Transcript: Plant Breeding Stories Podcast
S1E1 - Alison Bentley

[Podcast theme tune 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 m eet some of the amazing people who make plant breeding their life's work. Today's plant breeding story comes from Dr. Alison Bentley, who is Program Director at CIMMYT's Global Wheat Program.

Hannah Senior:

Today's plant breeding story comes from Dr. Alison Bentley, who has just taken up a new post as Program Director of the Global Wheat Program at CIMMYT. She previously worked at the UK based organisation NIAB, or National Institute of Agricultural Botany. It was fascinating to hear about her early work identifying wild and land race ancestors to expand the genetic diversity available to wheat breeders, how pre-breeding feeds through to the crops that farmers grow, and her tremendously international across four continents. I hope you enjoy it.

[Podcast theme tune fades out]

Hannah Senior:

Alison, would you like to tell us a little bit about yourself?

Dr. Alison Bentley:

Yeah, sure. Thanks for having me. I'm a plant geneticist and plant breeder, originally from Australia, currently based in Cambridge in the UK, and about to head to CIMMYT in Mexico as the Program Director of the Global Wheat Program.

Hannah Senior:

Tell me a bit about your background. Where did you grow up, where did you go to school, and how did you get into plants?

Dr. Alison Bentley:

I grew up in Sydney in Australia, so a very different climate type to what I'm now accustomed to in the UK. I became aware of and interested in plants at a relatively young age. My grandfather was a great amateur plant breeder and plant scientist, kind of tinkering with plants in the back garden. And many things about plants fascinated me quite early on. So we used to spend a lot of time bushwalking and a lot of the native plant species in Australia have really interesting survival and adaptation mechanisms, so sometimes you have to treat the seed with fire in order for it to germinate. Anyway, I found this endlessly fascinating and was forever borrowing people's smoking ovens for fish to try and germinate some native plant seeds. For me, it's always been about that biology in action.

Hannah Senior:

Was it always going to be genetics and plant breeding, or did you consider other angles of biology, plant science, food production, at any point?

Dr. Alison Bentley:

Yeah, I think it was always going to be biological sciences. Initially, I thought, "Well, veterinary scientists make a lot more money than plant scientists and crop scientists." Got a bit of experience in the animal science space and decided, definitely not for me, in terms of the things you can cut up and what happens to them. So very much, yeah, I think it was always going to be plants or soil. I was really fascinated with the soils of Australia, which are really complex and also contribute a lot to the underpinnings of food production. And then I remember, as a relatively young high school student, having the

opportunities to go to the Plant Breeding Institute in Sydney on a kind of extension weekend. They called it an Agricultural Camp. And we did this basic DNA prep where you use a very quick method to extract DNA or, essentially, the proteins surrounding DNA.

Dr. Alison Bentley:

And I remember just being in this lab as a high school student on a weekend and having this Eppendorf tube with this bit of congealed protein in the bottom of the tube and just being like, "Wow, this is unbelievable. Not only can you kind of see biology, but then you can go in the lab and you can pull out the genetic information." And that really sealed it for me, that exposure and understanding that genetics was also a tractable component of biology. So that really signed it for me.

Hannah Senior:

Brilliant. And it's really evident, even just the way you talk about it and you describe it, that it's something that gives you huge amounts of energy and enthusiasm and curiosity.

Dr. Alison Bentley:

Yeah, definitely. And I think that same weekend, we got to try out driving tractors, which everyone else was super excited about and I was like, "Oh my goodness!" and kind of managed to maneuver into a fence. So I definitely realized quite early on that that probably wasn't going to be my route into agriculture. [They both laugh.]

Hannah Senior:

Good stuff. And you're currently the Program Director for CIMMYT's Global Wheat Program, which we mentioned at the start. Why is wheat such an interesting crop for you to work on? And have you always worked on wheat, or is this something you've chosen more recently?

Dr. Alison Bentley:

Yeah, so I've always worked on wheat. And even during my undergraduate career, I really became focused on wheat and arable staple crops very early on, for the simple fact that they are really the basis of food and nutritional security for a large proportion of the world's population. There are many very nutritionally diverse foods and we're encouraged to eat diverse diets, but really at the core of that is being able to have something that you can grow on scales. So wheat's grown on 200 million plus hectares around the world. And half of that is in the developing world. So you have this huge demand for wheat as a primary product into processing all the things we eat in our day-to-day lives, bread, breakfast cereal, biscuits, cakes, pasta. But yeah, you've also got this angle of, this is really the primary product that a large proportion of the world's population rely on.

Dr. Alison Bentley:

And really in this, again, coming back to this biology in action, that we can do some really exciting science, we can do really exciting genetics. And we really should be using those tools to try and improve the food products, the primary agricultural products, that go into our food systems and really are the basis for ensuring that people have access to enough food to eat, and enough food to feed their families, and to make an income from.

Hannah Senior:

Yield growth has been slower in wheat than some other major crops in the last decade or so. Why is that, and what can we do about it?

Dr. Alison Bentley:

So wheat is a genetically complex crop, and the breeding process, it's an inbreeding crop, so we don't have large-scale commercial hybrids, which is where you see, in some crops such as maize, corn, big jumps in the yield. So year on year, breeders are making lots of crosses and selections, and moving forward the yields of the varieties that are available to farmers to grow. And this rate does go up over time, but there are several reasons why you don't see an acceleration of that increase, which we call the genetic gain, essentially. And I think there are quite a few reasons behind that. Wheat has a

very complex genome, so it's very difficult to be able to use genomic-based selection tools. I think that's changing, and that's something we're really looking at, how do we use these tools and technologies to accelerate our genetic gain over time.

Dr. Alison Bentley:

And also because of the production environments which wheats are grown in. So wheat isn't a very high-value crop, although it obviously depends on the context. But convincing a farmer to apply more inputs to get more yields doesn't always make financial sense. And so there is this optimization question, what's the price that you're going to get for a ton of wheat versus the input cost that you have to put into it to get that return, whether it be on the volume or on the quality of the grain. So it's a complicated answer to a relatively simple question, but I think we do see, from breeding, year on year gains in most parts of the world. I think there's work to be done, and that's a big part of my role at CIMMYT and the role of the Program. And several of the projects is really asking this question - how do we make sure we're accelerating this year to year genetic gain from the breeding program?

Hannah Senior:

And I guess it's a moving target as well, because with climate change and changes to rainfall distributions and so on, it's not like it's improving that yield against a constant baseline, is it?

Dr. Alison Bentley:

Exactly. The breeding process takes a number of years, depending on your registration system that you have in a country to allow varietal release. That process can take five to seven to 10 years to get a variety from your first crops into a farmer's field. So in the context of seasonal variation, it's actually quite a challenge just to get a variety out, let alone a variety that's able to respond to very variable and changing climatic conditions. The CIMMYT Wheat Program is really about future climate resilience, and heat and droughts. There's a lot of modeling data that gives you an indication of what the wheat production areas of the future will look like. And then a lot of research that still needs to

be done to say, "How do we actually make sure where we're future-proofing our varieties?"

Hannah Senior:

I first met you when you were at NIAB, which is the National Institute of Agricultural Botany. Was it work at NIAB that brought you to Cambridge, or were you in Cambridge before that?

Dr. Alison Bentley:

Yeah, I came to the UK and to Cambridge for the position at NIAB. Finishing my PhD in Australia at the University of Sydney and really wanting to move into the space of pre-competitive pre-breeding, which is the role that I had at NIAB. And that role was really interesting, because it identified a gap at that time. 12 or so years ago, with the privatization of plant breeding in the UK, between the academic sector and all of these really exciting discoveries, fundamental discoveries that we see in universities and institutes, and the translation of that to the private sector who are producing the final varieties, who are doing the breeding. And so the NIAB program was really set up to bridge that gap, to say, "What and how can we take forward innovations from the lab, and apply them into a breeding context and deliver them, in terms of germplasm or tools or resources, to commercial plant breeding to really address this question that we talked about before, about how we ensure that yield gains are increasing over time?"

Hannah Senior:

And how are you doing that? Can you give me an example of how that looks in your projects?

Dr. Alison Bentley:

One of the really interesting things that we worked on at NIAB was about expanding the amount of genetic diversity which is available for wheat breeders to use. So genetic variation is really important, because you want to have, whether it's climate resilience, or better pest resistance, disease resistances, you need to have available variation for

those things. And in the modern pool of material that's used in a breeding program, there is the question about whether you have sufficient variation for the different plasticities and responses to changing temperatures, or the ability to grow at a lower level of nitrogen input. So we've been really looking at the use of wild relatives and how we mine the diversity in the wild relatives of wheat and make it available for plant breeding programs to use, very much from the angle of public good. It's very useful for everyone if breeding programs have access to more diverse but still high-performing material that's being characterized and which can be then used in an informed way in the breeding process.

Hannah Senior:

I'm curious, this is an ignorant question, but no such thing as a stupid question. [Hannah laughs] When you talk about looking for a wild variety or a wild ancestor, are you visiting farms, and particularly smallholder farms, and saying, "What variety are you growing?" Or are you literally looking for things that have fallen by the wayside and have sort of grown up and multiplied?

Dr. Alison Bentley:

Yeah. So CIMMYT, in Turkey, have done a lot of work on landraces, which is the first point. Actually talking to farmers and seeing what's growing on their farms. I think the work that I did on wild relatives was actually crawling around grasslands. Think early plant hunters. Really, driving along a road, slamming on the brakes, and then clambering into the undergrowth. And I did a lot of that in the final year of my undergraduate. I did a project with Lester Burgess, really looking at wild relatives and native Australian grass species. So it had quite a lot of experience of that, of these country drives where suddenly you slam on the brakes and everyone gets out of the car and you kind of climb up a hill and try and look for these species, which is super cool because it's kind of at the interface of botany and biology and genetics.

Dr. Alison Bentley:

And so in Turkey, we did a bit of both. Surveying on farmers' fields, looking for the pathogens, specific pathogens in the wheat crop, but then also in the native grasslands,

which is an amazing thing to do. We were working with colleagues from universities in Turkey, at places like Çatalhöyük, which is my bad pronunciation of one of the oldest sites of human civilization. Going to those sites and saying, "At these sites where there's evidence for this very early human activity, is there also evidence for the early relatives or ancestors of our crop species?" So then you kind of see how these things come together. You had humans starting to change their behaviors, and also these wild relatives. And you start to see how these evolutionary and domestication aspects of plant genetics, really... Yeah, I guess it's a real visual on those things. So you've got humans developing and plants developing into crops.

[Theme music fades up]

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 both NIAB and CIMMYT are in this pre-competitive space, and you've sort of outlined what the role of that space is, in terms of generating new diversity or new varieties that then can go into commercialization. But can you talk us through, if you're working in a not-for-profit organization, what is the step that then gets from an innovation or a variety or an improvement that your team have come up with and something that's grown in a field by a farmer?

Dr. Alison Bentley:

Yeah, it's a great question, and it does vary depending on the geography. And obviously, I've been focused for the past 12 years on the UK, where we have a commercial wheat breeding sector which is very engaged with research. And we've had,

really, a privilege to have a really good two-way flow of information between the work we've been doing and the commercial breeders, which has allowed us to really optimize what our objectives are and how we deliver it into the private sector. And then obviously it's going into a breeding process once it gets to the private sector breeders. It will go through a pipeline which could take an additional 10 years. So we do 10 years of work to get some diversity from our wild relatives into an advanced line, and then that goes into a breeding pipeline and potentially produces a variety which would go into a farmer's field.

Dr. Alison Bentley:

And then I think in the CIMMYT context, so we're obviously doing research and development with a focus on international development and international agriculture. There we're really asking the question about what alleles, what traits, what genetics, are most relevant to our partners and the farmers that farm and live and produce in the developing world. We have very close relationships with the national programs there, which are the agricultural systems of those countries. And there we provide germplasm and we provide, again, information on traits or genetic information which supports those national programs in the process of identifying promising material, putting it into crossing programs, or directly releasing the material.

Hannah Senior:

All this research requires funding. How does the funding influence what happens? As you described, it's often long-term projects. Which projects are prioritized? Can you just explain a little bit about how that works?

Dr. Alison Bentley:

Yeah. I think it works differently in different places, obviously, and there's no one answer for all situations, but it is long-term public goods research. There is always the question of who pays for that kind of research, and can it be paid for as a 10-year blank cheque to achieve an objective, which is obviously the ideal for everyone in whatever sector they work in. But there is that question of really, this is what you're investing in. Is that

value over a long timeframe? So we're really talking about, potentially, a less quantifiable impact in terms of public good.

Dr. Alison Bentley:

CIMMYT's done several rounds of impact analyses, and these always show a huge multiplier on the investment, in the case of CIMMYT and the CGIAR system. These are huge multipliers, in terms of the money that goes into support for this research and development and breeding, into livelihoods, and number of people reached by improved varieties or improved agricultural interventions.

Dr. Alison Bentley:

Particularly in the UK, with a three-year funding model, you're always having to make the case of, "This is scientifically excellent and it's also strategically relevant." But it's a constant challenge, as it is for everyone in science, trying to make the value proposition for their work. There's lots of different ways and socioeconomic tools to measure that, but really fundamentally, that investment is supporting the lives of those people living on less than $2 a day. And for them, varieties that encapsulate all the latest science are the ideal, because then you're delivering something with huge amounts of value that can have huge impacts on livelihoods.

Hannah Senior:

You described right at the outset, you're Australian by birth. I know you through your work at NIAB and Cambridge in the UK. Before too long, you'll be moving to Mexico. And so I'm curious, did you always plan to be a citizen of the world, or is it one of those things that just happened?

Dr. Alison Bentley:

Yeah, I think if you grow up on an island, you go one of two ways. Well, I'm sure there's a lot in between that, but yeah, I guess I was always kind of curious to leave Australia and to really understand what happened in the world. And I was very lucky, my father works abroad. He worked in Indonesia on, essentially, similar international development

projects, but in the space of ISO accreditation, in how you certify labs in the developing world to allow them to certify their systems as the basis of trade.

Dr. Alison Bentley:

And I remember these discussions as a high school student, having these philosophical discussions about the importance of international trade, particularly for developing countries. So if you have a rice crop, which was always my, "We need to produce more rice, or better rice, or have better varieties." But my father's perspective was like, "If you're producing better varieties, you want to be able to become an exporter, but in order to become an exporter, you need to be able to certify that your kilo or your ton bag of rice is actually a kilo by an internationally recognized standard." So really kind of lucky to have these discussions to really be able to contextualize the multifaceted nature of impact. It's never about one simple component. It's about productivity, but then it's also about how you sell, or how you monetize that productivity.

Hannah Senior:

And for many years now your portfolio of projects and collaborators has been super international. And of course, that's going to continue at CIMMYT, with a particular focus on the needs of low-income farmers in the developing world. Can you tell us a little bit about how that has been? What is it like to be working with such a diverse range of collaborators, and how does the work you do impact the needs of those communities?

Dr. Alison Bentley:

Yeah, so for the past five or so years at NIAB, we've been working quite a lot with partners in Northern India in particular, and that's been really eye-opening and really important in terms of the wheat nitrogen challenge. So we're interested in the relationship between wheat productivity and nitrogen fertilizer, because nitrogen is obviously a really important input on the one hand, but also a polluter and an economic cost to farmers. So that work in India has been done with a number of partners, and it's really allowed us to really stretch our thinking, I guess. So we can really go from, we have a genetic question, but what does it look like in the fields? And those relationships

have been really important in doing that, because it's allowed us to really work with the partners to understand the context and where the intervention points may be.

Dr. Alison Bentley:

And that's been very interesting, because often we want the answer to be genetics, because then we can go back into the lab and work it out and write a really nice paper on it and get some outcomes. But a lot of the time, the outcome isn't a genetic outcome. The outcome's first, we need to reduce the amount of nitrogen in the system. Right, okay. That helps you to really prioritize where you should be putting that research effort. And more recently about, so we need an environmental monitoring system as well. So that's been really interesting. I think for CIMMYT, the CIMMYT Program is internationally-focused. It's a Global Wheat Program, and with a specific focus, particularly in our new accelerating genetic gains project, in South Asia and Sub-Saharan Africa. And there I think your question about how do you prioritize and how do you work with the communities there to understand the demands, is really important.

Dr. Alison Bentley:

So there's lots of elements of that. There's the elements of consumer preference, and understanding the processing. Is that wheat going to be used for local consumption, is it going to be moved, is it going to be processed, is it going to be exported? All of those are very important considerations. Then you have the gender elements. In many crops, there's a gender element in terms of preference of who's doing what parts of the cropping work, who's making the decisions. Also, a move from rural to urbanization, you have this question of how will you engage and empower youth. So how do you actually kind of sustain the development of rural communities? And then you have the question about how does the system actually function, and could it be improved in terms of the pure plant breeding and delivery of new varieties?

Dr. Alison Bentley:

So that's really at the heart of what we aim to do, is to make sure that process really takes into account all of those factors and consolidates them and uses that as a

data-driven way to make decisions that are actually implemented in the breeding program. Or in the decisions, working with the agronomy teams, to really kind of match the varieties with the production system.

Hannah Senior:

It sounds like you're not just working in international teams, but also multidisciplinary teams, maybe social scientists, processing experts, et cetera. Is that true?

Dr. Alison Bentley:

Yes, that's true. And I guess that's one of the really exciting things for me about joining CIMMYT, that there is a Sustainable Intensification Program, there is a Socio Economics Program. And it's really important in these contexts. It's not just about, I need a variety for my farm, which is in Cambridge here, and it has this level of rainfall, and this is the amount I want to spend on fertilizer. This is really about a kind of global view on where the major impacts will come from. And you have to really understand that context. It's really important that the varieties produced are going to, A, perform in that environment, but also going to be acceptable and going to be useful for the product profiles, the things that they have to feed into once they're grown.

Dr. Alison Bentley:

Because it's only half the battle, growing the crop, as any farmer will tell you. You've then got to harvest it, and essentially sell it into... We don't eat a bag of wheat. We all eat downstream products. There's lots of different levels of processing. But that's the reality. So that's, for me, one of the really exciting parts of joining CIMMYT, is to have those interactions with the wider disciplines. And then across the crops as well, and to be able adopt best practice in the breeding across crops.

Hannah Senior:

Do you think that the plant breeding landscape is changing, and do you think it's changing to accommodate more of that cross-disciplinary work? Or, indeed, in other ways?

Dr. Alison Bentley:

The challenge, I would say, is that if you've trained as a plant breeder, it's sometimes difficult to really understand or really grasp where you can assimilate this additional information. Because every additional bit of information you're accumulating, you could take everyone's suggestions and quadruple the size of your breeding program. But everyone knows you can't do that, because you've got a fixed amount of costs. So I think there has to be some rationalization of that. But I think, I think there's definitely a recognition that a more joined-up approach, so understanding really what you want the crop to do at the end of the production cycle, really should be informing not only the management of the crop once it's in the ground, but that base material, the seed and the breeding that's gone into the development of that seed.

Dr. Alison Bentley:

And that's definitely something that we're working towards within the Global Wheat Program, is having these pipelines that are really targeted at the market segment or the end use type that is demanded in the geographies that we serve. Plant breeding will move in that direction, to allow a more targeted investment into genetic gains to really deliver an output that is quantified, that is a predictable output for the system that serves.

Hannah Senior:

So it sounds like we're moving from an era of yield being the primary focus, to the current stage which has a much wider range of breeding priorities, and a challenge of how do we trade them off and influence them all, to a future which is one of a much more targeted interventions to influence those highest priority requirements in a very focused way.

Dr. Alison Bentley:

Yeah. And yield is obviously always going to be important. And for the CIMMYT programs, the disease resistance packages is very important, because it's really important to remember, not everyone has access to plant protectives. So having yield

and disease resistance is a non-negotiable, but then, yeah, how do you bring in all of these other things that you want to have and then make it targeted? These are kind of big challenges at the moment, to really understand how to do that effectively and efficiently.

Hannah Senior:

What would you say has been the biggest challenge that you've faced in your career so far?

Dr. Alison Bentley:

I've seen, with COVID in particular, this massive mobilization of energy and resources to really find a cure or find a way forward. Governments can take huge actions and make really big interventions very quickly. I think that the climate crisis was also very high on the agenda before COVID. I think the food production and the food and nutrition security agenda also needs to be there. And I think the challenge for us, as advocates of crop improvement and the transformative value of agriculture in producing food, is really about having that message as high on the agenda as dealing with pandemics and addressing the climate crisis. Because I think that the food question and the agriculture question has to be there, and it deserves to have the same amount of light shone on it.

Hannah Senior:

Lastly, are there any influences or influencers that you're particularly grateful for along the way?

Dr. Alison Bentley:

I guess not in the conventional sense of mentors, but I'm really lucky to have a set of really great peer mentors. They're people at the same stage of career, and we meet often to really share this vision of what we want the future to look like. And that's been really, really strengthening, I think, to be able to draw on that network of people in the same stage of their career, really with a very similar shared vision about kind of an equitable, diverse, inclusive future, which is really using a scientific lens to look at

interventions in breeding to deliver impact. So that's been very empowering for me, in terms of my career development.

Hannah Senior:

It is a hugely motivating vision that you outlined, and I think one that many people would subscribe to and would also find hugely motivating. So thank you very much for sharing your story with us today. Dr. Alison Bentley of the CIMMYT Global Wheat Program. Thank you.

Dr. Alison Bentley:

Thanks a lot, Hannah.

[Podcast theme tune plays]

Hannah Senior:

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[Podcast theme tune fades out]