

Transcript: Plant Breeding Stories Podcast
S3E3 Mark Messmer, CoverCress



[Theme music plays]

Hannah Senior: Welcome to this episode of the Plant Breeding Stories Podcast, where I talk to leading lights about plant breeding, asking what they do, what makes them tick, and what fascinates them about the world of plants. I'm your host, Hannah Senior of PBS International, world leaders in pollination control. We design and produce specialist pollination bags and tents used by plant breeders and seed producers all around the world. And through this, I've been privileged to get a unique perspective on how plant breeding globally affects our diets, farming systems, and the environment. I'm excited to share a little of this with you, as we meet some of the amazing people who make plant breeding their life's work.

[Theme music fades]

Hannah Senior: Today I have with me Dr. Mark Messmer, Vice President of Breeding and Product Delivery at CoverCress. CoverCress is the name of the company and the name of the plant that he works on and this is a fascinating story of plant based agricultural innovation centred around a newly developed broadacre crop derived from the common weed pennycress. We discuss putting together a breeding strategy for a crop that's being developed more or less from scratch, finding the best markets, and establishing partnerships across the value chain - and doing all of that more or less in parallel. Transcripts of this episode and all our podcasts are available at [PBSInternational.com/podcast](https://www.pbsinternational.com/podcast). I hope you enjoy it.

Hannah Senior: First of all, Mark, welcome and would you like to introduce yourself?

Mark Messmer: Thank you very much. I'm Mark Messmer with CoverCress which is a new startup company, trying to develop a new crop out of a field pennycress mainly for bio renewable fuels and potentially food use in the future.

Hannah Senior: Now, one of the ways I almost always start these conversations and something I'm endlessly curious about is how did you get into plants? So maybe you could tell me a little bit about your background, maybe build that picture for me.

Mark Messmer: Sure. I actually grew up the son of a Brickmason in Southeastern Indiana. I was good at chemistry and biology in high school and so I went to Purdue university and started in biochemistry as my sort of my first major and the biochemistry class. I had a genetics class and that just really fascinated me. And I can remember going to the... Back then you had a hard copy course catalogs, and I can remember going into the course catalog and looking for something that genetics could be used for and came across agronomy and plant breeding. And so changed majors, progressed through the agronomy curriculum, got a job in the wheat breeding program at Purdue as an undergrad my final year there, and then via those connections ended up getting a graduate assistantship at university of Illinois in corn breeding. And got a master's and PhD there under Dr. Bob Lambert. And that was, that was the beginning. So my plant background, my family didn't have a lot of money so we grew a big garden and I was always interested in plants, but never did I believe or never did I even imagine that I'd ended up being a plant breeder and end up where I am today, try to develop a new crop.

Hannah Senior: That's a really good introduction for understanding how you came to, transition from I suppose a background where you have plants around you, but it wasn't a career that you grew up knowing all about when you first started thinking about what were you going to do for a living?

Mark Messmer: Yeah, I mean, I was always interested in numbers. I can remember when I was in the seventh grade, I kept track of weather data and just watched trends in weather data.

Hannah Senior: [Laughing] I love it!

Mark Messmer: You know, numbers fascinate me, data fascinates me, but the application has been really fun.

Hannah Senior: So you started your career after your PhD with the Garst Seed Company and then in the late nineties, you went to work for Monsanto. So just tell me about the work you were doing at this time and what kind of crops you were focused on.

Mark Messmer: I started at Garst Seed Company in 1983. Garst was almost a startup in a way in that there had been a legal separation between Garst and Pioneer, and Garst decided to start a corn breeding program. And I was the fourth breeder hired during the first year of that program. And we built that program up from basically zero germplasm, zero, anything. It was really a startup breeding program. And over the next several years ran a corn breeding program. I actually pretty much ran a corn breeding program for about 10 years. Although in the interim, I got involved in management and managing other breeders. To make a long story short, in 1995 the decision was made to downsize that program substantially and got the opportunity to go to Monsanto in 1997 as their Global Hybrid Wheat Research Director, which seems a little strange because I'd spent my entire graduate career and commercial career in corn breeding.

Mark Messmer: So Monsanto hired me into that position because of my experience with hybrid crop. And at that time, Monsanto was trying to develop hybrid wheat. And so they wanted somebody who had hybrid breeding background and so on. At that time, Monsanto was in the process of buying a large number of seed businesses around the world. And they had purchased the Asgrow seed business in the U S along with DeKalb and Holden foundation seeds. And they made a decision to try to integrate those programs together, obviously. And in late 1998, I was asked to come back and lead the integration of those breeding programs in North America. So I did that and really for the next 14 years, 14, 15 years until I retired in 2014, I either led or co-led North America corn breeding through a really exciting time.

Hannah Senior: And what you've just described for that period of your career it sounds like you were overseeing breeding programs and managing integration of breeding programs, you weren't hands-on with the breeding so much. So tell me what did you like and what did you not like as a consequence of that?

Mark Messmer: My favorite part of plant breeding is being in the field and sort of being in a situation where I'm walking through the field either alone or with somebody. And I said - it sounds a little bit crazy - but just trying to let the plants and let what I'm seeing sink in from a "what's actually happening?" standpoint either genetically or agronomically or whatever. And I just really enjoy that. I'm sort of a plant nerd. If you saw my house and my yard right now, you would think "These people are crazy! Why would they want to try to take care of all these plants?" And so I really enjoyed that part of the job and I think I probably spent more time in the field given that this program had 25 or 30 breeders and 20, 25 sites around the country and I'd travel around.

Mark Messmer: My favorite time of year was in the early fall when we would go out and just look at plots and talk about products and those sorts of things. And so that was my favorite part of the job. Pretty, obviously my least favorite part of the job was the administrative stuff. What I enjoyed was being in the field and of course in the position that I was in, most of my job really was the administrative stuff and the people management, and I enjoy the people management because I enjoy trying to pull teams together and encourage people to work together. And we were quite successful, as I said with that and again, the reason for that was we had sort of a singular goal that everybody was bought into. And when we just emphasized that goal and emphasized the necessity for people to really work together and help each other achieve the goal.

Hannah Senior: Your self description of being a plant nerd, I think you'll be in good company with a lot of the listeners and myself included [She laughs]. So we've found our community! [They both laugh]

Mark Messmer: Yeah I think so!

Hannah Senior: You mentioned earlier that you retired in 2014. But you're still working very hard - many years after you quote unquote "retired". [Mark laughs] What happened?!

Mark Messmer: [Laughing] Yeah, that's a pretty good story. When I retired I turned 57 that summer and people wondered, "well, what in the world are you going to do?" I said,

well, I really don't have a plan other than a few of these things, hobby type things. But about two weeks after I retired, I got a call from a guy named Mike Roth who was one of the founders of CoverCress at that time, it was called our Arvagenics. And he said, "I know you just retired, but what are you thinking about doing?" And I said "Well, in the first place, I'm not thinking about doing anything for about six months." And so I said "I'll come out to talk to you - give me a call back in the fall."

Mark Messmer: So about four months later, they called me back and I went out and started talking to them. And one thing led to another and they said, "Well could you start writing a, sort of a breeding strategy for this crop?" At founding back in 2013, in the spring of 2013, they had gone out and collected several hundred pennycress accessions from along roadside ditches and from farmer's fields and so on and so forth to sort of form a germplasm base. And they had planted those out and a number of those out and started to do evaluations, but they really needed somebody to come in and sort of develop a real live breeding strategy. So before I even started to work for them I put together a breeding strategy and was talking to them about that in the fall of 2014. And then by the time January 1st, 2015 came on, I was on board with them with an agreement to work a day and a half a week, trying to implement this breeding program.

Hannah Senior: You are now the VP of Breeding & Product Delivery at CoverCress, which has bred, developed and is now commercialising a novel plant also called CoverCress. Can you tell me a bit about the crop and why it is so unique?

Mark Messmer: Yeah. So Pennycress's scientific name is *Thlaspi arvense*. This is a very very common weed across much of the temperate parts of the world. It's called pennycress because it's seed is born in little penny shaped pods - many, many penny shaped pods on the plant. It's a winter annual crop so it germinates in the fall, establishes a rosette, anywhere from a one to a four inch rosette on the soil surface in the fall. Early spring it kicks into action, starts to grow very quickly, bolts, and by the time May rolls around, you've got a plant that's anywhere from 18 inches, two feet tall to

three feet and even three and a half feet tall, depending on sort of the agronomic situation that it's in.

Mark Messmer: Pennycress is naturally sort of a crop of disturbed soils. The seed are very tiny, they're about a milligram per seed. Wild pennycress has a thick, very fibrous seed coat and can stay in the soil seed bank for up to 20 years. So you have to serve soil, you turn the seeds to the surface, the seeds need light and moisture to germinate in the fall and there you go. The one unique thing about pennycress and the reason that it turned into a crop candidate was the USDA back in the, in the 2006, seven, eight timeframe when that was back in the biodiesel craze. So the USDA had a program up in Peoria, Illinois that was looking at alternative crops and trying to determine what possible other species could be used as a winter annual to sort of fill that gap.

Mark Messmer: And probably the earliest thing to mature in the spring time as a winter annual is pennycress or, you know, the brassicas. And, and they, they made the call that that pennycress was probably the best candidate. And so back at that time, there was an initial attempt at commercializing by another company, an initial attempt at commercializing wild pennycress as a biodiesel crop.

Hannah Senior: CoverCress is different from pennycress in that it's been bred specifically to be a oil crop. So what were the challenges that you had to look to breed characteristics into or indeed out of pennycress?

Mark Messmer: The challenge there is that - and we figured this out over about a 18 month or two year period after the founding of CoverCress - there are a number of things that are very difficult from a crop standpoint with wild pennycress. One is that thick seed coat doesn't allow germination to happen very dependably. Second of all, when you talk about the business plan around pennycress as a crop, the oil makes up about two thirds of the value. So crushing the seeds for the biodiesel or the renewable diesel, the oil makes about two thirds of the value and the meal, which is a high quality protein meal will make up the other third of the value. But the meal with that thick seed coat contains way too much fiber to be really effective as an animal feed. So one of the things we learned we had to do was get rid of a lot of the fiber in that seed coat.

Mark Messmer: Pennycress has two other natural substances that we needed to mitigate. And one is erucic acid, which is a fatty acid, had negative connotations for human health and heart health. So we wanted to get rid of most, if not all the erucic acid, in case we wanted to use CoverCress as a food oil source. And then back to the meal side, pennycress has a substance called sinigrin, which is a glucosinolate, which is sort of an antifeedant and can be toxic in high concentrations and we needed to get that removed from the meal as well, to enable feeding that meal to animals. Really, when you think about it, the entire story is very, very similar to the development of canola from oil seed rape, all of those same challenges existed in canola. They were mitigated over a number of breeding generations and breeding cycles. It was more complicated in canola because canola well... Pennycress is a diploid species, so pretty easy to work with. We only had one glucosinolate, which was objectionable, and that was sinigrin. And so pennycress ended up being a pretty simple target to try to fix.

Hannah Senior: Okay. So tell me then how did you go about doing that? And in a relatively short period of time!

Mark Messmer: As I said earlier, the founders had collected germplasm. We had nearly 900 accessions. The first thing they did and we've got pictures of these three founders out in the field in the fall of 2013, crawling on their hands and knees with a little quarter teaspoon sprinkling seed on the surface of the soil to plant the first nursery, which is a it's pretty humble beginnings! But that did work. They went through in the following spring and selected around a hundred accessions that they wanted to put into yield testing in the fall of 2014. Those yield tests were planted over, I think, six different sites, probably three reps per site. And so really my first job, when I came to work, was in addition to sort of outlining what I thought might be a breeding strategy or a breeding program was to go out and start to try to learn about this, this plant.

Mark Messmer: And so these trials were planted out across the Midwest, and that's what I did, and that's what I love to do so that was a lot of fun to be able to go out. It was a little cold, I was used to being hot when I look at corn, but it was a little bit cold doing that. But it was fun. We ended up, I think, with two sites that we got reasonable data

from. And from those two sites, I narrowed that list of a hundred accessions down to 25 that I thought I'd start trying to cross together. And those were in all honesty, they were the ones that established in most reliably across those sites and they were the ones that appeared to have the best potential yield. And so we started making crosses among those 25 accessions, generated segregating lines and as quickly as possible got those into a field trials across a number of different sites.

Hannah Senior: And I understand early maturity was also a key breeding trait - tell me more about that?

Mark Messmer: Yes. The concept for this crop is to come in and plant right behind harvest in the fall. And at that time we said it was corn harvest, but right now we think we can go behind corn or soybeans in the fall. And then get that crop off early enough in the spring to enable the farmer to go in and effectively plant the following summer crop. And at that time we figured we would be followed by beans. At that time the push toward earlier soybean planting wasn't as, as distinct and extreme as it is now. I mean, farmers now... Back then, and this was only, not even 10 years ago, back then farmers were planting beans maybe early to mid may, even late may and felt that they were doing the right thing. Today a lot of farmers are planting soybeans before corn and they're planting in early to mid, late April. And so our concept was, our original concept was to try to push early maturity for CoverCress back to May 15th as sort of a target date. And that's still our target.

Hannah Senior: Were you just using conventional breeding techniques or did you use emerging technologies like gene editing too?

Mark Messmer: It became obvious that if I was going to make the necessary progress for yield and maturity, that we needed to find a different way to improve those composition traits. And gene editing was just in its infancy really, I guess you would really consider that it still is. And we decided as a company to establish our own gene editing program. And to make a long story short there we've been amazingly successful in establishing this gene editing program. What we've achieved is we can very quickly, within a year... So if I make a selection and I'm in the process of doing that right now,

make selections from this year's data, this year's field trials on native composition pennycress plants.

Mark Messmer: I make a decision in the next two or three days on which of those I'm going to carry to the next generation. I can hand up to 40, 50 of those off to our lab and a year from now, we'll have what we call whole grain CoverCress, which is a CoverCress that contains low fiber and lower erucic acid that can be used as whole grain chicken feed. So it's just an amazing transition and it makes the breeding program for yield and maturity so much easier not to have to worry about those things. You know, you develop a high yield early maturity, and you hand it off. And a year later you've got your potential commercial product.

[Theme music plays]

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Hannah Senior: You just mentioned chicken feed as an end use for the crop. Was that an original target or did it come later?

Mark Messmer: Yeah, so the original big, big target was biodiesel renewable diesel, but when you think about trying to create enough raw material for a large crushing facility in a biodiesel facility to work through, there's a gap there. And the gap is that we're trying to introduce a new crop to farmers. I live in the show me state of Missouri and farmers are pretty much a show me group of people, which I don't blame them for at all. But we needed to be able to introduce this to farmers and sort of get volumes up in order to get crushers and biodiesel processors interested. And so the question was how do we bridge that volume gap? And so the idea came up that chicken processors would love to use more canola. The problem is canola really doesn't fit the Midwest growing season, it ends up being too late for a follow-on crop.

Mark Messmer: CoverCress in its final form really is almost exactly, from a nutritional profile, canola other than we have a slightly lower saturated fat at the end than canola does. So this idea came up as “Could we use the chicken gizzard as a crushing mechanism?” and use yellow seeded CoverCress - what we call cover CoverCress Wholegrain - as a way for us to expand our base to the point where we can have enough acres that biodiesel crushers and biodiesel producers would be interested in the volumes that we could provide. So really the chicken feed idea was a commercial bridge to allow us to grow volumes, make some money, pay back the investors [laughing] to a certain point! And then get into the big acre biodiesel or bio renewable fuel market.

Hannah Senior: And was the chicken feed idea something that came from CoverCress or was it an external influence?

Mark Messmer: I believe this was actually an idea from the chicken processor that was brought to us when they heard about the characteristics of CoverCress being nearly the same as canola, because they had done the same thing I believe with canola. And basically it would be incorporated in a 4% to 6% portion of the overall chicken ration and it would substitute for other oil sources like chicken fat or those sorts of things.

Hannah Senior: So one of the things that's genius about this whole idea of turning pennycress into a crop is yes, it provides a feedstock for the chicken market and it's a potential biofuel, as we've talked about, when the volumes get big enough. But there's also very real benefits for the farmer and for the environment. So let's talk about that for a bit, because it's part of what makes this so interesting.

Mark Messmer: Yeah, it, it really is. There continues to be more and more of a move toward awareness of soil health and of course carbon sequestration and all of those things. So for the farmer as we've developed this thing as a crop concept, one of the really heavily driving factors for us has been we want this to be a very low cost alternative to another crop for a farmer. And so almost everything we've done has been pointed toward allowing our agronomic system to just bolt on to existing passes across the field for a farmer. For example, right now our initial recommended planting method - although there are many different planting methods that could be conceived with

CoverCress - our initial recommended planting method is to incorporate planting with a vertical tillage pass across the field right after harvest and many, many farmers in our initial target market area of Illinois and I think it's expanding, do do that to break down the heavy corn stover cover that's left after harvesting a 250 bushel corn crop. And if they've got a seeder on their vertical tillage tool we see that five pounds per acre or so makes it a really easy one pass method. We're not adding a pass across the field, we're seeding off the tillage tool to get planting completed.

Mark Messmer: We actually, from a business standpoint, our plan is to actually supply the seed to the farmer free of charge. The farmer plants the seed, we come in and help the farmer decide in probably early to mid March whether they have established a stand that's adequate to support a profitable yield. The one thing that it takes for CoverCress is a timely rain in the fall to get things going before it gets too cold, and sometimes that'll happen and sometimes it won't. There is a fairly broad window there. So anyway, we come in to talk to the farmer and give them recommendations on whether they have a commercializable stand in mid-March early, mid-March. Their first real investment, assuming they didn't make an extra pass across the field to plant in the fall, is to apply 50, 60 pounds of nitrogen and probably some sulfur in the early spring, similar to what you would do with wheat.

Mark Messmer: And then it's the farmer's responsibility to harvest and deliver the crop to a collection facility. At the point they deliver to the collection facility, they get paid and we get paid. So it really is the payment and the whole financial piece of it is predicated on how much crop you can generate. But the farmer has very little investment until they apply the fertility in the spring. And the only other investment they have is, is running the combine through and getting the product to the collection facility.

Hannah Senior: And what's your target yield level?

Mark Messmer: Our target yield level for CoverCress for profitability for everybody in the value chain is around an average of 1500 pounds per acre, which would equate to maybe 35 bushels per acre. At that level, and it's probably gotten better in the last few months with the fact that oil prices have gone up - we're sort of tied to the price of

soybean oil - the initial payback to the farmer would be a net \$50 per acre. And at that level some farmers are interested. Some farmers say, "You know, I'm not sure it's worth my effort". But what our objective is, is to get this thing introduced and over time as yields go up as the value of the oil goes up just naturally with the demand for biodiesel, biorenewable fuels, that profitability for us and for the farmer will arise as well.

Hannah Senior: So that net \$50 an acre, it might not be astronomical in the grand scheme of things, but that's over and above what the farmers get for that conventional harvest isn't it? It doesn't impact on that?

Mark Messmer: That only way that it impacts on that is if we're harvestable too late into the spring and soybean planting or the follow-on corn planting gets to be much later than what they want it to be eventually in the spring, if you plant late, you're just going to start to lose yield on the follow-on crop. And so that's why we have a lot of focus on earlier maturity.

Hannah Senior: How did you get the farmers on board? They are a diverse group with different interests. So how did you go about even having the conversation, understanding their concerns, understanding what would it take for this to be attractive? You know, just talk to us about that.

Mark Messmer: A lot of our early farmer discussions really revolved around talking to our plot trial cooperators, that we were able to find that were willing to plant this weed in their fields and, and trust us that it wasn't going to create a problem for them. And I'd have to say thank you to those people, because it wasn't the easiest conversation to say, "Hey, I'm going to come plant weed seed in your field and do yield trials on it!" But in the last couple of years, we've really ramped up the farmer connection process and in particular, in the last six to eight months, we've done that. We had a number of field days at our research sites over the summer. At these field days, we had a number of not necessarily farmers, but influencers of farmers. And those people have been just so helpful in sort of spreading the word. We also this spring for the first time hired a chief commercial officer with many, many connections to some of the ag retailers and so on.

And so we've really begun to get integrated with them in terms of helping us build toward that commercialization event.

Hannah Senior: I have to tell you that when you said influencers in that context, it made me think of sort of social media influencers, which might be a slightly different thing! Describe an influencer in this context.

Mark Messmer: There are a couple of guys that support sort of the ag technology community in St. Louis that I can think of that have been to several of our field days. And they're people that basically have connections to groups of farmers and they talk to farmers about what's up and coming. It's just folks that are sort of independent from us. I mean, we've got a vested interest, they don't really have a vested interest, but they've heard our story a number of times and they understand our story reasonably well and our objectives. And they've been to the fields and they've seen the fields and they think, "You know this could actually work!". So it's really a soft sell sort of a situation. We don't really want a hard sell. What we want to do is prove this technology and have it stand on its own and not really have to hard sell it.

Hannah Senior: You mentioned going to talk to farmers and saying, "Hey, can we try this weed seed in your fields?" And it does raise a good question about, are there risks to this crop? You know, if it's generated from a weed, could it go rogue, could it become invasive? Could those introduced properties become a problem for natural varieties and the biome diversity? Tell me about that.

Mark Messmer: Yeah. We've thought a lot about that and actually this lower fiber seed coat thing is a really good example. You know, there's obviously a concern that native pennycress is very persistent in the environment. Now, the good thing about native pennycress is there isn't a broadleaf herbicide that exists that won't kill it. And a guy that works with me, he says "cold, hard steel is really good too!" [He laughs] So, I mean, it's not hard to control if you harvest CoverCress in the spring and you follow it up with soybeans, CoverCress does not do well with hot temperatures. It needs a lot of light. So if you close a canopy above Pennycress, it's basically going to die. The other thing is it needs to be vernalized. So in the follow-on summer crop you're not going to get

vernalization and therefore you're not going to get bolting and it's going to stay as a Rosetta on the surface of the soil. So there's no way that it can compete with the follow-on crop. I mean that thick seed coat that we removed...I mean, we removed 50% of the fiber from that seed, and so from just a degradation standpoint in the soil, we, we believe that this will actually be way less soil persistent, and between that lack of persistence and the fact that there are so many ways to eliminate pennycress, CoverCress from a weed control standpoint that we don't believe that's going to be a problem at all. And in fact one of the biggest challenges for us in running the breeding program is to find fields that are *free enough* of winter annual weeds, that we don't have to compete with them. Because at this point in time, we don't have a way to control those weeds. Now we're developing a way to control those weeds, we've got edited ALS tolerance in the field and Wisconsin right now, that's been sprayed about three weeks ago and it looks great. So we're going to have a system, but we haven't had a system at all and everything else, everything else kills pennycress. [He laughs]

Hannah Senior: Mmhmm [affirmative] So what's next? What are you looking forward to?

Mark Messmer: We're working really hard on thinking about the commercialization process here over the next couple of years, and we've learned so much. Typically when you think about, you know, historically there are lots of papers that have been written that say that the growth in yields in agriculture are both due to agronomic improvements and genetic improvements and this is absolutely the same story. For me it's going to be really fun to see us work hard, to get the crop planted under the right agronomic conditions, that introduction so that the customer has a good experience. I just hired a breeder and a genomicist to sort of take the breeding program to the next level. I'm really looking forward to what those guys are going to be able to do. My objective in this really was to get us to the point where we had a commercializable level of yield and agronomic understanding. And I think we've gotten to that point, but there are so many things that can be improved from a profitability standpoint, higher oil, higher yield, earlier maturity, disease resistance. If we go to 10 million acres, there are going to be disease problems that are going to crop up and we're going to need to be prepared for that. And

we've actually started working on some of those things. My focus, like I say, has been mainly yield and maturity but these new folks with their focus more on the genomic side of things, I'm hoping can carry this breeding program to be a really 21st century breeding process, breeding program, using all the tools that are available. And the commercialization thing and seeing the breeding program really become a modern high-tech breeding program are the couple of things that I'm really looking forward to.

Hannah Senior: Knowing what you know now, if you were to look back to the start of your career and do it all again, is there anything you do differently?

Mark Messmer: I don't know. I mean, I might have remained in the field as a breeder longer than I did. [He laughs] 'Cause that's the part that I really enjoy. But in the end, if I had done that, I might not have taken this opportunity. And this CoverCress thing has been really a unique opportunity. I mean I think to myself, how many people get the opportunity to try to invent a new crop? It boggles my mind that I'm in the process of trying to do that. And I think it could be really transformational in starting to think about ways to carry agriculture forward. And so other than the fact that I always loved being in the field and there were a number of years that I really couldn't be just because of other responsibilities I wouldn't change very much and I think that the fact that that happened probably drove me to say "yeah, I'm not just going to quite retire yet - I think I'll try to make this weed into a crop". And it's been really fun just trying to fight through all of the challenges. And there've been so many times that we've come to mid-May and we've really wondered whether we were going to make it through the June or July board meetings [he laughs] And we always have by the skin of our teeth and I think we're past that point now.

Hannah Senior: That is a great note to wrap things up on. It's been such a pleasure. It's such an interesting story, Dr. Mark Mesmer of CoverCress. Thank you very much for your time today.

Mark Messmer: Thank you too, I enjoyed it a lot.

[Theme music plays.]

Hannah Senior: You've been listening to Plant Breeding Stories by PBS International, and I'm your host, Hannah Senior. Plant breeding is a pretty specialist podcast topic, which can make it difficult for people who share our interest in this kind of thing to find it. So if you've enjoyed the podcast, recommend it to your friends and colleagues and please help others in the plant science community to find it by rating this episode and subscribing to the series. I'd love to hear from you, if you want to suggest people you'd like me to interview. You can contact me on Twitter at PBSInt, or on Instagram at PBS_Int. Until next time, stay well.

[Theme music fades out.]