Taken from Dr. John Navazio's speech

Debunking the Hybrid Myth

I have the unenviable task here of stripping down what I consider the overblown 'myth of hybrids.' Even though hybrids have worked out okay for many of the farmers that I know, they've worked out because there hasn't been enough emphasis on the non-hybrids and OP's. I'm going to tie the topic of comparing OP's and hybrids and their relative strengths in with a discussion about what the true vibrancy and diversity of a real seed system looks like. Matthew Dillon and I started Organic Seed Alliance because we saw an incredible need for farmers to really know how to grow high quality seed with all the necessary traits that farmers need.

Genetic resources need to be preserved and carefully managed. But they do constantly co-evolve with the humans who select them and who use them. If you have vital varieties that really work for people, that really feed people, then there is a constant interplay of the farmer, the variety, and selection, both natural and farmer selection, as well as adapting to all of these changes. What I do is the research and the breeding work which is actively done with farmers. I do not do any plant breeding that doesn't involve an equal partnership with farmers. So my world is centered on working with and helping farmers.

I'm going to talk a little bit about participant plant breeding. PPB is basically where the farmer and the breeders work together in true concert, as true equals. Nash Huber is a farmer who grew up on a farm in Carbondale, Illinois. He's in his early 70's now and he remembers that most of the crops that they grew they'd save the seed from. So when he got to Sequim, Washington, and couldn't get the carrot seed that he needed he said, "Heck, I can grow my own carrot seed." He has the great benefit of having less Queen Anne's lace than you folks do. In this image many of you may think it looks like a stand out in a roadside ditch of Queen Anne's lace, but that is carrots (figure 1).

These carrots are an old OP, he doesn't tell anyone what it originally was, but it's no longer available. This is their label, it's called 'Nash's Best,' and everybody around Seattle loves them. Nash produces about 30-40 acres every year, and about two-thirds of this is from his own seed.

This is the way that all seeds used to be. If you produced carrots you either grew the seed yourself, or you had someone in your community or region that you traded with for the seed. Maybe the trade was for cash money, though, as many of you know, farms were not as heavily into the cash economy in days of yore as they are today.

There was some international commerce on seeds, going way back. Melons travelled from India to China long before anyone even knew there were even trade routes. They must been handed from person-to-person one mile at a time. Seeds, and involvement with seeds, were an everyday reality of being a farmer. It was a part of the fabric of being a farmer and it was a reflection of whether you ate and whether, as time went on, you were successful or not. The thing many people don't realize is that it really wasn't until the 1880's that there was any kind of widespread seed companies, regional seed companies indeed, but pre-1880's isn't that long ago. Isn't it amazing really when you think about that?

Until the 1880's basically all agricultural crops were maintained as what people very frequently now call 'landraces.' I once heard someone say they prefer to call them 'farmer varieties' instead of 'landraces.' This is because the expectation there is that they are of the land, whereas it's really a combination of the land, the environment, and the human hands that do the selection, nurturing, and domestication. All of our crop plants were wild plants at one time. Most of them, barely edible, were selected by human beings who never went to school in their life. Well-maintained material didn't happen until the1880's.

You've probably read about Nikolai Vavilov and his centers of origin in very topographically diverse areas of the world. If you really get into the centers of origin, or areas of diversity, you will find that you can spend your whole life studying the different theories on how many of these there are. The point is that all of these areas are very topographically diverse, usually meaning altitude with very quick, steep hillsides and lots of microclimates therein. So it was Vavilov's idea that domestication happened quickly and radically in these areas because of the diversity of the selection pressure and as well as the humans there trying to carve out an existence under challenging conditions.

So let's talk about tomatoes for a second. Wild tomatoes are from the Americas. By the time that the conquistadores landed in the area of what is now southern Mexico and Guatemala there was in fact a semi-domesticated form of tomato growing. The key is that the tomatoes that the conquistadores took back to Spain first, and then disseminated to Italy, especially, were small and basically cherry tomatoes. There hadn't been a lot of breeding work by the Mayan peoples of that area. In Europe, it didn't spread very quickly because everyone thought it was poisonous.

All of this variation that you see here happened in a 200-300 year period, from a bunch of cherry tomatoes. They disseminated across the landscape in very diverse climates and were selected for new varieties by the humans who

decided to give them the extra effort and domesticate them, the climatic influence that is natural selection, and then good old recombination in genetic terms. Genetically, new combinations are coming up all of the time both from something called transposons, but also just good old combination and recombination of the DNA. How did they go from cherry tomatoes to these big beefsteaks in just 200-300 years? It was because they had eyes on the ground. Every farmer, every eater, was a seed grower and they were totally tuned in to watching for variation and picking the best. It was plant breeding at its best by people who were in tune.

When you have things in really diverse landscapes, such as potatoes in the Andes, there is a lot of selection pressure. Your environment at the top of this field is different than the environment at the bottom of this field so the selection pressure of nature is different from the bottom to the top.

Figure 1, photo by Micaela Colley, Organic Seed Alliance

This picture, from Guatemala, is of a white corn planted in a field with colored varieties used to plant what's called the border row. They plant these wild colored ones only on the edge of the plot because they want most of their corn for the year to be white. If you go deep into the plot most of it is white with the occasional color here and there. They always save these wildly colored ones separately and plant them on the border of the plots. Why? Because they have learned through experience and by being incredibly observant that when these are present there's more adaptive change available in their crop to go through genetic selection. Whenever they wouldn't plant this at the edge of their field the robustness of their crop would go down.

Figure 2, photo by Teddy Morelock, University of Arkansas

What happens when you don't keep your stuff diverse? Well Dr. Morlock found out what happens when you grow spinach on the same piece of ground 25 years straight (figure 2). And guess what folks, these are the kinds of disaster and challenging situations that are actually happening right now here in North America. This is how we breed disease resistance and Teddy's material has got the best White Rust resistance, which is the really bad disease there.

Now is there still variability in our crop plants? I thought when I first got into this that we're losing all of the variability. I'll tell you quickly at first I thought about the variability across varieties. This variety's got different variation and another variety has that variation, and put them all together like in the tomato picture and you see all that incredible variety. What I've come to learn and love and devoted my life's work to is how you get intervarietal variety.

When I was working at a large seed company, some seeds people from Italy showed up and they said, "We want you to look at our spinach. This is the best spinach in southern Italy. This is what all of the farmers grow." I thought it would be some spanking new, totally uniform deal. I was totally shocked when I planted the seed out of this commercial packet of spinach 15 years ago and this variation is what I got. I was blown away. I could breed six new varieties of spinach from that one variety.

Variation like that spinach and this 'Variegata de Chioggia' from northern Italy (basically a raddichio, or chicory-we have found that chicory is the best winter green leafy vegetable where we live where it gets down to about 14 or 15 degrees) is what a lot of Italian chicory still looks like. When you get a really uniform radicchio that goes to market in northern Europe and here in the USA, those are hybrids bred by the Dutch, who took Italian seed and made hybrids. There is real variation from seed I bought in a packet from a small Kansas seed company. There's a wealth of variation there and it's not just in color. We run it through our nursery; there's differential rotting rates; I don't even know the diseases yet, I'm just learning, and cold hardiness variation is different from plant to plant. We've been selecting for varieties that will go through our

cold winter so we can be eating chicories all winter long- which I've done for the last two winters.

Farmer varieties are genetically resilient. So all of these, what I originally defined as landraces, and up until the 1880's, were much more variable than modern varieties adapted to the challenges of the specific geographic regions where they came from because there was always-and this is a big one folks-strong natural selection on the material. People were not pampering it, people were not watering it with sophisticated irrigation, and so when you put plants under stress like we saw on the ridge top today with the kind of weather you all have been having - that 100 degree weather, you really start to see the variation. Then you have an opportunity to work in concert with natural selection if you care to improve your crops just like our ancestors did. They would be all over that lettuce field we went and saw today; of course three quarters of the plants were dead from disease, but some were alive.

So agronomically these older pre-modern periods were rustic by our standards today, though there are many varieties in the Seed Savers collection that are truly these farmer varieties. In the advent of seed catalogs and the varieties bred between the 1880's and World War II, there was still, from what I've been able to determine, a lot more variety left. We really only got on the uniformity kick post World War II, except for King Corn of course that started a little earlier.

So let's talk about hybrid corn. In 1850, Charles Darwin was actually the first one to ever document making corn hybrids. Darwin did this and he noted hybrid vigor, and documented it very well. But it wasn't until 1900 that corn really became the model organism and the whole revolution that you have on all sides of you in Iowa really started. With the rediscovery of Mendel's laws, people started to make inbreds to make hybrids. Of course, Pioneer was started in Des Moines by Henry Wallace. He bred the 'Copper Cross' in the 20's in his backyard in Des Moines. It was the first commercial hybrid ever.

The neat thing in the history of hybrids, without being reactionary and completely anti-hybrid, is that the early plant breeders who worked on hybrid corn, were all farm boys. They knew which end of the plant goes in the ground, as my old boss used to say. They knew what was important to the farmer. People always say, hybrid corn, yield, yield, yield and certainly that's the song they sing, but in the early days it was stalk quality and disease resistance. Most OP corn, so I'm told, in large fields will lose five to ten percent based on poor stalk quality in any kind of wind storm, like with the winds you all had last week.

Once they bred these early generation hybrids, they went from zero to sixty in some counties in Iowa and adjoining states in 10 to 12 years, which is pretty amazing. This was during the late 1920's and 1930's, when those 1930 dollars were a little bit rarer. Here's a map showing the spread of hybrids in each county, there you can see Iowa represented strongly (figure 1). From 1936-1948, 10% of the corn was hybrid. It spread fast, like wildfire.

Why did hybrids work so well? Well through the breeding process, and making inbred lines, which are the parents of hybrids, you sort out deleterious traits. It allows you to see them clearly and eliminate them. They would often start trying to make a thousand new inbreds and they'd be lucky if they could find one that really worked. This is because most of them suffered from inbreeding depression so badly, especially in the early days, that they were immediately eliminated from the programs. Again, remember these were farm boys, they knew what corn plants were supposed to look like. They rolled up their sleeves and looked at tens of thousands of inbreds sometimes to find one or two good working inbred lines.

See the corn on the right (figure 2)? This is showing you the two parental types on left and right that went into making the hybrid that's planted down the middle. You take two short inbreds that were at least strong enough that they did not die from the inbreeding work and had some redeeming traits, you found two of them that were complementary, you crossed them, and voila, hybrid. There it is pictured in the middle.

Today the inbred stars are as big as the OP's were in the 1940's. I'm not here to sing the praises but it's a pretty amazing thing and it wouldn't spread across the countryside if it hadn't worked. You know what farmers do? Farmers pick up new ideas by looking over the fence post and they still do it.

Why are hybrids favored by seed companies?

1. Once the parental inbreds are fixed it is easy to make the hybrids year after year. You have two parental types and you cross them.
2. You can maintain those two homogeneous, very uniform parental types, and every time you want to make some new hybrid seed just plant it out in the field, detassle one, and let the other one make pollen. They've been inbred so much they're very easy to maintain, unlike OP's that have all that variation. You're seed savers, you've seen it, right? Once you've inbred the hell out of it you've basically made it so genetically narrow that you'll see that the variation is gone. Two uniform parents make a uniform hybrid.
3. Companies liked it because hybrids allowed instant proprietary ownership. If you maintained your own inbreds and didn't give it to anybody else you were the only one that could make that 'Copper Cross' hybrid and sell it. Whereas, previously, if you were Ferry Morse and released 'Detroit Dark Red' in 1902, within three years every home garden, farmer, and seed company in America had 'Detroit Dark Red.' Owners of seed companies loved this little trick, this little wizardry, and the breeders liked it because of the stacking of traits it is actually easier to breed hybrids.

What are the disadvantages of hybrids?

1. Inbred lines are genetically narrow and have less adaptation over time than many OP's. That's why so many of them died from inbreeding depression. You reveal these deleterious traits and narrow their genetic base so much that they're not adapting and evolving like our older varieties were at the hands of the humans who kept them. In fact, in studies of inbred lines they found that the best inbred lines tend to have less of McClintock's transposable elements which meant they stayed stable much easier and are the reason the companyies loved them so much. It's anti-evolutionary.
2. Hybrids are weaklings. When you grow inbred seed, and I worked at a company where I grew inbred seed, you have to pour on the chemicals, use more water, more fertility, you really do have to baby them. They are prima donnas.
3. F1's focus is often not on the best traits. They're really focused on the traits that are good for the centralized systems, where we do high input agriculture. It's the wedding of modern reductionist science and high input, high output. That's not the way Mother Nature normally works. Vandana Shiva talks about how the focus of science has been reductionist, and it's all about how can we figure out the input to get exactly what we need to get the right output. At that point you are taking a lot of nature out of the system and the new variation that gives us all of the diversity that we honor so much here today just doesn't show up as much.
4. When you save seed from the hybrids, they don't breed true, and when varieties are dropped they are gone! You don't save seed from hybrids, although there's always an exception to the rule.
5. Seed growing has become very centralized and very specialized. A hundred years ago all farmers had knowledge of how to grow seed for most of their top line crops. If you want to talk about loss of diversity, we have lost the people who know how to grow seed. This is as tragic as losing the genetic variation itself.

What are the advantages of open-pollinated varieties?

1. They carry variability, and this results in genetic resilience.
2. OP varieties can be bred to be tough in all stages. We can select for that in all stages. You can do that with hybrids too, but it's easier if you have that built in resilience.

Figure 3, Photo by Jared Zystro

Figure 2, Photo from Iowa State University News Service

Fig. 3. The spread of hybrid corn: Areas that planted 10 or more percent of their corn acreage to hybrid seed in specified years.

Figure 1, Photo from USDA

3. They can be very regionally adapted and continue or always will be adapting year in and year out. We need things like that right now, we're going through this climate chaos, and so is everyone that I speak to all over the country.
4. When you save seed they do breed true, if you followed your isolation, of course.
5. Varieties are not lost due to a business decision. Many of the farmers I work with actually went back to OPs' because they were sick and tired of seed companies dropping hybrid varieties that they'd actually come to know and love and learn to cater their system too. All of the sudden it is gone one day. In fact that was a lot of Nash's business decision with his carrot seed productions.
6. All farmers can be seed growers. They can certainly be breeders with this regionally based advantage.

What are the disadvantages of OP's?

1. They are genetically variable, and not always consistent. I don't know if any of you get frustrated on the garden scale of not getting as much uniformity as perhaps you would like - some cabbage plants don't really make a head or something like that. But we can also take advantage of this if we do our selection and upkeep, and learn how to foster that adaptation.
2. They are harder to maintain. I can attest to that having bred both hybrid and OP's. It's much harder to breed something that's genetically resilient, while keeping in enough variability to keep it strong, and enough selection to make it uniform. It's a real paradox, how will I get a uniform enough variety but keep the variability?
3. How do seed companies keep varieties exclusive? If we're just growing OP's anyone can go and grow it. That's a biggie. And the question that I ask all the seed growers I work with is, "What is the incentive for you to proceed if there is no business incentive?"

Here's a picture of Martin Diffley (figure 3). Bill Tracy, who is really the preeminent corn plant breeder in the United States, at least academically, from the University of Wisconsin-Madison, claims that Martin Diffley actually knows more about growing sweet corn and understands it better than any other human being he's ever met. And coming from Bill Tracy, that means something.

We started this wonderful Participatory Plant Breeding project several years ago because Martin was completely fed up with hybrid sweet corn. He did 25-30 acres of corn a year. Anyone who has ever bought sweet corn at the Wedge Co-op in Minneapolis knows Marty's sweet corn. How many people have eaten Gardens of Eagan corn? Now I'll just tell you a thing or two about this project. Martin was frustrated because the newest hybrids did not have good cold soil emergence. The hybrids he was buying 15-20 years ago had better cold soil emergence than the ones that he was finding today - at least in his market class in the Twin Cities area. Of course Martin is fanatical about quality and had to provide the sweetest, most tender sweet corn. Marty and I were talking about this one day and I said, "You know what, Martin? You're the perfect guy to do one of these projects right here on your farm. All we have to do is plant the starter population, work with Bill Tracy, and plant the stuff ten days earlier than anyone would dare ever think of doing."

And that's what we started to do. This is actually a sub-population from California. We planted it out every spring. The breeding material came from Bill Tracy, who first generated it and willingly gave to us – in cooperation with both OSA and Gardens of Eagan Farm. We started to plant it out and this picture is a good stand, sometimes in the field three quarters of the lines would not come up because we planted it so early, after all, that's what we wanted to find out. We have now selected for four cycles for cold soil germination. We have two populations now that we can reliably plant 10-14 days earlier than anybody in the area plants and most of it comes up. We have material that is delicious because Martin Diffley was there for every tasting, as well as Bill Tracy. They'll be two new open-pollinated high quality sweet corns. With seed produced here in the Midwest for you. And then you can keep your own strain and select it under your own microclimate.

So what do we need? We need a decentralized system where we have opportunities like this. Where we can breed something like these OP corns, and have them maintained in their area of intended use. And in fact even produce the seed. We need regional seed companies who understand the needs of those farmers and who are willing to produce the seed of what they need. We need skilled regional seed folks who just know how to do what our ancestors did - selecting it. We need to reinvigorate agriculture and seed growing knowledge. We firmly stand for abolishing all patenting laws, an for open source seed for people. So with that I'll say goodbye.

John Navazio, Ph.D. is both the Senior Scientist for OSA and a Plant Breeding and Seed Specialist for Washington State University Extension. John trains farmers, university students and others in organic seed production and the fundamentals of participatory, on-farm plant breeding for organic systems. His breeding work includes increasing genetic breadth in a number of vegetable crops for their nutritional quality, flavor, texture, ability to scavenge nutrients, compete with weeds, and resist heat and drought. John develops participatory breeding projects with farmers across North America to improve crop germplasm for regional seed independence. He is a lifetime member of Seed Savers Exchange.