Transcript: Plant Breeding Stories Podcast
S4 E2 Dr Susan McCouch

[Theme music plays]

Hannah Senior: Welcome to this episode of the Plant Breeding Stories podcast where I talk to leading lights in 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.

Hannah Senior: Series Four will be the last in this podcast. And it has been the most incredible experience to dig into so many different aspects of the plant breeding world and literally the world. If you're listening to this, you're part of a community that spans the globe, from Albania to Zambia, Adelaide, Australia and Ames, Iowa, to Zurich in Switzerland.

Hannah Senior: Appropriately enough, we're kicking off Series Four by talking to Professor Susan McCouch, whose plant breeding story has a tremendously international theme. That's partly because she's devoted her career primarily to breeding rice, a plant grown in more than 100 countries, many of which she's visited in the course of her work, and also because her whole approach to her work has been shaped by a global perspective she developed very early on as part of a life-changing adventure.

Hannah Senior: Transcripts of this episode and all our podcasts are available at pbsinternational.com/podcast. I hope you enjoy it.

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Hannah Senior: Thank you very much for joining me today Professor Susan McCouch. Would you kick things off by introducing yourself?

Susan McCouch: Sure. My name is Susan McCouch. I'm a Professor in the section of Plant Breeding and Genetics at Cornell, and I've spent almost my entire career working on rice with a focus on the international sector.

Hannah Senior: You know, already a focus on rice and a focus on international. So tell me a bit about your upbringing. Did you have a background that suggested that might be the way things would pan out?

Susan McCouch: Not at all. Not at all. As in many things in life, my career direction is totally serendipitous. But I grew up in a town outside of Boston called Concord, a very historic town, and it was a town that still had quite a lot of agriculture in it when I was young. But I think my love of plants and of agriculture as a component of the landscape and as a way of life comes from the fact that my grandparents lived on a farm and every weekend we went to visit them in Vermont. And that really embedded in me a sense of space and connection with plants that I've carried with me my whole life.

Hannah Senior: One of the things that really struck me when we spoke previously was that you described how you didn't originally set out with the intention of focusing on life sciences or genetics or plant breeding. You set up in a different direction. So just tell me a little bit about that and particularly about how a travel experience that you described really helped to change direction for you.

Susan McCouch: Well, I had an early interest in language, and I wanted to become proficient in at least one other language. It was sort of one of my deep-seeded, maybe aspirations. And in my family, we had both French and Spanish. But the Spanish had been a generation before. So it had sort of been lost in my generation of the family, and I wanted to recover it. I decided to pursue language and history in college, and I went to college and studied language and history. And when I graduated from college, my boyfriend and I decided to hitchhike from Boston to Buenos Aires. We were almost a year on the road, and we encountered, of course, many unusual and surprising things.

Susan McCouch: But I think the course of that journey really alerted me to the ways in which basic sanitation and food underlay so much of what I understood or I came to understand as human health and social health, that without adequate food and clean water and sanitation societies really struggled. And I had not really fully appreciated that fundamental truth. And so I think that journey opened my eyes to the realities of what a person like myself might do in life to improve the welfare of people who really struggled in the world. And that's where my long-term interest in dedicating a career to agricultural science came from.

Hannah Senior: And so you went back. And did you go and enroll in a whole new program? Is that how you came to change direction and focus on the life sciences instead?

Susan McCouch: Yeah. So I had completed a four-year undergraduate degree in Hispanic literature and history. And when I returned to the United States after that trip, I enrolled again in the university, but I had decided I wanted to study life sciences. And in order to do that, I had to go back really to bio 101, chem 101, physics 101, genetics 101. And I re-enrolled at age 24 after that experience with a whole crowd of 18-year-

olds. And my mind was certainly attuned to those studies in a very different way than it had been when I was 18.

Susan McCouch: And I remember landing in my genetics class and being absolutely lights-on moment where I suddenly understood that genetics held the key for some of the basic evolutionary principles that I'd been trying to understand in terms of language and history. And that was for me the absolutely stunning moment of intersection between the study of life sciences and my complete love affair, if you will, with genetics as a way of explaining and understanding change over time and change in language and change in history and change in the biological world all had a certain parallel. There was a great metaphor there that I was enlightened by. And so I think that really helped to focus my energies as I went back to school on areas of both plant disease and plant breeding.

Hannah Senior: Can you expand on that a bit? What was it about the languages and genetics that you saw the connection between?

Susan McCouch: During my long trip, my ear for dialects, vocabulary, pronunciation, and the lilt, if you will, or the tonality of the language evolved over time. And I found that I could readily identify at least a geographical region of a Spanish speaker from the way that they spoke. And I think it really started to make sense when I found myself in the world of genetics, that there are adaptations to geography and to space and time and place in language. Similarly, there are adaptations in biological communities and organisms to ecological and geographical regions.

Susan McCouch: If you stop and think about it, I was in the temperate region. I traveled slowly down through North America, into Central America, through the tropics, through the mountainous regions of Ecuador and Peru, and then down over into the tropics of South America and on in, down into the temperate regions. And as I got back

to the temperate regions, although the language was very different, the biology began to feel very familiar again.

Susan McCouch: And this really tuned me to understanding something that Darwin himself had observed and written about in Origin of the Species. And I could see those parallels without actually knowing anything about genetics, but when I landed in that genetics class, as I say, a light went on and I could see that the way that words change and pronunciation changes is very parallel to the way mutations happen in DNA, causing changes in phenotypes, many of which are gradual changes. They're not black and white changes. They're quantitative changes. And it was some years later that I came to understand that Darwin's use of the tree as a metaphor for how evolution works, that things come from other things and they grow out in new variations forming new branches and new continual variation at the tips of those branches, that concept had come from linguists who originally studied mutations during the Middle Ages when scribes manually had to copy manuscripts.

Susan McCouch: And in copying manuscripts, they occasionally made errors, which Darwin did not talk about mutations. But in a similar way, they made an error and then that error was then copied by the next scribe. And it became the norm in the manuscript from then on. And it was when I understood that Darwin had borrowed the concept of the tree from the linguists and not the other way around that my own appreciation of it also became more profound, that people hundreds of years before me had seen those similarities between the natural world and the world of phonetics and the world of linguistics.

Hannah Senior: It's such a vivid parallel, and yet one that I think very few of us have ever even thought about. So it's really interesting to hear you describe it. And you ended

up wanting to do a PhD, but you weren't allowed. So tell me a bit about that. How did that come up, and how did you end up doing it anyway?

Susan McCouch: I did want to pursue my studies and understanding so that I could work in agriculture and hopefully go back to the developing world to share some of the things that I was learning. I had finished a master's program in plant pathology, but I really needed a PhD to do some of the things I aspired to do. But in the meantime, I got married and I had a baby. And my husband was a student in the vet school at Cornell. I was able to look around and see some very interesting opportunities, and the one in plant breeding really caught my eye. And so I applied to be a PhD student in plant breeding and genetics.

Susan McCouch: I guess I didn't realize how unusual it was to apply when one already had started a family, but that was my situation. And I applied and I thought my application was strong. But I waited and waited and did not hear back. And finally, I got word back from the committee that I was not really a suitable candidate. And it was never really obvious why I wasn't, but that was the outcome. And I went to talk to a person in the plant breeding department who I'd gotten to know a bit. And he mentioned to me that perhaps I might be accepted as a provisional student because I had to prove myself. And the problem was that I had a three-month-old baby at home and this was considered in 1985 to be a reason not to accept somebody into a PhD program.

Susan McCouch: I was finally accepted as a provisional student. And it was a couple of years later when the rice project opened up to me and nobody else in the student population in my class wanted to develop the first genetic map of rice. I think because they weren't as interested in working overseas as I was. And so by pure serendipity, really luck of the draw, that project came my way. I had demonstrated, I think, capacity and dedication to the field at that point in time. And I was able to pursue my training in

plant breeding. But it was a juggling act. It wasn't easy. And I will just say I think today we've come a long way since then.

Hannah Senior: It's not all that long ago. And yet to hear that story does make jaws drop, like really? So...

Susan McCouch: Yeah.

Hannah Senior: ... yeah, things have changed steadily. You described how that led into rice, which has been a career-long interest, but at the time there wasn't a lot of interest in rice. And that surprises me given its importance as a food source and an international crop. Can you tell me a bit about that?

Susan McCouch: Well**,** there was plenty of interest and effort being expended in the world of rice breeding. So in 1985, China had just started to emerge from the Cultural Revolution and so science in China was not strong in those years. But Japan and Taiwan were very strong in rice science, in rice biology. And, of course, internationally, there was a huge effort in rice breeding across India, Indonesia, and IRRI, the International Rice Research Institute, with the Green Revolution had spent quite a lot of devoted international effort to breed the semi-dwarf rices that became the foundation of the Green Revolution in Asia.

Susan McCouch: But those breeding efforts didn't have anything to do with molecular biology or with what we now call genomics. And my work at Cornell was in the area of molecular mapping. And so we were at a very, very early point. We were really pioneers in developing the molecular maps and markers that became the foundational resources for expediting the breeding process. And it was molecular biology that was not being rapidly developed in rice. And rice in the world of molecular biology was considered sort of an orphan crop because as important as it was in terms of feeding people, as

important as it was in terms of a breeding target, it was the focus of only a very, very few efforts in molecular biology, mostly concentrated in Japan and a bit in Taiwan, as I said.

Susan McCouch: So it was the West that had really overlooked rice as a possible target for molecular biology simply because rice as a crop is not as important in the West certainly as it is in the East. And many of the countries that today are very prominent in rice, molecular biology and rice science were not in a position in terms of their own molecular biology capacity to devote many resources.

Susan McCouch: So I think we were at a moment historically when the world of molecular biology was just beginning to become a possibility to expedite the breeding of many crop plants, and rice just wasn't one of the vanguard plants for the societies that had the most advanced molecular biology.

Hannah Senior: And it was during your PhD that your long standing working relationship with IRRI began. Tell me more about how and why that came about.

Susan McCouch: We couldn't have made that first molecular map of rice without a connection to an institute like IRRI because the map itself required a population derived from two genetically diverse parents and not the kinds of crosses that most breeding programs were engaged in. But IRRI had a wide cross program and they were investigating a lot of both interspecific wild species times cultivated species crosses and crosses between, let's just say, genetically very diverse parents that were not likely to give rise to anything of any use in breeding but were of interest genetically. So we contacted IRRI initially to ask whether they might have a population we could use to develop this map. There were none such populations here in the United States that we knew of and certainly none at Cornell University. So it was a collaboration with IRRI from day one.

Susan McCouch: The second really important part of that was that IRRI not only provided the population we used for developing the original map, but they provided something we called trisomics, which enabled us to assign linkage groups to chromosomes, something which in the mapping sphere gave tremendous added value to the linkage map we had developed. And those resources, those chromosome segment substitution lines and alien addition lines had taken many, many, many years of effort on the part of IRRI scientists to develop before we ever made use of them. And so it was a really productive collaboration. And when we published the first map, it was in collaboration with IRRI scientists. So the road was paved in a way.

[Theme music plays]

Hannah Senior: You're listening to Plant Breeding Stories, brought to you by PBS International, world leaders in pollination control. We're exploring the personal stories behind people who've dedicated their careers to plant breeding, helping us to more productive plants, greater food security, and more sustainable agriculture. Now, back to the podcast.

[Theme music fades out]

Hannah Senior: So you did your PhD at Cornell and then took a job with IRRI in the Philippines. Tell me about that.

Susan McCouch: When I finished my PhD, the Rockefeller Foundation, which had been supporting the work that I had done during my PhD thesis efforts, also was supporting work going on at IRRI. And they wanted very much to help facilitate the transfer, if you will, of the map and all of those genetic resources and genomic resources so that we could start to apply them in the IRRI breeding department. So it was sort of laid out from day one that somebody like myself who aspired to work in the

developing world might be the prime target to take that technology then to IRRI and embed it in the breeding team and train the new generation of plant breeders that would be working on rice in the international sector.

Susan McCouch: So that's how it came about. And it was quite a logical thing. I sort of knew it from early on and I aspired to it. I had never been in Asia. I was very excited about that possibility. And I knew nothing about rice when I started. So there was a long learning curve where it was really a two-way exchange. I brought my expertise in molecular biology and molecular genetics, and my IRRI colleagues brought their experience with rice and with rice breeding. And we collectively then developed that program, which became the mainstay of the rest of my career.

Hannah Senior: You decided eventually to return to the U.S. and set up a lab at Cornell, but you continued to work alongside IRRI. Is that right?

Susan McCouch: When I first decided to return to the United States, IRRI found it helpful to essentially keep me on as a retainer. And for a three-year term, I traveled almost every two months. I went to IRRI for about three, four weeks back and forth, back and forth. And I had two young children at the time. So it was quite challenging for my family here and for my husband. But the point is that we really worked hand in hand for those first three years where I spent time at Cornell developing and pushing both the technology in the lab and a lot of databasing and digital technology to enable us to transfer information back and forth more readily. Don't forget this was, the internet had not yet become a real functioning unit for us, so the digital technology when it was in its early phases.

Susan McCouch: We were interested in trying to develop real-time exchange of information. Let's just say, the technology development to take place in a laboratory like mine at Cornell, and then moving that technology very quickly and some of the

discoveries we were making over to the applied form of utilization of that technology at IRRI. And we did that for quite a while.

Hannah Senior: You've maintained your relationship with IRRI throughout your entire career while also expanding to work with other organizations. Tell me more about how that's worked out.

Susan McCouch: I look back on that time and think about how much the IRRI requirements forged the early aspirations of the program that I set up at Cornell. So the Cornell program served in some ways the IRRI program. It was designed to do that. But when I started applying for money from U.S. federal agencies, including the USDA and the NSF, I started to realize that the work that I was doing was maybe not just in service of IRRI, that there were some basic frontiers that we wanted to explore and there were also other programs in Asia but also in Africa and in Latin America that would benefit from the same opportunities to share the technology.

Susan McCouch: And so my program began to expand. But it was always defined by the goals and the primary objectives were defined by searching for markers linked to traits or the genetic drivers of those traits to help the breeders make more rapid gains in terms of disease resistance, abiotic stress tolerance, grain quality, and other things that were critical to the breeding programs everywhere in the world.

Hannah Senior: You've always maintained a really strong ethos about the use of information that comes out of your lab. Can you expand on that?

Susan McCouch: I wanted to be very sure that everything we developed together was truly available without any intellectual property by people throughout the world who were struggling to keep ahead of the demand, not only for food, and rice is one of those basic foods that feeds a massive proportion of the world's poor, but also to try to minimize the

use of pesticides and to try to enable the germplasm that traditional farmers had developed to be brought up to speed, if you will, to meet the requirements of the markets in modern times.

Susan McCouch: And so it was an extremely strong sense of shared purpose, shared intention, and collaborative effort. And as long as people were willing and able to share germplasm with me, I felt it was my duty but also it was my strong conviction that we needed to be able to share the resources we developed in technology with them on equal terms. And so I committed my own program to developing everything as open source and to ensure that it could go back with those students for application in their own programs. And that was in fact the modus operandi of my lab. And I think it created very strong partnerships and a strong sense of trust.

Hannah Senior: And that was quite an unusual approach at that point in time. Why was that?

Susan McCouch: Many institutions, especially in the 80s and 90s, were sort of keen on the idea of moving that biotech or molecular biology was going to be a source of significant royalty flow back, the same way plant patents are. But I think my travels in Latin America really influenced me to think very deeply about who would benefit if we started to protect through intellectual property the resources that we were developing in the molecular sphere.

Susan McCouch: And I realized very quickly that not only was it a complicated process to manage royalties and reach agreements on intellectual property that required many layers of expertise and specialists within the legal community, but it also severely cramped the ability to share those resources with people in national programs who had little or no opportunity to pay any kind of royalty flow. And yet, in my case, I was breeding a crop that fed mostly the poor. And I just made a very conscientious decision

based on my understanding of the populations of people that I hope my work would benefit, that in order to reach them this would be the most expedient way that somebody like myself working, if you will, in a public-sector university could, should, and must, if you will, design the program.

Susan McCouch: Now, things have changed a lot over the years that I've been running this program. I still do everything open source. I still do everything without intellectual property. It's part of my ethos. But I do understand that in some cases not having a clear case of how materials and inventions can be shared can, in fact, inhibit their uptake if the private sector is the medium through which some of these innovations are expected to reach a certain population.

Susan McCouch: It's really interesting that in each case you have to look very carefully at how innovation does actually arrive, if you will, or how is it delivered to populations that you hope will benefit. In some cases, the private sector is extremely important and a very, very critical medium in getting it to people. That's an appreciation I have. But in other cases, I think the private sector is often not really in the game. And since rice is an inbred crop, and most people actually design and breed inbred varieties, they don't breed hybrids, the private sector has played a rather small role in the world of rice breeding compared to the role that it's played, for instance, in corn breeding, maize breeding, or many other crops that are bred as hybrids today.

Hannah Senior: So why is it that there's less commercial rice breeding? Is it because it's an inbred crop? And do you think that'll change in the future?

Susan McCouch: Well, fundamentally I think it's the fact that it's an inbred crop. And so the cost of developing the crossed material, the hybrid material is much larger because you're actually having to work your way around the natural inbreeding tendency of the species in order to outcross it. And that requires a lot of labor and a lot of management.

And so naturally, inbreeding species are typically less commonly bred as hybrids. On the other hand, if they are important in the industrialized world, often the private sector has seen it as part of their business model to breed hybrids anyway and to secure the advances in their breeding lines through very convoluted requirements of managing male sterility and other things. It's simply a matter of what kind of organization economically, socially, and in terms of labor management a country wants to have to drive its rice industry.

Susan McCouch: I will say I think the future may be bright for hybrid rice. There certainly is hybrid rice produced widely, especially in China. There's a lot of hybrid rice now produced in the United States. And hybrids are making their way into other parts of the world where the investments in the seed management and the breeding are there. So it's a wide-open question and a very exciting arena in terms of where we're going with rice breeding and rice biology in the future.

Susan McCouch: But I will say that from where I've come from, I think that we have only just begun to explore the incredible range of genetic variation that exists naturally in rice. And whatever tools we use, we're going to need all of them on the table to confront the challenges we face coming forward with climate change and human demand.

Hannah Senior: And there certainly are a lot of challenges facing us. And that leads me onto research funding. How is that changing? Is it changing?

Susan McCouch: I'm sort of at a crossroads in this. I think there's a lot of interest in understanding how to address climate change in both the public and the private sectors. We've been brought to our knees a bit now in terms of the extremes of both weather and climate events that are confronting the world at the moment and how that will affect our food systems going forward. So I do think that we've seen a massive shift in the way

funding is likely to work. But one of the ways in which I think it's, at least I see it going is that there are consortiums now of public, private funders. So people coming together.

Susan McCouch: We used to have federal funding, which was called public funding, on the one side and private funding from companies, corporations, for-profit institutions on the other. And we more and more see foundations and for-profit entities coming together to try to create larger pools of funding. Going forward, we have very different challenges ahead and very different sources of opportunity. And what we really need to do is think very carefully about how we mobilize in a way that's respectful of the natural world, how we mobilize both technologies and understanding to keep us from going way off track and simply destroying things and undoing environments that we really need to survive.

Susan McCouch: So I do think that there's been a certain awareness about the need for thinking in all dimensions. And it's not so much about the public good and the private good, but rather now coming around to think about how we're going to keep our world as a living world that's safe for both humans and other organisms that are needed.

Hannah Senior: Can you tell me about some of the challenges you faced in your career and how you've overcome them?

Susan McCouch: The arena I think that's been very challenging for many, many scientists over the last say 25 or 30 years is the public's understanding or lack thereof of what is plant breeding as a science, what is the history, how is it practiced, and what is the relationship between plant improvement and genetic engineering and sustainable agriculture or regenerative agriculture.

Susan McCouch: There were lines drawn early on that made it very difficult to contemplate what nature does in terms of mutation and selection, what humans do in

terms of selection and sometimes driving genetic change, and how quantitative genetics interacts with environment in complex ways to allow organisms to develop new traits and to survive in populations. That fundamental understanding is a very challenging one.

Susan McCouch: Maybe some of the issues that we've faced as plant breeders is that we've not had a clear road ahead to try to understand what we really could and should do, not just what we might be able to do but what the public would like us to do and also what will be needed in order to continue to enable a supply of healthy and safe food to be delivered to the population at large. On the other hand, I think we've seen some spectacular outcomes when people were able to really look deeply into the natural world and find new opportunities for populations to expand and grow.

Susan McCouch: Again, it's a system. It's a complex system. And I think the plant breeder is a player in that system, often trying to meet the requirements and the demands of the public but also anticipating the requirements of the biological system that underwrites our very capacity to continue to produce food.

Hannah Senior: And this sort of sense of how plant breeding isn't an endeavor in its own, it doesn't sit in glorious isolation. It's part of a much more complex system, biological system, economic system. It is part...

Susan McCouch: Yeah.

Hannah Senior: ... of what makes plant breeding so interesting, isn't it?

Susan McCouch: Yeah. Yeah.

Hannah Senior: Are there any influences you're particularly grateful for?

Susan McCouch: Well, I should just say that if there are any maybe middle schoolers listening to this conversation, I would like to share with them that my earliest recollection of an interest in the direction that would ultimately become this career of mine occurred when I was 13 years old in a social studies class in middle school. Two people had to take a story from the newspaper and bring it in and share it with the class and explain why they were interested in it. And the week that I had to select that, I remember that all over the front pages of the Boston Herald were pictures of starving children in Biafra, in Nigeria. And it was a horrible awakening for me to have to read through those articles and try to understand what the source of this terrible strife was. Turned out, it was two things. It was civil strife and it was drought. We've seen the same thing again and again over history.

Susan McCouch: But anyway, I took my article and brought it in and gave my presentation to the class. And at the end of class, I still remember Mr. Godfrey said to me, "Tell me, why is it that those children are starving in Biafra and you can go to the supermarket and get everything you need?" [Susan is audibley emotional] And I was struck. I couldn't answer the question. Still remember it. [Susan pauses for a while] That's why I'm doing what I do today. Truly.

Hannah Senior: There's a big hand of luck isn't there in where we end up in life and what we can do with our lives? And when you realize that it makes one want to use the advantages that one is given...

Susan McCouch: Exactly.

Hannah Senior: ... to make a difference. And that's a really clear example of that. So thank you for sharing it. It's very clear to me from this conversation that you have contributed hugely to making food more available in the world, but also in helping other

scientists think about how to change things and enabling people to make a difference through their work. And both of those are legacies that are remarkable each in their own right, but collectively even more. So thank you very much for sharing your experience, your career, your insights with me today. It has been the most interesting conversation, and I'm very grateful to you.

Susan McCouch: Thank you so much. It was wonderful. And I hope that we meet again and our paths cross. You're doing a wonderful thing here.

[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 @PBSInt or on Instagram @pbs_int. Until next time, stay well.

[Theme music fades out]