker settled on all outperformed their heirloom parents. ‘UC Southwest Gold,’ for instance, has 60% higher yields than ‘Zuni Gold’ (you can see how the new varieties compare to the heirlooms in Table 1).

There’s a couple of reasons why the UC–Davis beans outperform their heirloom counterparts. As the team chose progeny to carry forward through their trials, they directly selected for yield. The viny, non-senescing plants that were a real pain to work with were cut from the process. Plus, as they moved forward toward multi-year, multi-location trials, they were also learning about what it takes to run a moderate-scale organic bean operation.

A Moderate-Scale Bean Farm

Antonia Palkovic, co-author on the *Journal of Plant Registrations* papers and associate specialist for Gepts and Brummer, handled much of the day-to-day operations in the field. She coordinated undergraduate interns, orchestrated harvests, and worked with Student Farm staff to troubleshoot the problems that arise in a moderately sized organic bean farming trial.



The UC-Davis thresher. Photo by Kimberly Gibson.

"The biggest challenge is finding the appropriate scale of harvest equipment that's also affordable," Palkovic says. "We didn't really have the right harvesting equipment for these bean trials."

You can harvest your beans in one of two ways. In the Midwest, farmers tend to cut and combine beans all in one step. In California, on the other hand, farmers cut the beans, windrow them to let them dry out, and come back to thresh them.

"We have this old rubber roller thresher from the '60s, and once the beans were dry, we went around and threw them into the tray of the thresher, five feet off the ground," Palkovic says. "When we were testing heirlooms, some were very viny and non-senescing, and they didn't even dry after we windrowed them. They were so heavy, and the thresher really wasn't equipped to deal with that kind of wet material."

For a small-scale organic farmer incorporating beans into their fresh vegetable rotation, finding equipment can be tricky. Reeske, for example, ventured all the way to Turkey to find the right size equipment for his 9-acre farm.

Some farmers opt, instead, for hiring custom harvesters to come to their fields. Though this cuts back on the outright cost of buying equipment, timing can be tricky.

"I know of several farmers who were ready for harvest, but because their operations are small, they were bumped to the end of the line by the custom harvester," Palkovic says. "By the time the harvester came, the beans were too dry to work with."

One other challenge for organic farming is weeding. The team hopes that the ground-covering traits that many of their releases display will be a boon to organic farmers in the hot, dry summer conditions of California.

“With a plant type that covers the ground more, if you stimulate early growth, the canopy of the plant can smother the weeds,” Gepts says. “You get a canopy, a growth habit, that’s different than what you’d want for a conventional system, but for the organic sector, it’s actually an advantage. Plus, it helps keep moisture in the soil, too.”

So far, the team is getting positive feedback from growers using the beans. Breeding beans intended for organic growers on organic ground has helped the UC–Davis varieties keep yields up. But we’re missing one other important part of the story: how do they taste?

Cooking Up Beans

When it came time for Parker to see if his bean selections looked and tasted like their heirloom parents, he turned to a bustling field day at the UC–Davis Student Farm to wangle untrained tasters.

Parker cooked up all his beans the same way and offered blind taste tests in which participants rated flavor and culinary quality from 1 to 5. The participants had no idea which were heirloom or heirloom–like beans.

“It made sense to test these out with a whole variety of people who don’t know how to distinguish or name flavors because we know we’re getting their real impressions,” Parker says.

The tasters rated the beans highly on both cooked visual appearance and flavor and would be hard–pressed to decide which was heirloom and which the heirloom–like variety.

If the Student Farm tasters represent your average, untrained consumer’s perspective on bean flavor, Reeske’s tastings at Rio Del Rey Farms provides feedback from the

pros. Reeske routinely invites chefs and organic food aficionados to sample market vegetables and heirloom beans from his farm.

“When I started out, I naively started going around and handing out half-pound bags of beans,” Reeske says. “Once a few people took them and tried them, word got around. For a chef, these beans add one more color to the palette they can paint with, and they taste so good.”

Mike Reeske’s Recipe for a Dang Good Pot of Beans

1. Put 1 lb or more of beans in a large pot, adding water and 1 tablespoon salt per gallon. This is the brining stage—it doesn’t add salt to the flavor of the beans but does soften the seed coat to prevent splitting later on.
2. Soak for 6–8 hours (or overnight if you like). Drain and rinse.
3. Return beans to the pot, cover with liquid (water, vegetable, or chicken stock). Bring to a rolling boil for 10 minutes.
4. Turn the heat way down and make sure the beans are still covered with liquid. Now’s the time to add flavor: onion, carrots, celery, bell peppers, herbs, cumin, coriander—whatever you like. Avoid adding any kind of sugar, salt, or acidic flavors here. We’re going for herbs and spices.
5. Depending on how fresh your beans are, they’ll take an hour or more to cook. About 30 minutes into the cook time, take out a couple of beans. If they’re slightly soft, it’s time to add salt, sugar, and any acidic components, like tomatoes.
6. Cook for another 30 minutes or more until beans reach desired doneness. Test for this by biting into a few beans—they should be tender, but not grainy.

7. A secret finishing touch: add a capful or two of apple cider vinegar right at the end. "It perks it all up," Reeske says.
8. Serve and enjoy! Leftovers are great, refried beans are even better.

"Find a recipe you like. Try it with one type of bean, then switch to another bean and see how it is! Or, if you find one bean you like, try it in a bunch of different recipes. Beans are so versatile—get creative!" Reeske says.



Photo courtesy of Adobe Stock/narstudio.

Reeske talks through the merits of a good bean gravy, the best way to keep your beans from splitting ("You want to see the coat! You could wear 'Tiger's Eye' as earrings!"), and the best bean pairings for soup, refried beans, chili, or a hearty meat dish.



A taste test of the heirloom-like dry bean cultivars conducted by the UC-Davis team at the Student Farm. Tasters—all individuals interested in organic agriculture—compared the flavor and cooked visual appearance of both heirloom and new UC-Davis releases. Photo by Travis Parker.

These varieties capitalize on all the tender, meaty, hearty, creamy, rich flavors you could hope for from a good pot of beans. Gepts and Parker, both, say you just have to try them and see.

But if you don't have extensive experience in the careful process of soaking, boiling, and seasoning beans, you might be a little bit intimidated by the slow-cooking process.

"It does take a long time to cook them—a lot of consumers are really put off by that," Palkovic says. "But once you're familiar with how to do it, it's a whole different

experience."

Bagged dry beans are about a third the price of the equivalent canned organic variety. Both are a great source of protein, and the colorful seed coats contain antioxidants. Paired with a cereal, the humble grain legume provides a complete protein.

"We want to help the organic sector—that's our major goal. And we really want to make grain legumes more attractive," Gepts says. "We want to get someone like you to eat more beans!"

Parker is a post-doc at UC-Davis these days. Developing all these bean varieties was just one chapter in his doctoral dissertation, and he has big plans—along with co-authors Gepts, Brummer, and Palkovic—to continue serving the needs of organic

farmers through research at UC–Davis.

“This project was only possible because of the support of the organic farming community,” Parker says. “We’re giving these varieties back. We just want to see as many people grow these beans as possible.”

Dig Deeper

If you want to get some of these beans for yourself, whether for planting or eating, they’re publicly available. UC–Davis has a handshake agreement with Reeske to produce and sell the beans—visit the Rio Del Rey Farms website (www.riodelreybeans.com) to order yours. Parker has an informational YouTube video about his trials—you can watch him talk about the work he’s doing at UC–Davis here: https://youtu.be/h_QFqQTmeJw. Learn more about the beans by reading about them in the Journal of Plant Registrations (see Table 1 for direct links).

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