Transcript: Plant Breeding Stories Podcast
S3E2 Dr Anupama Hingane

[Theme music plays]

Hannah Senior: Welcome to season three of the Plant Breeding Stories podcast, where I talk to leading likes about plant breeding, asking what they do, what makes them tick, and what fascinates them about the world of plants. I'm your host, Hannah Senior of PBS International, world leaders in pollination control. We design and produce specialist pollination bags and tents that are 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, our 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: Today I have with me Dr Anupama Hingane, who is a pigeon pea breeder with the International Crops Research Institute for the Semi-Arid Tropics, or ICRISAT. She initially spent time researching two non-food crops, cluster beans and cotton, later transitioning to focusing on pigeon peas, a pulse crop that traditionally features heavily in Indian cuisine. We'll be talking about how reducing the time to maturity and developing the ability to create hybrid varieties opens the door to this crop becoming a hugely valuable addition to the rotation in large areas of India and far beyond. By offering a drought resistant source of plant protein, an extra crop each year which increases farmer profitability, and enhanced soil health. Transcripts of this episode and all our podcasts are available at PBSInternational.com/podcast. I hope you enjoy it.

[Theme music fades out]

Hannah Senior: Anupama, to get us started, would you like to introduce yourself?

Anupama Hingane: Hi Hannah. I am Anupama Hingane, a pigeon pea breeder at ICRISAT. I'm working at ICRISAT for the last 9+ years.

Hannah Senior: Tell me a little bit about your background. How did you come to be interested in plants?

Anupama Hingane: So I'm basically from a small town, Baramati, it's in the Pune district of Maharashtra state of India. To the north part, where I'm presently based in ICRISAT. So I grew up in a very traditional joint family, with around 35 people staying together. I did all my schooling in my hometown and then moved to Pune for my graduation and masters in agriculture. And then did my PhD at Mahatma Phule Krishi Vidyapeeth, at Rahuri, another district of the same state.

Hannah Senior: Why did you choose to study plants? What interested you about plant breeding and plants?

Anupama Hingane: Farming is our family business. So I'm born and brought up in a family where agriculture is a family business, and we stay in a farmhouse, all surrounded with the different orchards, guava, pomegranate, and different horticulture crops. So I used to be in orchards most of the time when not at school. I think I was wanting to be working with plants but then I think being from a farmer's family it was a very obvious choice.

Hannah Senior: Were you encouraged to go into agriculture by your family? Did your siblings do it too?

Anupama Hingane: Both my elder brother and sister are in the medical field. My brother is an orthopedic surgeon, my sister is a general physician and my mom wanted even me to opt for a medical field so she can proudly say all her kids are doctors. But to be frank, I always wanted to be in the agricultural field. And my dad supported me strongly in choosing this career because, so this was I think in 2000 when I got admission for my graduation and at that time hardly I could see around 5%-10% of students out of 200 students were girls. So it was not very common for girls to opt for this field. I decided to proceed with my advanced studies in genetics and plant breeding. At that time I just knew I wanted to be in the agricultural field and I was much more interested in horticulture science. And luckily I could get the admission to one of the

best colleges for horticultural sciences. So that is how my journey in studies and agriculture science began.

Hannah Senior: You mentioned a little about your family's farm - can you expand on that?

Anupama Hingane: My grandfather, Mr Hingane, was very well educated of his times, maybe 1940s, actually, and a very disciplined person, and our farms were managed under his guidance. And he was a very progressive farmer and very popular in our region. He used to manage our large agriculture farms, mainly cultivating horticultural crops and sugar cane. He was very keen that all his sons manages the farm, but made sure they all were very educated. He was actually awarded several times with several prestigious awards. Actually, he was awarded once from the state government for harvesting 110 tons of sugarcane from one acre of land. So I was always seeing all those advances and all those modern agriculture techniques being implemented on our own family farms here in our family. So I think that was a lot of knowledge I was getting from my farm.

Hannah Senior: So it wasn't just agriculture that was in your blood, it was also innovation and a very high standard of production that was also handed down to you. So then you started your career in plant breeding and one of the things that is perhaps a little different from some of the interviews that I've done through this podcast is that your initial work was on non-food applications of plants. And in particular cluster beans. Now this was new to me so, could you tell me a little bit about cluster beans? What are they, what are they used for, etc?

Anupama Hingane:

Yes, actually I worked on a clusterbean, locally called guar, for my masters in genetics and plant breeding. So cluster beans has mainly been grown for consumption as a vegetable, and it's a rich source of protein and it's a very drought tolerant leguminous crop. But then this cluster bean contains around 30 to 33% of gum in it’s endosperm. So

this particular trait, the discovery of galactomannan gum in the endosperm, has led to an insignificant plant gaining an industrial importance.

Hannah Senior: And how is it used, this gum? I had heard of guar gum as an additive in foods, but I think the main reason that you were focusing on it was for its use then in another sector entirely. Can you tell me about that?

Anupama Hingane: So it's really a very versatile crop. And it's an efficient biopolymer covering a wide range of industrial applications, mainly in the petroleum industry, for drilling fluids. It has been used in the food industry, pharmaceuticals, textiles industry, paper industry, even in explosives and cosmetics. So what is a strong hydrogen bond forming tendency in water. So that makes it a very novel thickener and stabilizer. India accounts for 90% of the world's cluster bean production and out of which more than 90% is exported. So most of the demand for this guar gum is due to the expansion of shale gas and oil industries globally. So it's efficiency as a lubricant and economical nature makes it very popular in the petroleum industry. So a lot of global demand for this, cluster beans has really… That's a new industry developing, in India, actually, for this particular crop.

Hannah Senior: Mmmhmm [affirmative]. And what were you looking at? What aspects were you focusing on in your master's work?

Anupama Hingane: My work was - there are two main contents, you know, galactose and mannose in guar, and I was to study the varieties which are having the high gum content. So I evaluated around 51 diverse germplasms. I received them from our national bureau of plant genetic resources, India, and then I evaluated those four different variety traits, mainly with focus on the mannose and galactose content. And also I studied that correlation with other yield contributing characters. So this was my small study and I could identify some varieties which could help us in developing varieties with having high gum content. And those can be potential varieties that can be

recommended to the farmers who are interested in developing varieties, especially for guar gum.

Hannah Senior: And after your masters, you went on to do your PhD, but in a different crop - tell me more about that.

Anupama Hingane: So for my PhD I worked on cotton. On cotton, I work on developing some inter-specific triple-cross of cotton for enhancing the fiber quality parameters. So for that I made a triple cross between a wild *Gossypium anomalum* to another wild species *Gossypium barbadense*. And it was a triple cross with *Gossypium arboreum* to transfer this fiber quality parameters to the cultivated gossiping arboreum, but at the same time having the high yielding…. Retaining all other characters. So because currently the spinning machinery using the textile processing industry sets the standards for fiber quality, mostly based on the physical properties like fiber, strength so important objective for my study was to introduce this fiber strand genes from *Gossypium* wild species to the cultivated species. And then fortunately I could get some good segregations with having the high fiber strength and at the same time we're having the high yield. So this is what my basic findings of my PhD work.

Hannah Senior: You started your career in non-food crops and non-food applications of plant breeding. And then you have now transitioned to working on a food crop. I mentioned at the beginning that you're, you're now a pigeon pea breeder. Out of curiosity, are there any differences between the world of plant breeding for food and the world of plant breeding for non-food?

Anupama Hingane: So in my opinion, as a breeder, I find that it's not much difference as far as breeding for food and non-food crops, because in the end the breeder will be breeding for the varieties for the economically important or maybe market preferred traits, or even sometimes traits that are important for the gender requirements. I can give an example - like suppose for the cotton, like non-food crop cotton. When in India the picking is mainly done by hand by human farmers, right? So there is one of the traits

like having open bracts. So this open bract will help humans to pick the cotton very easily, but similarly with the food crops, like pigeon pea where the size of the seed is a very important trait because size decides the price, because the millers want the varieties, which are having the high dhal recovery. So I think in both the cases we consider the traits which are preferred by the market with our end-users. So I don't feel as far as a breeders point of view that is there is any difference in the food and non-food crops. So maybe the food and non-food crops will be breeding for the traits which are required by the end-users.

Hannah Senior: Moving on from cluster beans and cotton, I'd like to talk about pigeon peas. But before we dive into your work, I'd first like to lay the foundations about the crop - what it is and how it's used and so on. And I'll admit that when we first met I wasn't familiar with pigeon peas at all, though actually now I have learned a bit more about them, I have almost certainly eaten several times, just without knowing it!

Anupama Hingane: So pigeon pea, scientifically called cajanus cajan, is an important, grain legume crop mainly off of rain fed agriculture. So it has mainly been grown in the Indian subcontinent, Africa and some parts of central America, Caribbean islands. So, so this crop, it's a very important pulse crop as far as India is concerned because there is a very rich source of protein and India has a large number of vegetarian population and this is a cheap source of protein. Of course, India is a very diverse country, so used in very different forms. But it's a part of a daily diet and it's mainly an important source of protein for most of the vegetarian population in India. So this crop has many users, you know, like fresh pigeon peas are eaten as a vegetable, grain is cooked and eaten as a dhal, the dry split cotyledons, which are known to be very rich in protein. It's a very versatile crop with a wide range of crop duration - ranging from 90 to 280 days.

Anupama Hingane: It's a short day plant, with a deep root system and it's very hardy, it tolerates drought. But at the same time, it is also very sensitive to water logging. It is also very sensitive to photoperiod and temperature. Until recently it was referred to as an orphan crop, so where nothing is to grow this farmer used to broadcast this seed and

they used to get reap and it was actually not grown commercially. Investing more than six plus months for this crop, was not what farmers were preferring to do. But recently it is really gaining importance and it is commercially grown in the entire country.

Hannah Senior: You mentioned that there's diversity in the crop, and you said 90 days to 280 days, what does that refer to?

Anupama Hingane: When you sow the seed to harvest the pod, it used to take 280 days. So that is the traditional pigeon pea varieties being grown. But then due to several breeding efforts, now we have varieties maturing as early as 90 days. But then traditionally, mostly varieties grown in India are mostly with the duration of 160 to 180 days. So that is the preferred maturity duration for pigeon peas in India as of now.

Hannah Senior: Okay, that's helpful. And you said that it's not been much of a focus for breeding so far, and it's been a bit of an orphan crop. Before we go further, why is that? Why has it been overlooked when it's such an important crop, particularly for Indian agriculture?

Anupama Hingane: This crop was really initially growing only in those rain fed regions, where nothing else was growing. But now 'cause, you know, farmers will grow what is going to earn them benefit of profit. The moment that is some irrigation source, the farmers will grow… Will shift to other commercial crops, like cotton or other horticulture crops or vegetables. But somehow the productivity of this crop has remained stagnant to around 800 Kgs per Hectare for more than six decades.

[Theme music plays]

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]

Hannah Senior: We've been talking about Pigeon peas as a crop, and how until recently it's been neither high value nor a high priority crop for breeders to target. Can you tell me a bit about the approaches you have been taking in your pigeon pea breeding program at ICRISAT?

Anupama Hingane: So different approaches have been followed here at ICRISAT in collaboration with our partners. And recently we have developed a commercially viable hybrid technology. It's the first of its kind in any grain legume, using a cytoplasmic male sterile system of course derived from a wild species. And we could find these hybrids, have been yielding around 30 to 40% more yield than the commercial varieties. So we have identified the source, we have some hybrids and we are working towards commercializing this technology. So I feel that this different approach - like breeding for different biotic and abiotic traits, breeding for different varieties, for different ranges and then developing a commercially viable hybrid technology will certainly help us bridging this yield gap.

Hannah Senior: Mmmhmm [affirmative] Pigeon peas are useful for the edible part. But then also there's a much wider use for the plant. So can you tell me about all the other characteristics, even in an unimproved state of the pigeon pea that makes it useful?

Anupama Hingane: So being a leguminous crop, it enriched the soil through symbiotic nitrogen fixation, and it also adds to valuable organic matter and micronutrients. But what is the special mechanism of this particular crop is it sheds all its leaves at maturity. That's a huge biomass. And this leaves a particular acid called piscidic acid. So the piscidic acid, when it decomposes releases soil-borne phosphorus and that is made available to the succeeding crops. So it actually enriches soil. It also produce dry stems, about 10 tonnes per hectare. So these dry stems are used as a fuel wood in rural areas. It has actually provided a great relief to the rural women for eliminating the drudgery of collecting fuel wood from the forest areas. There are some studies that these dried

pigeon pea sticks, when used as a fuel wood, were found to be having very high fuel efficiency of around 3000 calories per Kg.

Anupama Hingane: In addition to this the broken seed and husk from the dahl mills is also used for the feed for the livestock. So you can imagine those...So each and every part of this plant is really useful for these smallholder farming communities.

Hannah Senior: It is a pretty amazing crop when you think about it. There aren't many planets where every aspect of it has a use like that. And I didn't clarify, forgive my ignorance, is it an annual crop? Does it need re-sowing every year?

Anupama Hingane: Yeah it is an annual crop. In nature it is a perennial crop but then due to our breeding efforts it's commercially now grown as an annual crop. Now we have different varieties and different maturity duration, so that makes it possible to grow it annually. So in India it has mainly grown at the onset of monsoons. It starts from the 10th of June here. So it's going to be a busy cropping season now. So mainly it's traditional varieties that I was mentioning. It is six months variety so sowing is done in the month of June and it extends up until to January, mid January or December and mid January. So it's grown annually actually. Yeah.

Hannah Senior: I know you can see some really exciting potential for this crop. So tell me about where you think the potential lies and then afterwards, we'll talk about the plant breeding work that's going into, "how do we realize that?".

Anupama Hingane: Okay. So I have been mentioning again and again that pigeon pea is very sensitive to photoperiod and temperature. So this has really restricted its expansion to wider latitudes and altitudes. In addition to the existing long and medium duration varieties which are grown, are not really suitable for diverse cropping systems and other ecologies. What's really exciting now, you know, so recently me and my team have developed a photoperiod and temperature insensitive super early varieties. So super early, and they are really super early by, they mature just within 90 to a hundred days. These super early varieties have identified new production niches, like growing

pigeon pea into different cropping systems like wheat, rice, even sugar kane intercropping. So introduction of this super early pigeon pea in diverse cropping systems will not only generate additional income, but it also improves soil health and productivity. So as I was mentioning the traditional pigeon pea varieties are very medium duration to long duration, so they are able to grow only one crop in a year. But this is why we developed the super early so farmers will be able to take to two crops in a year. So that will add to the diversification and end up taking two crops in a year. So that will be an additional income for the farmers.

Hannah Senior: And you've also bred this to be a determinate crop - so maturing all at the same time - can you expand on that?

Anupama Hingane: So what is happening, this allows that all parts get mature...There is synchronized maturity. So that will actually ensure the timeliness of operations. And then that can be harvested mechanically as against the traditional varieties that are harvested manually, because pods does not get mature at one time. So farmers have to actually wait for a long duration to get all the pods mature, and then that has to be harvested manually. So development of this recent super early varieties has made it possible to grow pigeon pea in non-traditional areas, marginal lands and to fit in a narrow window of time between harvesting and planting of important cereal crops. So I think this is something very exciting. I'm looking forward to promote this, super early varieties in India, and globally now.

Hannah Senior: So with these super early varieties a farmer can have one crop of rice or wheat or something and then use pigeon pea as both a cash crop and soil cover - so the farmer gets another crop and enriched soil, and that's pretty amazing. And I know we mentioned this earlier - but you said you have managed to increase yield by over 30%. That's a really impressive yield increase! Talk to me about that, how you did it?

Anupama Hingane: We have different… Two approaches actually to increase the yield potential of the varieties, we can refer to it as the vertical expansion, and then can be

the horizontal expansion - to increase the production as a whole within the country. So for vertical expansion, of course our efforts are mainly for developing high yielding varieties, with resistance to all the major biotic and abiotic stresses. And developing varieties to agroecology. And then the second approach can be, as I mentioned, we have recently developed a commercially viable hybrid technology based on the cytoplasmic male sterile system. So these hybrids has a potential to yield around at least 30% higher than the commercial varieties. It's possible to grow… A bean insensitive to photoperiod and temperature can be grown in wider locations in non-traditional areas like with the wheat cropping system and the rice cropping system. So what will happen. So growing it in the non-traditional areas will help us to increase the production. So I think increasing the productivity can be one approach and increasing the production can be one approach. So I think both the approaches can help us to break this, yield stagnation to a significant level.

Hannah Senior: So then if this pigeon pea, which is drought resistant and the new high yielding varieties that can…Are super early maturation plants can be used on all the land that would otherwise be standing fallow between one crop and the next, That would massively increase the amount of pigeon pea that's produced. And, I wonder, is it possible for the market to absorb that quantity of pigeon pea, even if it were produced?

Anupama Hingane: OK, I missed to mention it earlier, like India is the largest producer of pigeon peas. More than 80% of pigeon pea area and production isn't from India. But at the same time, India is the largest importer of pigeon pea. India depends on Myanmar and Eastern Africa. African countries like Kenya, Mozambique, and Malawi to import pigeon peas. So we actually import around 0.5 million tons of pigeon pea annually. So I think considering the requirement, as I mentioned, it's a main source of protein for the vegetarian populations. There is a huge demand for this crop. Introducing this crop in the non-traditional areas and the post rainy season and the rice fallows, or even increasing the yield with the hybrid technology. I think we will be able to

meet our internal demand, and then we'll not be needing any more to import the pigeon pea from the other countries.

Anupama Hingane: Another thing is like, I think there's a lot of popularity nowadays about plant based meat. So as I mentioned, the pigeon pea has a high protein content, from a range of from 18% to around 30%. So that is an increasing interest for this… for this pulse to be considered for putting in protein extraction. So I feel like we become self-sufficient in this crop. There are several other possible opportunities to introduce this crop, this produce, globally.

Hannah Senior: Well, that all sounds really exciting. And so I guess the next question is what does the future look like in order to make that happen? Or *how* will all that happen?

Anupama Hingane: So the main effort is evolving these new plant types that has been to reduce the maturity duration to induce more synchronized development in terms of pod formation and to re-partition of this dry matter for that more of it will be diverted to the formation of the seeds. So that can be the focus of our breeding efforts going forward.

Hannah Senior: Tell me what is attracting your interest and energies at the moment?

Anupama Hingane: So recently at ICRISAT efforts have been made towards modernizing our breeding program. And that's what is attracting my interest for now to this initiative. To us this initiative, most of our machinery required to carry a breeding operations is upgraded. Then further, we have already digitalized all our breeding data. We now use tablets for recording breeding data, all our breeding activities from historic pedigree information, selection of patterns, making crosses, advancing nurseries, data analysis is entirely managed by our breeding management system. It's a breeding data management tool. So this has really helped me and my team to greatly enhance efficiency and accuracy, and also in taking the right breeding decisions. Further now we have lots of availability of molecular markers for the traits of our interests. So we are

deploying them in our breeding program to enhance the selection accuracy and in addition to this, recently we have also developed a rapid generation advancement facility at ICRISAT, and I'm really excited because, I think you are also aware, that traditionally to breed any variety, to reach to stage one, stage two, it at least requires eight to nine years to develop any variety. And considering the requirement to meet the ever increasing demand of growing population, climate change, we need to breed varieties faster.

Anupama Hingane: So I think the speed breeding and other modern techniques like marker assisted selection, genomic selection, I think we will be able to enhance the rate of genetic gains in our breeding program.

Hannah Senior: So tell me what opportunities do you see for the future?

Anupama Hingane: Okay - so a very interesting question as a pigeon pea breeder. I see that are huge opportunity for this unique pulse crop globally. Our rising global awareness about the meat impact on environment and overall health, alternative plant-based meat gain, like, skyrocketing popularity. And I see a huge scope for the pigeon pea going forward, considering high protein content, you know, up to 30%. A drought tolerant crop, a very hardy crop and so many users. And then already there has been an increasing interest in countries like Australia and USA. They have been approaching us to introduce this crop in their country. And I'm sure the day is not far when this pigeon pea will be recognized as a global crop than, rather than just being a crop of a specific country like India, Myanmar and eastern Africa.

Hannah Senior: Excellent. That feels like a really good place to leave it. Thank you very much for your time today, Dr. Anupama Hingane of ICRISAT.

Anupama Hingane:

Thank you. It was really, really exciting. I really enjoyed talking with you 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, please recommend it to your friends and colleagues and please help others in the plant science community to find it by rating this episode and subscribing to the series. I'd love to hear from you, if you want to suggest people you'd like me to interview. You can contact me on Twitter at PBSInt, or on Instagram at PBS_Int. Until next time, stay well.

[Theme music fades out.]