Transcript: Plant Breeding Stories Podcast
S4 E8 John Letts

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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 4 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.

Hannah Senior: John Letts started out interested in seeds and plant breeding, But life, as sometimes happens, took him in a different direction. He became interested in history and historic agricultural practices, and ended up becoming an Archaeobotanist reconstructing our understanding of what people were growing from ancient evidence. The twists and turns of his story involves a shoebox full of roof thatch, a return to plant sciences and an entrepreneurial spirit that allowed him to self fund his research. Today, he's pioneering a radically different climate resilient approach to grain production.

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Hannah Senior: John, it's a real pleasure having you on the podcast today. Can you kick us off by introducing yourself?

John Letts: Good morning, Hannah. My name is John and I've been working with grain for 35 years or more. I'm based in Buckinghamshire now, I lived for a long time in Oxford where I did a lot of my work. And I've studied in various places. And you

can probably tell by my accent that I'm not born in Britain but I've been here a very long time. But I'm Canadian by origin and I grew up in Ontario.

Hannah Senior: And I know Southern Ontario has a lot of agriculture, did your interest in plants and so on start at an early age?

John Letts: Well, I grew up in a small French Canadian speaking village actually, in southern Ontario, where it was just all cash crop farming. So I worked on farms, all of the farms in the area, on different crops, more as a labourer, and grew up on the farm. I was always really crazy about seeds. And I think I fancied myself as Johnny Appleseed. And I used to collect apple seeds and fruit seeds and spread them around and think, Oh, I'll come back in 30 years and eat those apples. I was always obsessed by seeds and gardening. I think that I got that from my father and my mum was really into that. But there wasn't really room for me on the farm, as it were. So I thought well, I want to be near plants and farming and agriculture. I didn't really want to live in a big city. By the time I went off to uni, I thought “Well, yeah, I think I'd quite like to be a plant breeder.” And I’d become quite environmentally aware by that time already. And I think I was quite socially aware in the sense, perhaps I was naive, but I really wanted to go into plant breeding to produce crops to feed a starving world. So I went off to uni and decided to study botany and genetics.

Hannah Senior: So you set out on a career path with the intention of being a plant breeder, but you actually switch directions fairly early on. Why was that?

John Letts: In my village, there was the biggest, largest, private plant breeding company in Canada. And so I started working there as summer jobs while I was still in the village, and we were working on mung beans in the field one day, and it was incredibly windy. And because mung beans are an indeterminate plant, they just keep growing, or at least they did - that's what we were trying to change, that they kept growing. And we wanted them to ripen and die so we could harvest them with the machine. And so we were spraying them with defoliant, while with Agent Orange, it was purple at the time, as I remember, you know, desiccants and herbicides. And I kept screaming to the fellow saying, “Look, this is not landing on the crop! It's just

blowing everywhere!" And he said "What?!" and he turned and sprayed me with the sprayer. Covered with purple spray and of course it took me half an hour to get back to have a wash of any kind and I have to say that was a moment that really changed me. When I grew up, you don't you didn't wear gloves, you didn't wear masks, you're using all sorts of chemical sprays. Nobody really thought about it. But we also have some of the highest cancer rates in Canada, in the village and you think well, there is a connection here. So I switched, actually, universities and went into environmental science and studies. But I never let go of the science or the genetics, I really still very much and still believe that clearly we have to draw on all the science we can to solve the problems we have. So it wasn't a kind of a hippie anti-science move.

John Letts: So I kept the genetics up in the botany and started to think more about environmentally sustainable production methods in agriculture I suppose.

Hannah Senior: Your story is a two pronged story. You have science and plant breeding in one hand, and history and archaeobotany in the other. Tell me about what ignited your interest in history?

John Letts: I got very interested in the native peoples who had lived in that area hundreds of years ago called the Huron, Iroquois native polopation. But they were pretty much wiped out by what happened when the Europeans arrived. But I got very interested in native food ways. Native peoples lived more in harmony with nature, and all of that kind of concept. And I was very interested in that transition from hunting and gathering to farming. Somewhere in there, we messed up as a civilization as humanity. And because clearly, well, I thought that the agricultural systems we have today are not sustainable. So I wanted to understand how those early phases of agriculture and of crops and how that change happened. I did a lot of research on the food of pre European native peoples, and how that interacted ecologically, how that influenced the environment.

Hannah Senior: So I'm gonna fast forward your story a bit. After university, you moved to London in the UK, and you found yourself working as a chef. But then you

enrolled into University College London's archaeology department to study archaeobotany. So tell me about that?

John Letts: Yeah, I was looking for ancient evidence of how farming systems worked in the past that I thought were more sustainable, more benevolent to the environment, and yet still fed people. And I thought, well, okay, people write about the past but I want the evidence, I want the hard evidence, scientific evidence. So you can find seeds in archaeological sites. The seeds can survive archaeologically for thousands of years if they've been turned into charcoal, basically, if they've been charred. And every archaeological site has that thing - the detritus of human occupation of civilization ends up in fire pits and rubbish pits. And you can tell a lot by people's latrines and fire pits. So the day after I finished my thesis and handed it in, which was on the food of early pre contact native peoples in Canada, I got a job at the Museum of Natural History in Oxford, analysing seeds and plant materials from British archaeological sites for the Oxford archaeological unit. So they've come in with a sample of a bag of black soil and little bits of charcoal that they'd found from some fire pit from could have been Neolithic, they could have been mediaeval. So I would analyse those seeds and identify them separate and say, well, that's wheat, barley, oats, rye, weeds. So you get some idea of reconstructing the environment within the field. And you might find beans and you might think, “Okay, were they rotating crops?” Or “what were they doing and what crops were they growing?” and you come up with a bit of a story and interpretation of how these seeds reflect what they were eating, what the local environment was like, and what crops and plants and things they were using.

John Letts: And that was really interesting and really fun to work on a lot of Roman sites, and I was very interested in the mediaeval period, which people were less interested in, but that connected me to North America and Canada and the first Europeans there.

Hannah Senior: Now I know around this point, you had a chance encounter with some thatched roofing from an old building in the UK. And that changed your career trajectory. Can you tell me what happened?

John Letts: I was sitting at my desk in the University museum picking samples apart and a friend of mine (Per) walked in with a shoe box, literally a shoe box, full of wheat. And his wife worked in a building museum, a historic building museum in Buckinghamshire, and her boss was asked to do a recording of an old historic building that was having it's roof redone. So the thatch was stripped off and replaced with some modern thatch; water reed, but he realised this was a mediaeval building. And the thatch on this building was the first layer that had been put on when that building was constructed in 1425. So he had two bin bags of this old mediaeval thatch full of the most precious ancient cereals that if you're interested in that… And he was about to put it on a bonfire! And she said, "Whoa, wait a minute, I have this friend who's a little bit of a wheat obsessive in Oxford, where my husband works and can I bring him a sample, he might be interested in this?" So by pure luck, she gave it to Per, Per walked in and said "Here, John, what do you think of this? It's from 1425". So I took the lid off, and it really was like, it was my Howard Carter in the tomb moment and I was amazed. What it looked like, if you could picture… Well there were about 25 ears of wheat in there. And every one of them was different.

Hannah Senior: Whole ears of wheat?

John Letts: Whole ears.

Hannah Senior: Did you know anything about thatching or thatched roofs Had ever crossed your mind?

John Letts: I knew nothing about thatching. I just think you put straw on the roof and it kept the water out. I didn't know how it worked, we don't have thatched roofs in Southern Ontario. And the other two archaeobotanists who were there, who were quite experienced, they looked and said "it couldn't have survived very long it must be fairly new" because with thatch you strip it off and put a new layer on. Well, that's

not how thatching works. I didn't know that the way historically, thatch works, you put a bottom layer of thatch on a roof, you tie that down, that's your permanent base coat that is never removed. Then you put weathering coats on top. And at the beginning, you don't even strip those half weathered coats off. So after 30, 40 years, the roof has weathered a bit, you just slap another layer on. You do that for about 200 years, and then it starts to become a “one off, one on” situation. So you've got the first 200 years build up of a record of the cereals that were put on that roof. And if the roof is dated from 1425, or I have something 1350, if not earlier. I actually have a late Norman sample. That is an incredible record but it's also an archaeological record because it's layered. So most archaeologists are looking down in the ground. Well, I started looking up into the roof and said there we have the best preserved examples of cereals, cereal landraces, anybody has anywhere. And it's a uniquely British and to some degree, Irish situation. And some of those years I recognised right away. I knew that it hadn't been grown in Britain for 200 years, not commercially. So I knew the date was already quite old. But the fact that all the bread wheat, the Triticum aestivum wheat in there was also, every ear, a bit unique. It was clearly from a mixed population of land races. And he said, “I've got two big bags of this!” And that changed my life.

Hannah Senior: That's amazing. So where do you even start?!

John Letts: You know, in a sense, there was too much information. So all these people are sitting there picking apart samples of wheat, barley, rye, oats maybe, because all this material is very fragmented and broken down. You can't say very much about a crop but I want to know about yield, I want to know about, ultimately, about sustainability and how mediaeval the fields worked. So this was a pile of data that allowed me to reconstruct yield. And because I had the whole ear and a good part of the stem, so morphologically, by measuring the kind of internode, because a wheat plant has all these nodes along the stem and they're in a mathematical formula. So I can look at the ear, I can count the florets, I can count how many grains are there, I can come up with that idea and then I can relate that to the height of the straw. So I was able to reconstruct the average height of a mediaeval crop. And

remember, wheat from even 1550-1600 is very, very similar to the wheat that was grown 1000 years before that. So wheat has changed more in the last century than it has in the previous 1000 years, if not more. So it's a key into the ancient history of all of our cereal crops. Anyway, I was able to conclude that your average mediaeval wheat was about six foot tall and yielded about 600 kilos. That's the short of it. And crops were never pure. And I think this thatch reflects what most farmers grew, what most people grew certainly for local markets and for themselves.

Hannah Senior: Now, obviously, you can't plant those grains. But have you been able to, I don't know, take the genetics out of them and somehow recreate them? Because that would be a really interesting comparison, wouldn't it?

John Letts: I've been wanting to do that for 20 years. And we just started a project at Bristol University doing that very thing. And there may be some very weird genetic stuff that will come up there. I don't know where it'll go. But we're just getting going on that. But also, it'll allow us to see the connections between the cereals and the flow of grains. Has our wheat come from Scandinavia? There might be some lines in it from Spain or something. I grow barley, a mixed population of barley, some of which is Bere barley, B.E.R.E, from up in Orkney and Shetland. And the view was always that that came in with the Vikings. But I'm convinced it was the ancient Neolithic barley that arrived here in 4000 BC. Incredibly beautiful, productive six row barley. So there's all sorts of mysteries that we can unravel by having this amazing mediaeval thatch samples. I'd like to think it'll point us in the direction of certain gene combinations or traits or whatever that I think could be really, really useful.

Hannah Senior: I want to dive into plant breeding specifically now, because despite you turning away from it when you were younger, you did end up pursuing a PhD in plant breeding. So how did that come about?

John Letts: I was doing this work at Oxford, but it was very much in a museum in a historical kind of context. But I'm a botanist, I wanted to look at genetics, I wanted more science, and I wanted to be back in a proper science department, not an

archaeology department. So I was approached by Reading Plant Science, and ended up beginning a PhD there in the plant breeding section of agricultural botany.

Hannah Senior: Did you enjoy being back in the sciences again?

John Letts: It was challenging. I really wanted to be in a science department. But all of what they were doing there was molecular, it was all GM, it was what was leading. Biotech was really gaining steam. And it was about herbicides, and it was about conventional production. So there I show up saying, “Oh, what we need to do is reintroduce genetically diverse land races from the ancient past, and we need to understand mediaeval farming if we're going to have sustainable farming today. And we need more organic farming.” And they just looked into shook their head and said “No, mate, that's not the future.” And I thought it was the future.

Hannah Senior: So you started out in your PhD, if I understand it, trying to develop a variety that would reproduce or draw on the mediaeval grains. So talk me through how you approached that and how your thinking changed over time.

John Letts: So what I did was about how do I, how do I deal with this cornucopia of cereal varieties I'm finding in these mediaeval roofs, every one is a bit different. I thought I'll go to the gene banks and I'll pull out all the samples I can find that look like the ears I've found in these roofs. Now the seed is dead, no seed is going to survive, of cereal, is going to last for more than five years. Which is why we only have a trickle of the genetic resources that… A tiny slice of what was grown in the past. And the types of wheat and rye and barley that I'm finding in these samples, some of them are completely unusual, very unusual. There's rivet wheats that I don't think according to the experts should have evolved. But they're in those samples! There was massive genetic diversity in our fields in the past, and that gave crops resilience. So I started pulling samples of these wheats out of gene banks, not just in Britain, but all over France, Belgium, Canada, America all over. So I grew them out in trial plots. And maintaining a collection of a thousand wheat varieties, harvesting them, measuring them all, was quite time consuming. But I did that for five years for a lot of different wheats. And I kept them all separate, because I thought, “well, that’s

plant breeding, right?" and you select and narrow and you select a narrow and select and purify, and you create a variety! Which you can then release commercially, which is this high yield and all the characteristics you want. But in the end, what almost all plant breeding is doing is creating a field full of clones, it's creating a monoculture, every plant has ideally got all the advanced characteristics that you very creatively and amazingly bred into one line using any number of techniques. But really, every plant in the field is identical and it's an industrial production system. As long as you keep adding the inputs, you're going to get the output of grain, but you're wiping out the existing ecosystem, the soil is pretty much dead. Because it's so short, you need herbicides to control the weeds, because they're all clones, you need to spray in the fungicides to get rid of the disease. Yes you can breed disease resistance into that but it tends to break down. And with climate change, which is starting even then people knew about it, you know, you've got to think 20 years ahead, and we're on a race, biological race here that diseases are evolving more quickly than we're going to be able to breed our way out of it. So I thought, "Well, what did they do in the past?" Well, the sample I had in front of me was probably very disease resistant, it was really tall, so it didn't matter about weeds, massive root systems to survive drought. Our modern wheats are very short with shallow root systems, because when they dwarfed wheat plants with the dwarfing genes to create our modern elite hybrid varieties that also dwarfed the root system, so it can't absorb water and nutrients from very deep. So there's all these things that I was seeing in the mediaeval sample that I thought, "okay, it may not be perfect, and the yield was low, but can we take that concept and tweak it and improve it to create a modern version of the mediaeval land race that works in low input systems?"

[Theme tune 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 tune fades out]

Hannah Senior: So you're growing out all these grains that you've selected from gene banks all over the world, based on what you saw in your mediaeval thatch samples, in an effort to recreate a sort of mediaeval grain crop, which was really diverse. Now that sounds more like evolutionary plant breeding rather than plant breeding in the modern sense. Tell me more about that process of why you chose this approach.

John Letts: Plant breeding has been pretty much all about selection and purification and uniformity. But there have been many people before me saying, “well, let's have an evolutionary approach” But evolution can't happen unless there's genetic diversity. So they would create modern populations. For example, you could take 20 elite varieties, modern hybrid varieties and mix them together and create a swarm of diversity there. What normally would happen is you would then select the best ones out of that, and then take them forward and create a new pure line variety. But if you kept that group with all that diversity, and you just grew it in the same field, in whatever conditions you want, nature is going to impose its own selective forces on that, so that's evolutionary plant breeding, and then humans can tweak it a little bit. But my problem with that is not that technique, that approach is brilliant, that's allowing a crop to be exposed more to nature and to be more adaptive. But you've got to start with a massive amount of genetic diversity to begin with. So I wanted to go back and create a hugely genetically diverse population with as much resilience that I could in there. And I did tweak it and select ones that I thought looked a bit more hiring, high yielding, but yield is not the only thing we have to go for. I accept the yield penalty in return for sustainability and that I know I'm going to get a decent crop every year. I want a tough crop that can deal with all these situations. So my selective criteria, I suppose, are very, very different.

Hannah Senior: At this point, the funding for your project had run out. So how did you find more?

John Letts: 95% of the funding in the department was just from big grain companies working on molecular genetics and plant breeding and stuff. And I knew that wasn't going to be my future. There was no way I was going to be able to keep 500 or 1000… I have several 1000 lines of wheat in my freezer here. How am I going to keep those all separate? And why? I'm not a gene bank, I'm not I'm not running a normal plant breeding project to create a pure Line variety. I only want to grow the wheat that survives in my area. So it was a difficult decision. But it was a necessary decision. The only way I could… And I don't have land. I don't have a farm. I don't have a tractor. How am I going to do all this? So I thought, well, I have to go into the marketplace. The truth is there's very little money in grain and I realised right away that there's no way I could make any money by selling grain. Grain is a commodity, it's super cheap, farmers get so little for the grain it's almost uneconomic in the UK to grow it or it has been the prices are just going up - because of crop failures, which is slightly contradictory. So I thought "how am I going to make this work?" Well add value to it. So I was very much entrepreneurial because no one was interested in funding this bizarre idea. So I managed to hook up with a family farm here where I am in Buckinghamshire near Great Missenden and they were really good. They were interested in thatching straw and it was an organic farm so I knew it wasn't laden with chemicals and the soil was quite healthy. And I found an old barn. So I rebuilt the barn and some other buildings, and I bought a mill and a threshing machine. And I found an old winnowing machine from 1895 in perfect condition. I got in flaking machines, grain polishers, sieves, and what I needed to start a small heritage grain business.

Hannah Senior: So talk me through how you grew out your heritage grains, your crop? And how does thatching come into this because I know you're still involved in the thatching world?

John Letts: So I literally took all of my wheat from all of these years and trial plots. And I threw it all into the same bushel. And I went to a local farmer and I said, "Look, can you just grow this for me?". And because you know, the way a mixed population works, a land race, it's about cooperation as much as competition. So I'm going to

recreate one of these mediaeval populations. And because it's genetically diverse, it's more resilient. And that is important in the thatching sense as well, because we have a crisis in the thatching industry. Basically, wheat has become so short that most of the varieties are useless for thatching, they're just too short. So I was working with thatchers to improve the quality of thatching straw. And one of the problems is you've got to cut that by hand with a Reaper binder and then stoop it up in the field and let it dry and then comb it and process it to get it into the state of thatching straw. And you're very limited to 10 or 20 acres. You can't do more than that by hand. And then it ripens. If it ripens fully, you've then got to cut thatching straw when it's slightly green… This might seem esoteric but it's actually quite important - but you gotta cut the straw just before it's fully ripe. You just can't get to a large acreage with an old fashioned reaper binder and do it all by hand. Nobody wants to stoop wheat in a field for a week. So if I mix all my best thatching wheats together, and it'll ripen over a longer period, and then I can harvest the crop, sell the thatching straw for a really good price, which is far more than the grain. Plus I have the grain that I can sell as a flour for baking. So I thought there's a double harvest. That's what people did in the past. I've got to find a way of doing that sustainably. But I know my yield is quite low compared to a modern farm. But that's okay. So I literally threw them all together with a view to producing the good proper thatching straw. And I was interested in the bread because I baked and I and I knew a few bakers who said, "Oh, that's very interesting old flour, that's probably the taste of the past." So I thought, well, here we go, I need money to pay my bills and to fund my research and my crop development work and so I will make thatching straw and grain and it's got to be a mixed population.

John Letts: So I literally threw hundreds and hundreds and hundreds of varieties into a field. And it worked! People wanted the flour, it was delicious. It was flavorful. The straw was good for thatching. Those varieties that weren't well adapted that were too short, they'd be out competed, it worked. And it's been evolving and adapting on four or five different farms for almost 20 years now, never had a failure,

knock on wood. Never had a climate failure, never had a crop failure. I've had human failures, but mostly not.

Hannah Senior: You've touched on the fact that this is a low input system, but not specifically organic. I wonder, can you quantify how your grain crops stack up against conventional intensive farming and organic yields?

John Letts: In the UK, if you're a conventional farmer you could grow wheat continuously, with all your sprays, your fungicides, your nitrates, whatever. The soil is just the medium you'd grow it in. But basically, it's a continuous conventional chemical based production method. And if you get anywhere from three to five tonnes an acre, over five years, but you'd need one break crop, you've got 15 tonnes, let's say. But that whole approach to me is just not sustainable. And we've got to find a different way. So what's the alternative? Organic. Okay, of course, organic today is certified organic and there are lots of rules about how you do that. So if you're going to grow grain, organically, you need to grow three years of clover to build nitrogen to build organic matter, then you plough that down and grow a single crop of wheat, milling wheat for human consumption. I'm interested in growing wheat for humans. And remember, organic farmers are growing modern varieties. Those modern varieties are shallow root systems, they're adapted to high input systems. So you grow them organically, they produce a third of the yield that they would with the chemical regime. So in five years, you've grown one crop of milling wheat. And you're lucky if you get two tonnes, so two tonnes in five years for an organic system, at least 15 in the conventional system - well, okay, there's a price to be paid for that which is destroying the planet, we can't keep doing it. So looking at organic, okay, organic's the way in the sense of not having chemicals, but it's just not productive enough. We are not going to feed the UK if we use that rotational system, because for every acre of wheat, you need three acres of clover grass lay. We'd have to cover the country in clover grass just to produce the grain we're feeding. Remember, two thirds of the grain conventional farmers grow in the UK is fed to animals. And we're importing grain too, high quality grain from Canada and various places. There's no way the UK can be self sufficient. So we have to do better. So

how do we do better? Well, I call it natural grain farming or restorative, continuous cropping.

Hannah Senior: And when you say continuous cropping, what do you mean?

John Letts: I lose a couple of percentage points of my harvest out the back of the Combine every time I harvest. And that grain falls on the ground and starts to grow. farmers call it volunteers and they go, “Oh, you must kill the volunteers! There's gonna be a green bridge of disease. That's terrible for your crop!” Well, I have massive genetic diversity in my crops so I don't have disease or I have every disease, but they're all at a low level, because I have an ecosystem that's developed - at least a genetic diversity. So I'm walking through this field after the harvest, and I'm seeing all the seedlings. I'm saying, “Well, I've got a wheat field already growing. So my combine is acted as a drill!” So what any farmer would do is spray it off with glyphosate or plough it and then start over. But every time you plough, you just plough in more weed seeds. I'm creating a rod for my own back. So we spread Clover down and the clover suppresses all the weeds, adds loads of nitrogen to the system. And I started doing it year after year in the same field because I didn't want to rent the fields for three years when they were just clovers because I don’t have any cows. I don't want any animals. I left all the straw then on the field because I thought well, “okay, let's think back to the Neolithic” where I got into this about these first farming communities. They collected the ears but there's no evidence of ploughing for 5000 years. People didn't till the soil when they first started farming, I realised. So I just shred all the straw, it breaks down, feeds the soil surface the worms, pull it down. It's a slow release of nitrogen. And then I thought well, I'll just broadcast the seed like out of the combine. So I started actually doing that and it worked fine. I had beautiful crops. And I'm consistently getting 1.2 tonnes an acre. Now they'll say “What?! 1.2 tonnes an acre, that's abysmally low!” So if I get 1.2 tonnes per acre, and an organic farmer might get 1.6 1.8, maybe two. But I get it every year. So if you go 1.2 times five, I've got six tonnes, and an organic farmer gets two tonnes. So I'm producing three times the grain of an organic system, but of course, no animal products. But that's fine with me. So I believe my system, which I

call restorative, continuous cropping, is producing three times what an organic system requires. And the two key things are getting Clover understory, the only thing that leaves that field is the grain. I welcome weeds. I want to rewild the wheat field. So it's a combination of that productive system, which is mimicking natural ecosystems and anything that was done 1000s of years ago, but you also need the crop that is genetically diverse. So it's the two planks of this system, and I starting to call it natural grain farming. And it works.

Hannah Senior: And how does it stack up for the consumer? Is it a lot more expensive for them?

John Letts: To make a pizza in London, standard pizza, £14, let's say. The amount of flour you need to make that pizza costs about nine pence. To make it from Heritage grains, you have to add another 0.11p on to that. That's the price of saving the planet if you love pizza. Are you willing to pay another 11p for the sake of having a grain that's grown in a very sustainable way that's gonna have more flavour, I would argue? More nutrition I would argue. I actually think most consumers are willing to pay that. We can afford to grow grain in a way that is benevolent to the environment that is sustainable, that actually sequesters carbon.

Hannah Senior: We are running out of time. So one last question from me, you've been bridging the world of modern plant breeding and historical cropping techniques. So I'm curious to know what you think modern plant breeders need to take away from this interview? And what direction you think they need to go in in the future.

John Letts: People will say, “Oh, we've been genetically altering our crops for 10,000 years.” Well I would say crops have been altered genetically for 10,000 years, but it doesn't mean we were breeding them. “Joe” Crusader would go to the Middle East and pick up a handful of grain and come back and maybe throw it in his bushel. And most of those would die out. But some might have stayed there. So you had gene flow that was happening at that population level. And the goal was not just high yield. It was sustainability. You needed to feed your family every year guaranteed. So you needed a tough crop with deep roots that you knew was going to

produce what you needed. And we've changed all that. And plant breeders really got going, I suppose somewhere around the 1830s, 1850s certainly in the UK. It was industrial revolution, wasn't it? It was about having the highest yield you could. And uniformity because mechanisation was coming in and they wanted industrial crops. So they narrowed all that, we lost all that genetic diversity, plant breeders threw out all that genetic diversity as they were improving crops. And they really genuinely and benevolently wanted to improve yields for farmers. But of course, as soon as the yields went up prices come down, and farmers are basically where they were. And who's benefiting? You could argue. So we ended up in, let's say, the late 1800s with quite a few, I suppose “pure line” crops that had been selected from the ancient populations. And in the UK, the first hybrid wheat was released in 1906. So that's when plant breeding, scientific plant breeding, really kicks off. And then everything else is genetically uniformed monoculture as far as I'm concerned. When I use the word heritage grains, I very much mean pre 1900 or thereabouts. When plant breeders really get going on understanding inheritance and more intensive selection methods and hybridization and all that. So plant breeders are just there as a tool of industrial grain production. Boy, that's a phrase that maybe people won't like! And it's perfectly logical that humans want to grow, to have a crop, that's the highest yielding crop possible. I understand that desire. And that's what we've been gunning for for 150 years. Now, most high yield you can manipulate, the plant structure, you can manipulate its efficiency, you can do everything you want. But it's all geared towards having the highest possible yield. Well yield doesn't come out of nowhere. They've developed crops that are incredibly good at producing high yields. But only if you have massive amounts of inputs to maintain them. It's a sterile eco… Well they replaced the ecosystem. It’s not an agro-ecosystem in any way. It's just a medium called soil with rows of plants that are genetically identical for producing all that food. I just don't think that's going to work anymore. We destroyed the environment biodiversity is pretty much gone. Soils are dead you know, we've got massive climate change. “Ah but we need to feed people!” Yeah well, I always refer to modern varieties like Formula One cars. Now if you put aeroplane fuel in the engine and put them on a flat track, with all the right mechanics and millions of people helping, yeah,

that cars gonna go 250 miles an hour. But that car right now for me is racing towards a brick wall at 250 miles an hour. If you take that F1 car and you put it on a country lane with lots of holes and bumps, and dirty diesel in the engine, it ain't going very fast. But a good old tough Jeep's gonna get there. And I think that's where we are, we just can't keep racing forward. So I want plant breeders to look at low input production, these crops from the past were efficient at getting nitrogen. As soon as you create, make fertiliser, it's incredibly energy demanding and spraying, it's going to kill your soil to the mycorrhiza, all that kind of thing. So I want to find really, really efficient plants that are able to grow in natural, low nitrogen conditions. There isn't a single ecosystem in nature that has high nitrogen. That's what I want, I want a mixed population that's very, very genetically resilient, that can deal with drought and rain and all the stuff that we're gonna get. Having one variety, where every plant in the field is the same, you can try to breed in all the resilience you want but if you want serious resilience, you need a bio diverse ecosystem. And then you need genetic diversity within that crop. And to go back, I've never had external funding for this, I've had to pay my way. And the only reason I'm still here is it works. It works at every level, and it works... Well it certainly works for farmers financially, we pay the farmers who grow for us for growth for me on a per acre basis, not a per ton basis. All we do is we literally broadcast the grain into a field, perhaps drill it if you have the right equipment, and then I mow the stubble. So I'm broadcasting into the previous year's tall stubble, I mean, you know, a couple of foot tall stubble. And I mow that to create this mulch over the grain and I walk away, I close the gate, and I come back and harvest it. And you think - there's no fossil fuel use. There's no contracting costs. It's actually incredibly cheap to do. As Fukuoka would say it's lazy man farming, I wouldn't say lazy, but it's just the less you till the less you put in, the more profitable it is. I know the yields are lower, but we're on this kind of conveyor belt of production and you end up with a crop of wheat that is very cheap to sell anyway, you hardly make any money. It only survives through subsidies, let's face it. This system is broken. Plant breeders have catered to that system. And they've got to think outside the box in terms of what's coming in a climate change sense. I think plant breeders are scared of the black box. They need to control everything. It's like you're painting

that you've created. But I'm happy to accept a mixed population with 2000 varieties in. I can't name you all those varieties. Well, I can tell you roughly. But which one in proportions? I don't need to know that I don't really care. All I know is that it works.

Hannah Senior: That feels like a good place to wrap things up. It has been such an interesting conversation and very thought provoking. Thank you very much for sharing it. It's been really fascinating.

John Letts: You're very tolerant to listen to me blabber on so much, but I appreciate it.

[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]