Course Name: I Think Biology

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Week:6

Lecture:32

W6L32_BT Cotton - Part 1 (Case study)

Hello and welcome to another lecture in the I Think Biology NPTEL course. And this lecture is on the applications of genetics, where I'll be looking at B.T. Cotton. So the outline for the lecture is given on this slide. I should mention that most of the material that I have used comes from the chapter on cotton in the I Think Biology textbook.

So in the first part, we will be looking at the history of cotton growing in India to provide some context for the lecture. Then we will be looking at the particulars of the cotton plant itself. So some botany and agriculture related particulars of the plant. After which we will be looking at improvements which have been made to cotton. And here we will be looking at two technologies. One is that of hybrid cotton, which you could say is more conventional technology to improve a crop. And the other one is that of recombinant technology where we will be looking at B.T. Cotton. And again here in particular, we will be looking at the actual technology of B.T. And secondly, we will be trying to assess the impact of B.T. Cotton on agriculture in India.

So the idea here is that we will use this as a case study in assessing a new technology. So giving you a background to this whole lecture, I will start with a brief history of cotton growing in India. And cotton has a very long history in India. There is evidence of cotton fibers being found at different sites in the Indus Valley civilization. So we know that cotton was being used for at least 4500 years.

And cotton has been the mainstay of India's economy for a long time. Certainly during the Mughal era, the global trade in Indian cotton was quite widespread and by some estimates it might have accounted for 25% of the global industrial output in that era. Shown on the right are examples of cotton fabric produced in India and you can see the high level of expertise we must have attained in producing such exquisite cloth. Some more examples of cotton growing in India. So on the left is a picture of women carrying cotton which has been harvested probably to the mills.

In the middle is a picture of a woman who was using a hand gin to extract lint from cotton seed which is the first step in the process to making cloth. And then on the right again we see a woman wearing some very fine cotton fabrics. Giving you some more

detail about cotton growing in India during the colonial era. So the British East India Company started trading in cotton which meant that they started importing Indian cotton cloth and then selling it for large profits in Europe and in England. And there was certainly a rage for Indian cloth because people recognized its superior quality.

And there are many anecdotes related to this. And the other aspect is that the colonial era coincided with the start of the industrial revolution in England. And one of the first developments in that was the invention of the cotton gin. So the cotton gin is basically a machine to extract lint or the cotton fiber from the seed. And since this was a machine which could be powered by steam, the level of lint extraction was much much faster than could be done by hand.

And the industrial revolution also led to the invention of different other kinds of machines which were used in the spinning and weaving of cloth. So here is an image of a milling machine in the mid 19th century. So all these different developments meant that the British could start producing cotton textiles on a much faster scale than had been done before. Because remember in India the textile production was all done by hand, whether it's the extraction of the lint from the seed or it's spinning into a fiber and then finally the weaving of the fiber into cloth. So as I said before the industrial revolution led to the development of this textile industry in England where they could produce cotton textiles on a much faster scale.

And here is an example of a cotton mill in England and you can see the very large factory which is being used to produce cotton cloth. Of course England had many such mills and we also had mills in India especially in Ahmedabad and Bombay. So of course because they were producing a lot more cotton cloth they needed to explore new markets for these products so they were looking at their colonies both in Asia, Africa and of course in America. And Indian farmers grew mainly two varieties, I mean two species of cotton which are Gossypium arboreum and Gossypium herbaceum and these are all short stable length cotton which means the length of the lint which is extracted from the seed is smaller. And the new machines which were being used required a longer staple length which could not be supplied by these varieties which the Indian farmers.

So what the British tried to do was they tried to replace these varieties of short staple length cotton which Indian farmers were growing with American varieties namely Gossypium hirsutum which is a long staple cotton. And they went to the extent of inviting plantation owners from the Americas to India in order to teach British colonial officers and Indian farmers how to grow this hirsutum variety. But it didn't actually take. So what happened was by 1947 we were still only growing arboreum and herbaceum with hirsutum providing only a small percentage of the total yield. But the other thing which happened was that we stopped producing textile and we only started supplying raw cotton to the mills.

The result of that was that you know it destroyed the spinning and weaving industry in India and it also led to the loss of biodiversity of the native species of Indian cotton because we had a large variety of different kinds of cotton but now we only started to

grow particular species which were most suitable for the mills. And then post-independence the government kind of continued with this program so there was a strong drive to grow high yielding varieties of all crops not just cotton. One was because we needed to grow more food for a burgeoning population and the other was that farmers could also get more income if they are growing more cash crops on their farms. And so with relation to cotton the government also concentrated on the cultivation of hirsutum varieties which is this long stable cotton. And then in the mid 60s with the Green Revolution coming on there was the production of hybrids of a variety of plants starting from food crops like wheat and rice to cotton.

And these hybrids grew well and they especially responded favorably to applications of fertilizers and pesticides which gave rise to increased yields. But what this did was that it changed the nature of cotton farming. So cotton farming became more capital intensive because these hybrid seeds also cost a lot and then you also had all these chemical inputs on your farm in the form of fertilizers and pesticides. So the farming of cotton became very capital intensive. So with that brief history before I move on to the next section let's look at a couple of questions.

So the first question is knowing this historical perspective does it change your views about the science which agriculture uses especially for cotton cultivation? And the other question is do you think it is important to know to have this knowledge of history about cotton cultivation in India? And the second question is what factors need to be taken into account when you decide which species or which strain of cotton you want to grow? And so is there always a balance which you would like to achieve between economics and the environmental impact a particular species might have? So I'll leave you to think about these two questions and we can also discuss them later.

So let's look at the cotton plant in particular. So cotton belongs to the Gossypium genus and the family is Malvaceae. It's also called as the hibiscus or mallow family. So hibiscus belongs to the family Malvaceae. And the Gossypium genus has 50 species. It grows naturally in the warmer parts of the world both in the tropics and subtropics. And it requires temperatures between 21 to 32 agriculturally to grow well. And it grows in all kinds of soils from alluvial soils to the famous black cotton soils which are used for cultivation of cotton in India. India has three main zones where cotton farming happens, the north, central and the south. And we are one of the major cotton producers in the world.

And four main species are cultivated for making fiber. So Gossypium hirsutum and Gossypium barbadense which are these long staple cotton. And then Gossypium arboreum and Gossypium herbaceum. So India is one of the few countries in the world where all four species are still being grown for the production of fiber. And along with that we are also producing growing hybrids, cotton hybrids.

So we still have some amount of diversity in the kinds of cotton we are growing. And actually we also produce certain naturally occurring species of colored cotton. So Indian farmers also grow a green cotton, there is a brown cotton and there is also a black cotton.

But of course these are grown in very small quantities compared to something like hirsutum.

Here are images of flowers from the mallow family. And on the left is the cotton plant, Gossypium arboreum. And you can see that the flowers are very showy and they have this kind of umbrella shape with a central spot right at the center. And then you have the stile and anthers emerging from there. And the leaves also have a lobed appearance. On the top right is another plant from the mallow family.

This is a hibiscus and this occurs naturally if you perhaps go hiking in South India you might find it growing on some rocky outcrops or even along the side of a road. And then at the bottom right is a plant which all of us know well because we eat it. This is bindi and bindi also belongs to the mallow family. And again you can see that looking at the flowers, the similarity between the flowers and also the similarity in some of the leaf shapes. So as students of biology when we come upon botany with all its terms we should also try and look at certain patterns so that we start to recognize how these terms allow us to focus on these patterns.

And allow us to recognize perhaps organisms within the same family or maybe sometimes the same genus. So here are the botanical names of these two other species. Focusing more on cotton, here are two species of cotton, hirsutum and arboreum. And again you can notice that the shape of the flowers is very similar. And the leaves are lobed in both cases but the depth of the lobes are different for both the species.

Looking at the cotton plant in more detail on the left is an image of the flower with the parts all labeled. So you will recognize and be familiar with most of these terms. If you're not you can take pause the video and study these parts in more detail. Then on the right is shown the branching pattern of a cotton plant. So the cotton is actually a tree but we tend to grow it as a shrub.

And the pattern of growth is that it has a monopodial stem which means, a monopodial just means single axis. And the growth is indeterminate which means at the terminal point it can keep on growing. And arising from the main stem you have a number of other branches produced in a spiral pattern. And then you have these sympodial branches. And these sympodial branches have a terminal bud which ends in a flower.

Then it has another bud on which is produced a leaf. And then it has a third axillary bud which gives rise to the next sympodial branch. So if you look at a single branch for a cotton plant, the flower which is closest to the main monopodial stem will be the oldest flower. And the flower which is at the very top, at the very tip will be the youngest flower. And this has a lot of importance because a. farmers want to maximize the number of branches that a particular plant produces because you will increase the amount of cotton that plant will produce. And also the timing of this branching is important so that the flowers which are at the bottom should ripen the first and the flowers which are at the top should ripen the last. So that there will be a picking schedule which you can use. And here is a timeline of cotton right from the seed to getting a mature cotton boll. So it takes about five and a half months and all the various stages are shown.

And finally let's look at the part of the plant which is most important to us which is the cotton fiber. So the cotton fiber is actually a single cell which emerges from this epidermis of the seed. Right? And these are some of the longest cells in the world and they can be up to three centimeters or longer in the case of Gossypium hirsutum. So it's amazing to think about a single cell which is that long. And the cell has three different layers. The outermost layer is called the cuticle. Then there's a primary wall and the secondary wall. And the secondary wall is almost exclusively made up of cellulose. And the inner lumen is hollow and flattened. And on the right is shown a scanning electron micrograph of a bundle of cotton fibers.

So you can see that it has this kind of flattened appearance with a natural twist to the fiber. Another aspect which is important to know is what are the pests of cotton. So cotton can be attacked by a wide variety of pests. But there are two main types, sucking pests and bollworms. Within that bollworms are lepidopterans and in the caterpillar stage they burrow into the cotton boll.

And then later on they will emerge as moths from there.But what they end up doing is they destroy the cotton boll which is the main part of the plant that we are interested in. And in India two species in particular are important which is the American bollworm. And the pink bollworm. So with that ends the first part of this lecture. And in the second part we will be talking about hybrid cotton and B.T. cotton. So see you in a little while. Thank you.