Legal and Regulatory Issues in Biotechnology
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Module - 01
Regulation of Biotechnology Research
Lecture - 01
Biotechnology product development cycle and critical issues

Hello all, welcome to the 1st module of the course Legal and Regulatory Issues in Biotechnology.

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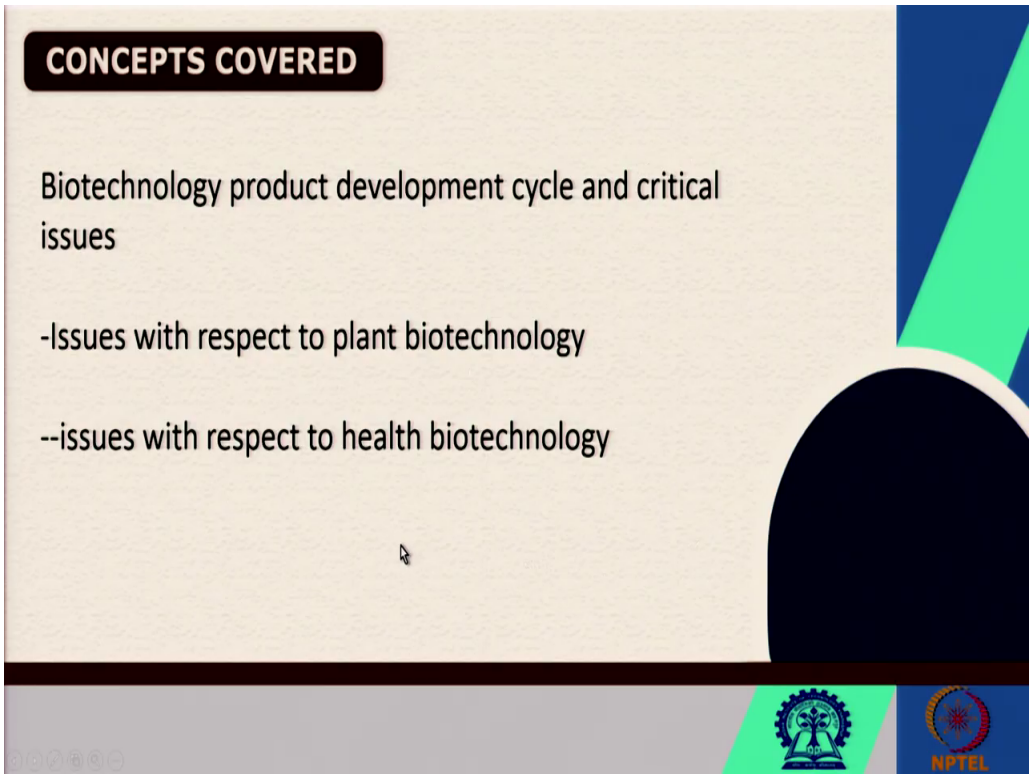

In this course, I will like to cover the introductory part regarding the concept of biotechnology product development and the major challenges associated therein. So, as we know the biotechnological product may range from anything which is, anything which is coming out of the plant or animal or any microbial organisms.

And the major products are GM food crops and biopharmaceuticals and various bio-industrial, chemicals or metabolites and there are many. But, majorly I would like to deal with the issues with respect to plant biotechnology as well as the issues and challenges related to the health biotechnology sector, also in between, I would like to cover some aspects of animal biotechnology as well.

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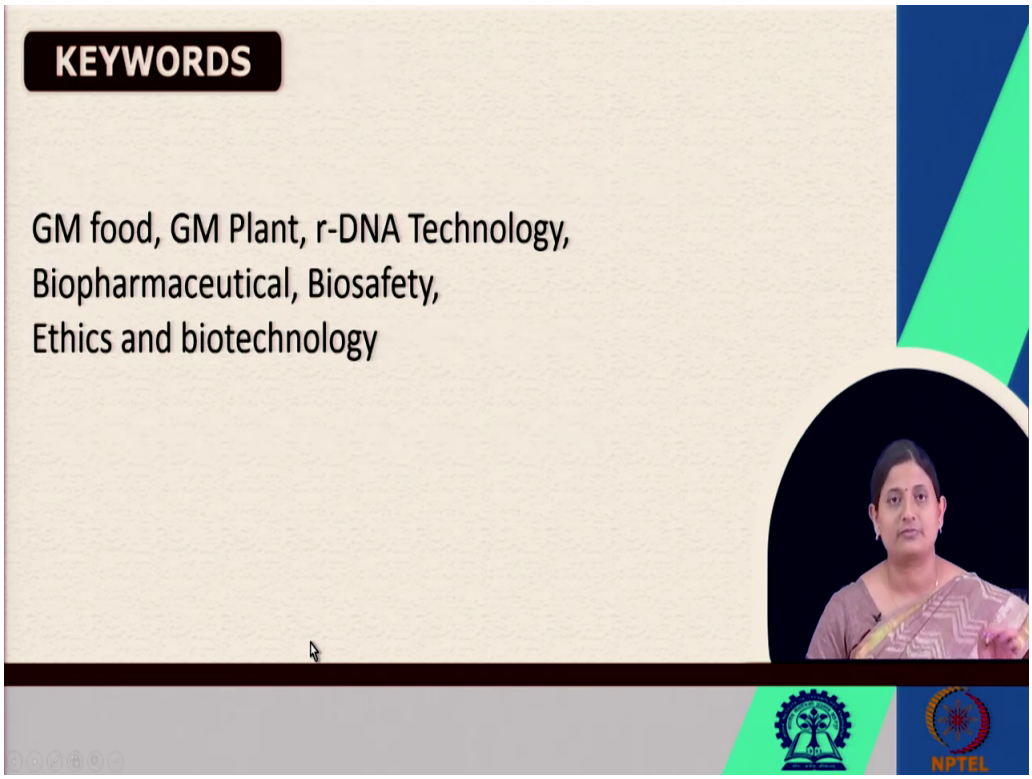

So, these are the few keywords, which you would be hearing throughout this lecture.

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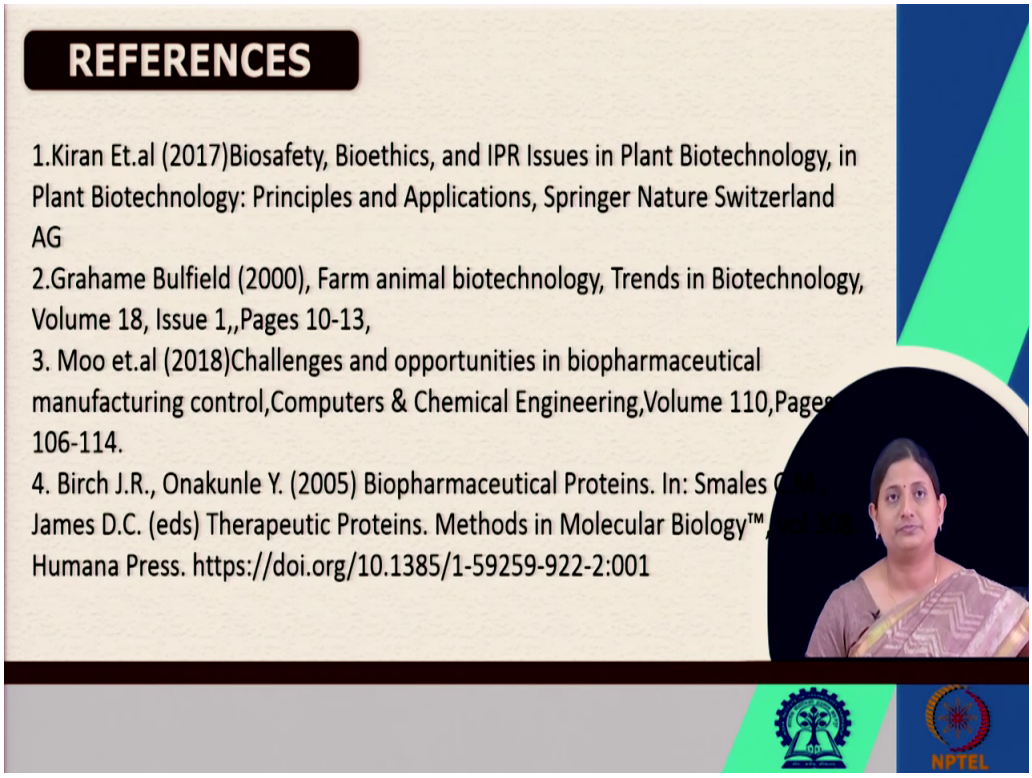

And a few of the selected references.

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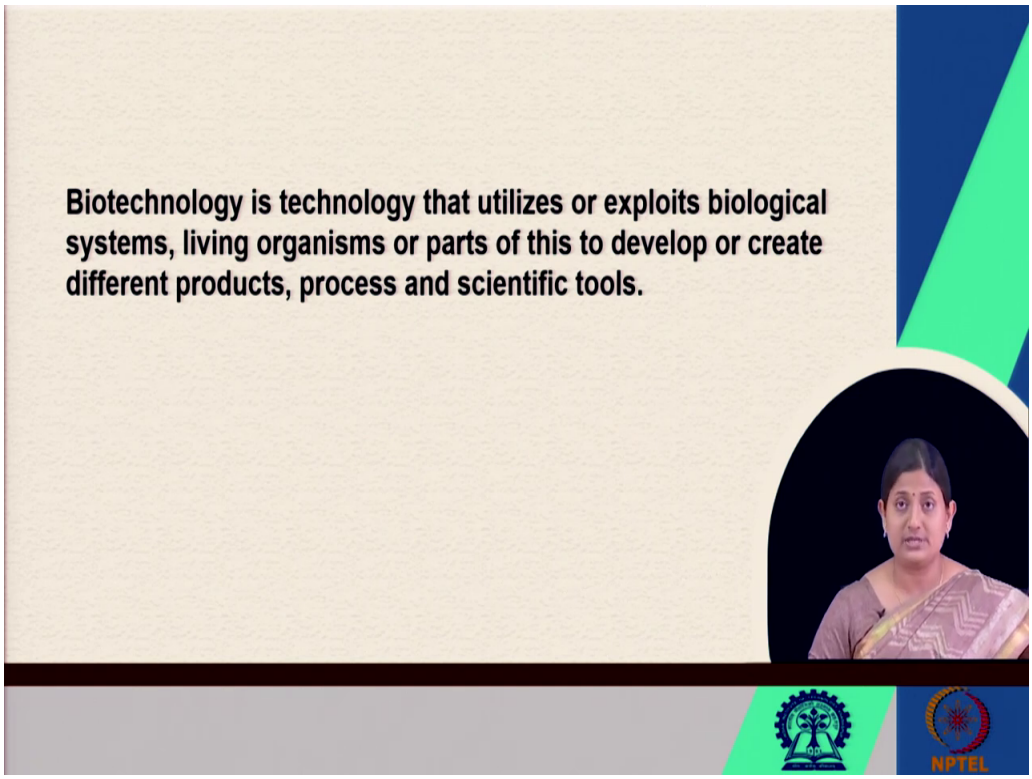

Now, coming to the concept or this topic of legal and regulatory issues in biotechnology; first of all, we have to understand what is biotechnology. As many of you might be knowing, biotechnology is a kind of technology, which involves the modification of living organisms. And this modification of the living organism may involve the smallest microscopic viral particles to bacteria, to plants or animals or even human cells.

Human cells may include the normal somatic cells or embryonic cells or stem cells. So, any modification of the cell, where after the knowledge of genome sequence or when for the first time in the history we understood the composition of the DNA, RNA and the genetic material inside our body; thereafter the science, the biological science, the science of genetics and all that are moving forward.

Particularly in the 1970s, when for the first time the recombinant DNA technology was invented or developed, wherein a foreign DNA from any other living organisms can be inserted into a target individual and that may lead to the development or secretion of the desired protein.

So, after the development of recombinant DNA technology, biotechnology has grown like anything. And the utilization of biotechnology is not only restricted to only any aspect of the pharmaceutical product; no, it has multiple usages.

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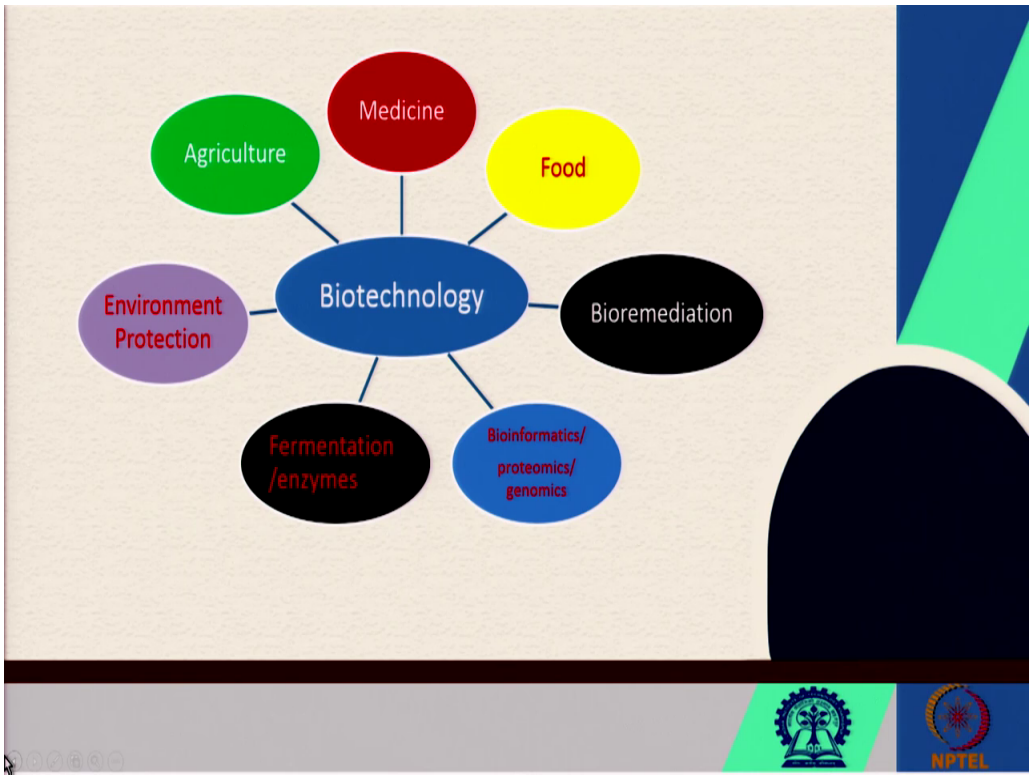

So, if you see, in the last five decades we are seeing a number of technological miracles or technological developments, where biotechnology is particularly applied with respect to agriculture, with respect to medicine, with respect to food, with respect to environmental protection or degradation of certain carcinogenic or pollutants in the environment and development of certain metabolites or development of enzymes, which may be used in various industrialized process.

The amalgamation of biotechnology with information technology has given a new dimension of bioinformatics, genomics, proteomics etc. So, this biotechnology has become interdisciplinary in nature, leading to the development of a number of products; not only products, but now, through this biotechnological process, we are developing products, we are developing different processes, we are also developing various scientific tools, which are being further utilized for new kind of research and developments.

So, with so many usages, now the concern or the problem you may see with respect to biotechnology is that, as expected and as progressed, and as the research is progressing; we have not seen the products or we are not seeing that proliferation of the biotechnology in all the mentioned fields in every part of the world.

The development of biotechnology is very much concentrated in some countries, particularly as you know; developed countries have the facilities or have the resources to go with this high demanding research in the biotechnology, they are doing very good and some developing nations like India, China, Brazil they are also keeping up to the pace.

But somewhere given to so many usages, we have not seen those many products or those many things as desired or as it should be. The reason being, even though the biotechnological product has made and aims at making our life simpler, these products also come with certain challenges or risks or certain concerns; because it is a high risky research and development process through

which we are manipulating living cells or we are extracting a gene or we are modifying a gene and then putting it somewhere else and getting new products.

Somewhere the perception, that whether or not the product is safe to us, what kind of risk it may come with; whether proper measures have been taken before the product has come to the market or not, a number of questions are always associated with it.

So, therefore, biotechnological product development is always seen as a complicated process, where the regulatory requirements or the legal requirements are strictly followed and rightly so; because these are the products that are directly interfering with the human in terms of their medication or terms of with their food.

So, any alteration or any undesirable effect may cause a serious problem to human health. Therefore enough precautions are taken, enough safety studies or risk assessments are generally carried out before a biotechnological product is developed into the society or the market.

Now, having said that here I would like to take you through some examples in relation to plant biotechnology and health biotechnology, so that we can understand the challenges with the biotechnological product development and why we need the legal or the regulatory aspect to be properly followed.

And since many times it happens that, those who are in or who are from the biotechnological domain, do not get a chance to enter into the legal aspect of this technology or vice versa those who are from the legal domain when they are dealing with something related to the biotechnology since they do not have the scientific know-how, they find it little difficult to take both the science and technology together.

So, here in this course, I aim to bring these two fields quite close to each other, so that both the legal as well as non-legal persons can understand the challenges with respect to the biotechnology product.

And accordingly, they can plan properly; like for a technologist they can plan properly what may be the future hurdles or future challenges and the path has to be decided as per that, and for the legal person, yes we understand why and how that legal aspect or that regulatory aspect has to be followed if the technology demands so.

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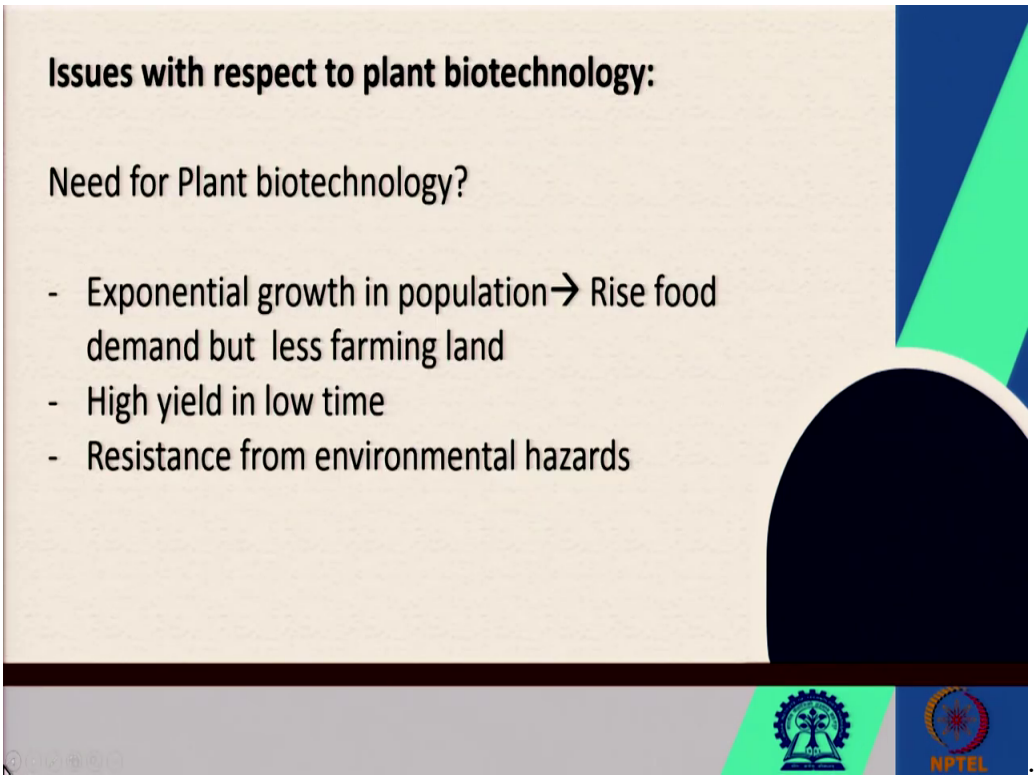

So, having said that, now let us start with plant biotechnology. So, what is this plant biotechnology? As mentioned already, biotechnology is a process where you modify or alter the genomic composition or the cellular constituents or other things related to the cells or the living organisms. But why do we need so?

So, as you know the population of the whole world is increasing with an exponential growth rate and it is estimated that by 2050 we may need 150 percent more food to cater for the need of all the humans on the earth. But the farmland or the lands are the same or even decreasing; the quality of the soil, the quality of the microflora, the nutrients and the climate conditions are also getting changed and that is why the productivity of the crops are also getting affected.

In 1970 we had the green revolution, whereby utilization of the various techniques and new high yielding seed varieties; we had met the challenges of the food somewhere, but again the demand is ever increasing. It is not only the food supply; but a good quality food supply, where at least the problems like malnutrition or the poverty or the children who are not getting food, can be met with the best possible way.

So, the simple solution is through the biotechnology, like through the biotechnological process you can create a high yielding variety or you can create a high yield in a low time and a kind of a variety, where these are resistant from the various environmental hazards; it may be drought resistant, it may be a heat resistant variety, it may be a temperature resistant or herbicide-resistant, pathogen-resistant varieties.

So, these are possible through biotechnology. So, plant biotechnology is serving as a tool for meeting the high rise, high food demand as it is coming by.

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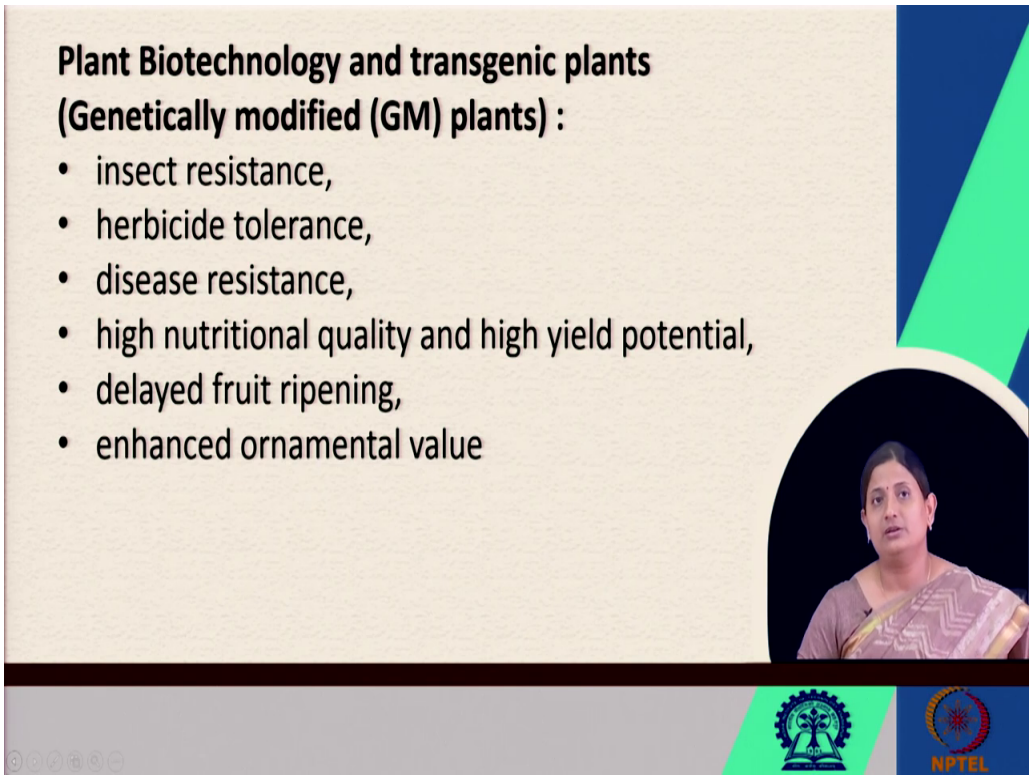

Now, this has led to the formation of genetically modified plants, which is popularly known as the GM ps, whole plant itself and the food, which we get from the GM crops is known as the genetically modified food or the GM food. So, the GM plants are of different varieties, like there are instances where insect resistance varieties have been developed, herbicide-tolerant verities have been developed, disease resistance varieties have as been developed.

Then food with high nutritional quality and high yield potential has also been developed. Then there are techniques by which the fruit ripening has been delayed or something which has s more ornamental value which increases the market potential of the product. Those kinds of things are also being developed.

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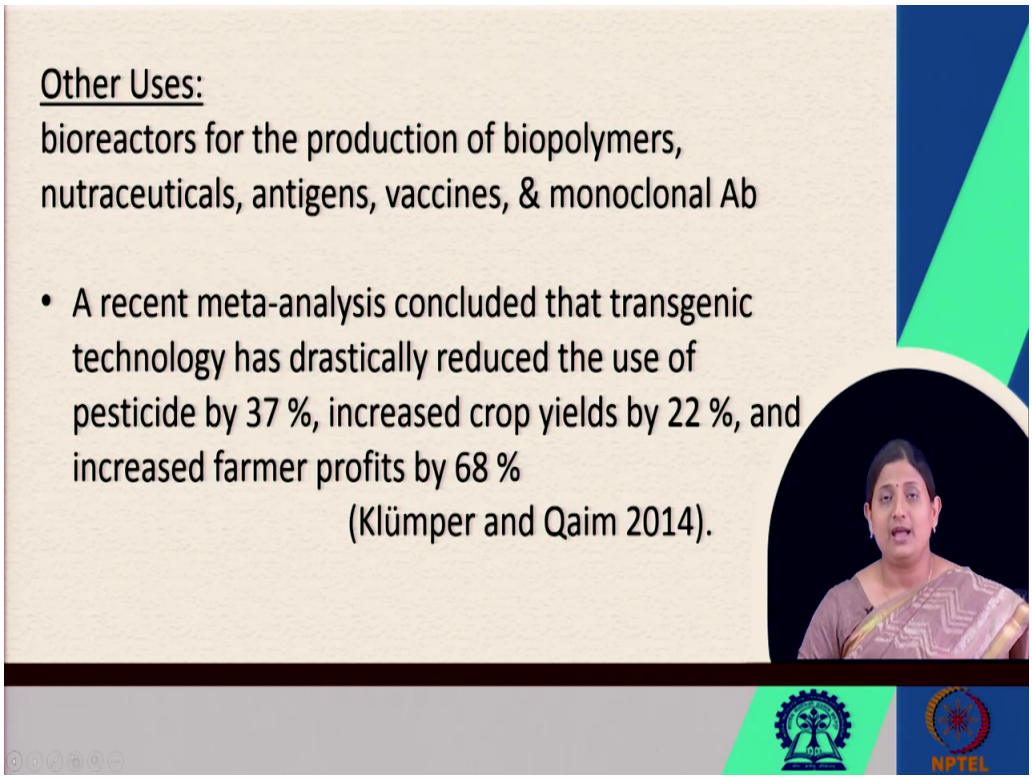

And if you see the other uses, now the plants are also acting as a bioreactor for the production of the biopolymers, nutraceuticals, antigens, vaccines, monoclonal antibodies, which is known as the farming, farming from the plants. So, the biotechnology research in the area of the plant is going in a positive direction.

And the studies have shown that the use of such technology, the transgenic technology where a gene from different variety has been incorporated into other variety has drastically reduced the use of the pesticide by 37 per cent and increased the crop yields by 22 per cent and also the farmers have got the profits by a margin of 68 per cent. So, you can see, the usage of the biotechnology process has helped the farmers in their growth.

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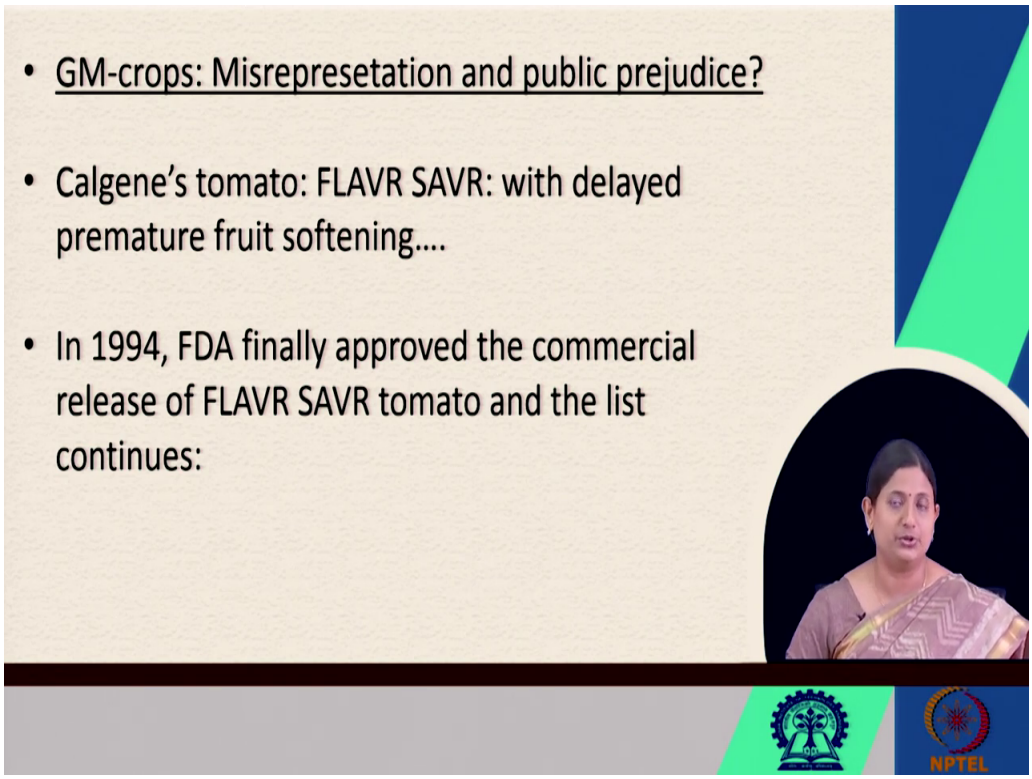

Now, again nothing comes for free, there are challenges. If there are profits and prosperity, there are also some kind of challenges in it. And particularly with GM crops, the challenges are with respect to the misrepresentation of the facts or kind of public prejudice.

So, to just simplify, I would like to give you one example of tomato variety, which is developed by Calgene and the name of the variety was FLAVR SAVR, where it has for the first time introduced a kind of a gene which delayed the fruit ripening for the tomatoes. Do you know, the self-life of the tomato depends on how tight the skin is. So, now the with this kind of technology, transgenic insertion; they have successfully created a variety where the premature food softening can be delayed.

But, when it was introduced in the European market, it came with a lot of prejudices; people were not sure whether this product is good for health or what kind of side reactions it may have. So, before the product came, even though it has been substantiated with the number of data; but still there were concerns among the general population, there were a group of NGOs who are against this GM crops or GM varieties.

So, finally, in the year 1994, FDA approved the commercial variety of this FLAVR SAVR. This became the very first example and after that number of recombinant GM products, recombinant products or GM crops has been introduced into the market.

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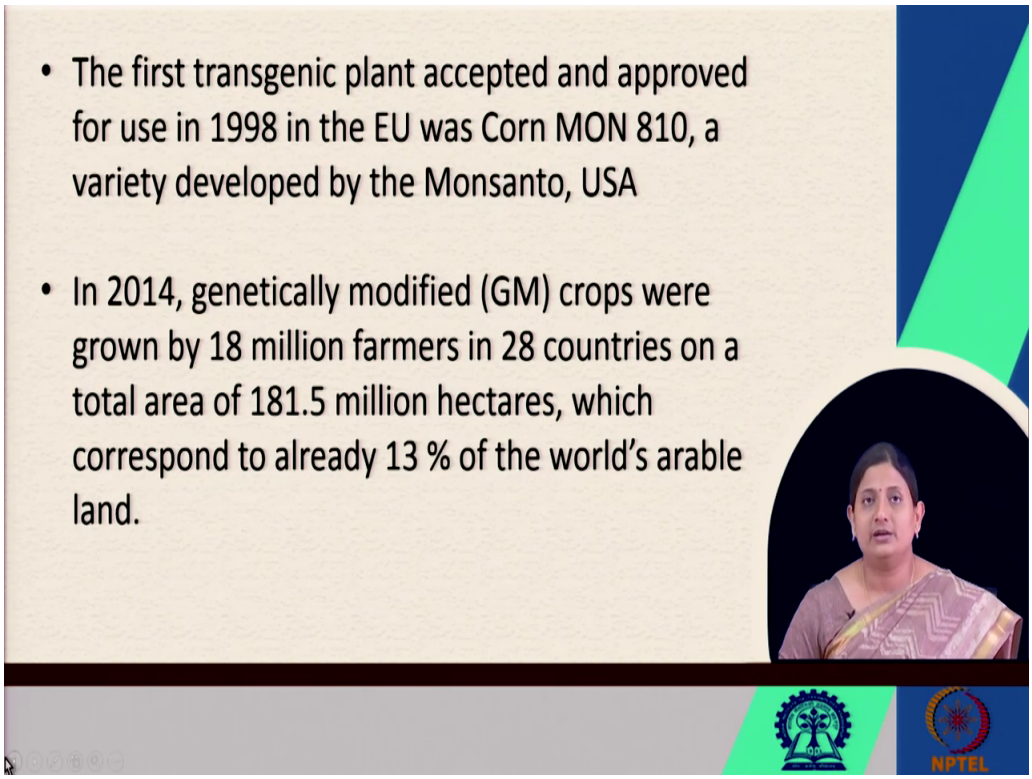

And the first transgenic plant which is accepted and approved for use was the Corn variety Corn MON 810, which was approved in European Union and was developed by Monsanto, A USA based company at that time. So, after that, there has been a number of genetically modified plants, which are being under development and have already been developed not only in developed nations but also in developing countries.

So, if you see the recent statistics, by 2012, the GM crops were grown by 18 million farmers in 28 countries and in an area of around 181 million hectares and which is basically around 13 per cent of the world's arable land. So, it is a good number, but still, we could have done more.

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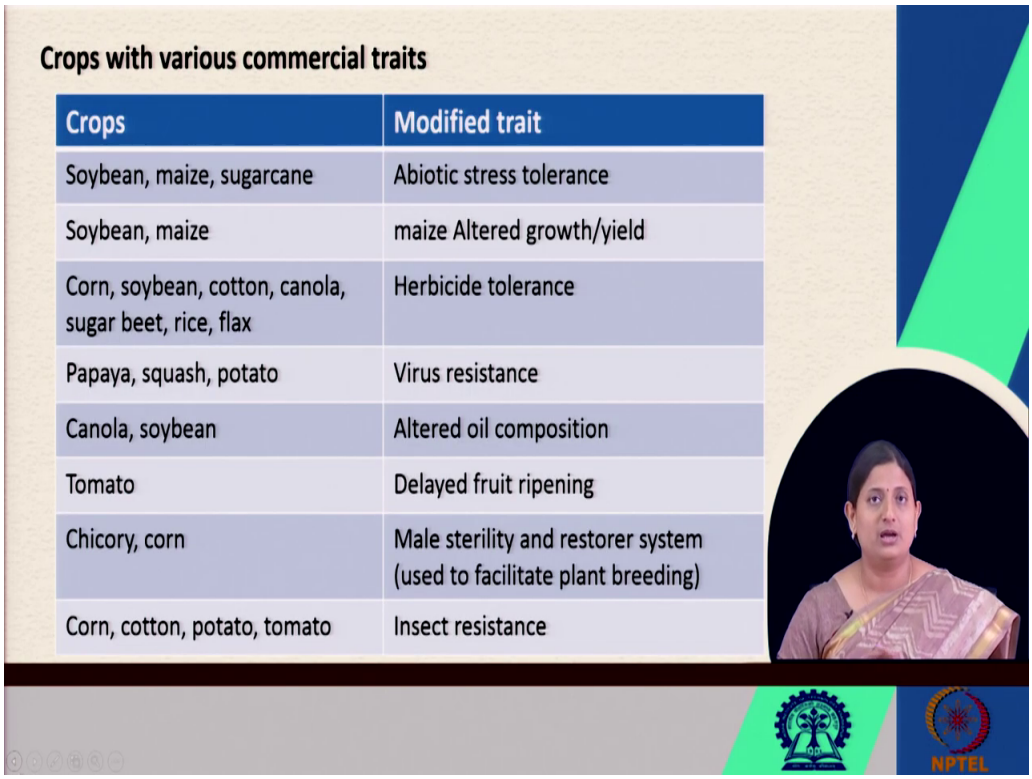

But again if you see the major crop varieties like soybean, maize, sugarcane, then canola, then papaya, squash, potato, different traits have been inserted in those varieties. Soybean, maize, corn being the staple food in many of the countries and highly used varieties have seen a drastic growth in the cultivation of those recombinant strains.

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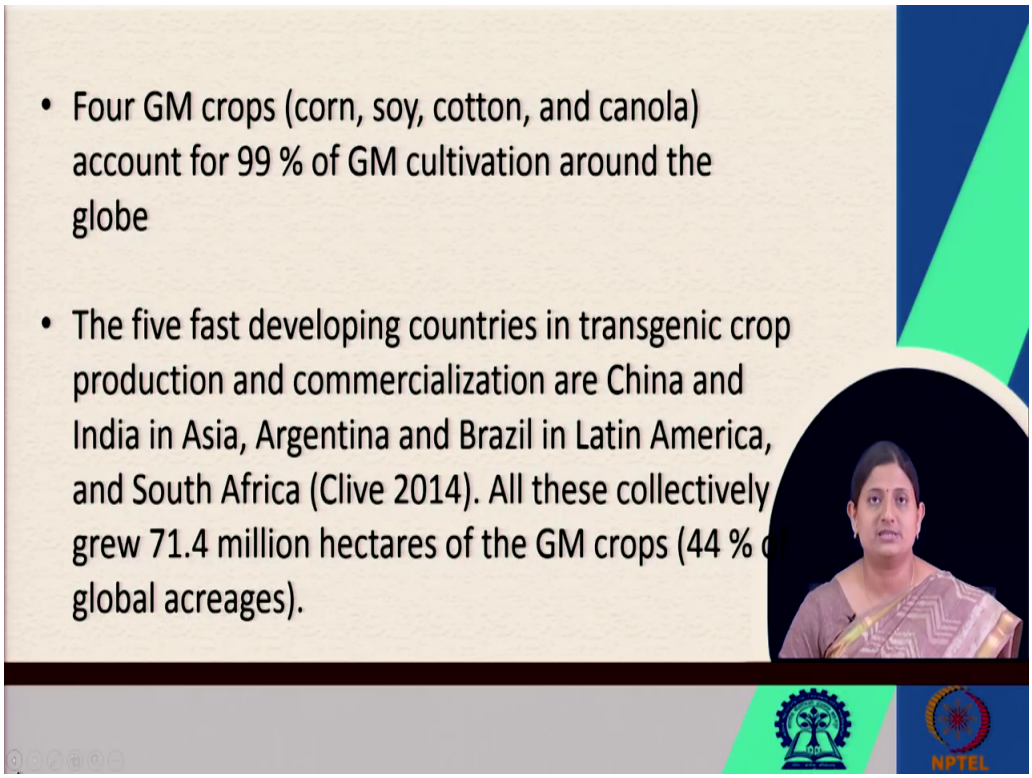

So, as I said, corn, soy, cotton and canola account for nearly 99 per cent of the genetically modified plant cultivation around the globe. And if you see the list of developing countries- India, China in Asia, Argentina, Brazil and South Africa; these are the developing nations that are moving fast with respect to genetically modified plants. And like all these five countries together they contribute around 44 per cent of the total cultivation of GM crops.

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Having said that, as I mentioned earlier, we are growing; but that growth is not as expected. So, given the benefits of the plant varieties which is reducing the use of pesticides or herbicides or where the problems like malnutrition can also be resolved; so the cultivation should have been expanded on a larger scale! But why we have not been able to do so?

So, if we try to compile the public fear or the problems with respect to the GM crops, we can have three reasons for it; first the apprehensions regarding the unforeseen human or animal health, like animal health hazard which may happen, then the apprehensions regarding the environmental effect, and the undesirable socioeconomic consequence. So, these are the three major reasons for which the GM plants have not been that successful or these are the challenges currently we are facing with respect to the GM crops.

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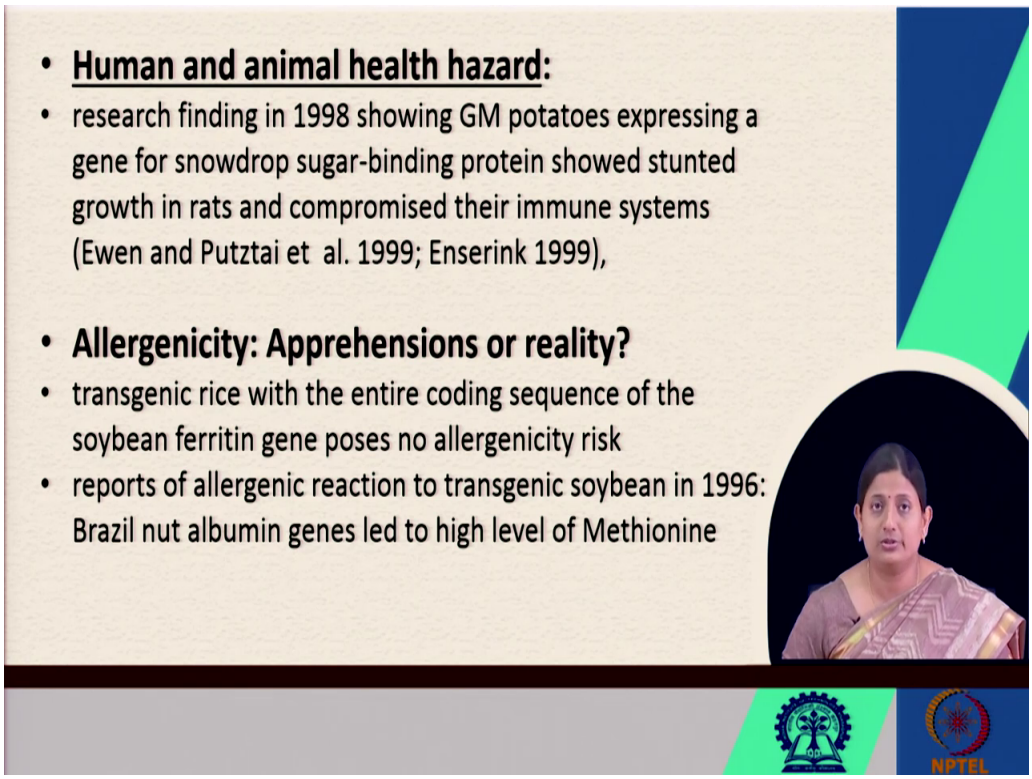

So, now what kind of human or animal health hazard is possible? Yes, biotechnology process yes you are inserting foreign DNA into a particular plant that is true. But again when such kind of plant is released to the market, the regulators do take care of the proper thing, proper risk assessment procedure to verify or establish that those plants or those modified traits are safe to use.

But sometimes it becomes difficult to judge; because you never know how it may react to the human body or the animal body. Like for example, in 1998 in one of the research showed that the genetically modified potatoes expressed a kind of a gene for snowdrop sugar-binding protein and which resulted in the stunted growth of the rats and compromised the immune system.

So, this kind of study created great fear in the minds of the consumers; though this is one of the studies which showed the negative effect, many other studies did not show that kind of effect. But still, the fear remained because, with the biotechnology process, we are trying to create something which has not existed in nature.

Manipulation of nature is not accepted wholeheartedly by all the strata of the consumers. So, this is one of the examples which had laid the number of arguments in, particularly European Union. Similarly, there are issues with respect to the allergenicity of genetically modified plants; there are instances where it has been scientifically proven that sometimes the expression of a particular character in a plant may lead to certain protein or certain molecules, which may result in the allergenicity of a particular individual.

And for example, there was a case where transgenic rice which was made with the coding sequence of the soya bean ferritin gene, have soon to poses the allergenicity risk. However, again there are limited studies; but in the instances of the transgenic soybean which was introduced in 1996, the Brazilian nut Albumin gene which was expressed in that soybean was soon to create certain immunogenicity reactions or allergenic reactions in the individuals.

When it was compared with the normal soybean, those individuals were perfectly fine; but when it was a modified variety, it had resulted in the allergenic reactions and which lead to the again like retrieval of that variety from the market. So, there are instances. So, it becomes very essential before a product is being released into the market that, to assess it properly; the risk assessment process or the safety assurance process for this kind of product is again very much crucial.

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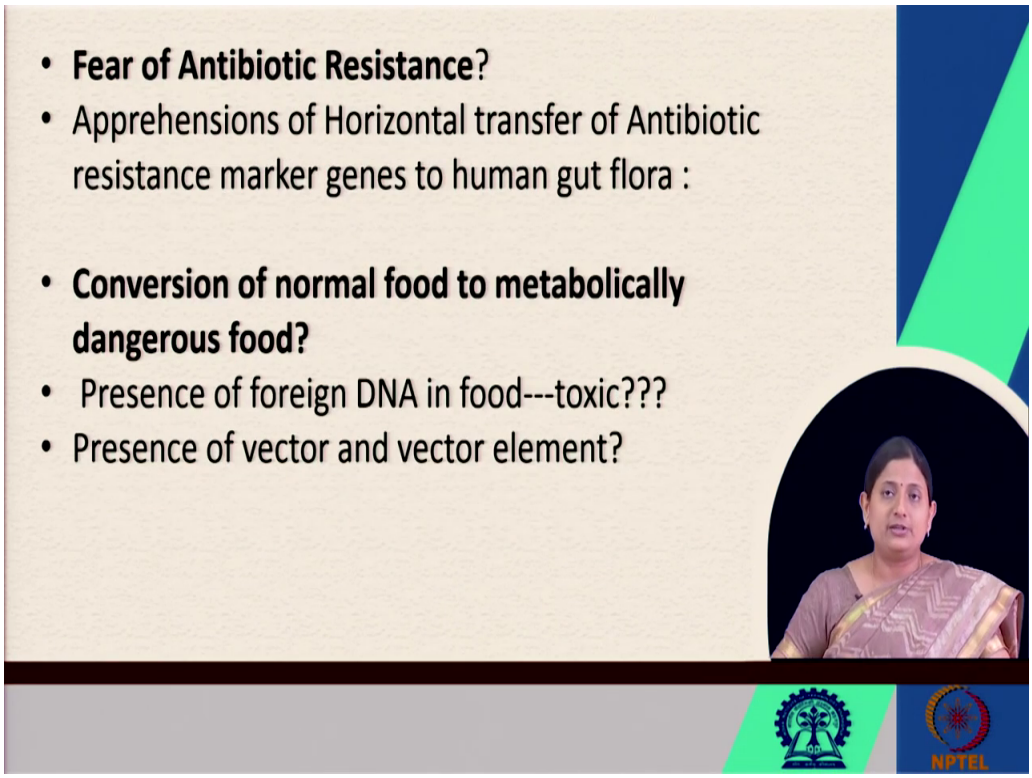

Another fear with respect to genetically modified crops is the fear of antibiotic resistance. In earlier times, people have shown apprehensions regarding antibiotic resistance in human beings or animals. What happens, during the development of these kinds of genetically modified varieties; the antibiotic resistance gene is used as the marker genes and those marker genes remain in that construct.

So, people have the fear that when we consume those kinds of the antibiotic-resistant gene, that might get transferred into our body, like through the horizontal transfer process. But again many scientists believe that this is not possible. And generally, the kanamycin or neomycin is the resistant genes that are used as the markers and which is generally available in the soil or sometimes in the other microbes also.

So, we humans, do not pose the threat to those kinds of gene transfer. But still, again that is a concern and it again creates a certain kind of fear in the minds of the public. And sometimes this 'genetically modified' plant or GM plant or GM food the name itself creates a fear again; whether the DNA, foreign DNA in the food is toxic to us or not, and how the other foreign vector or the vector element will react to our body. So, that apprehension is there which is again bringing it down.

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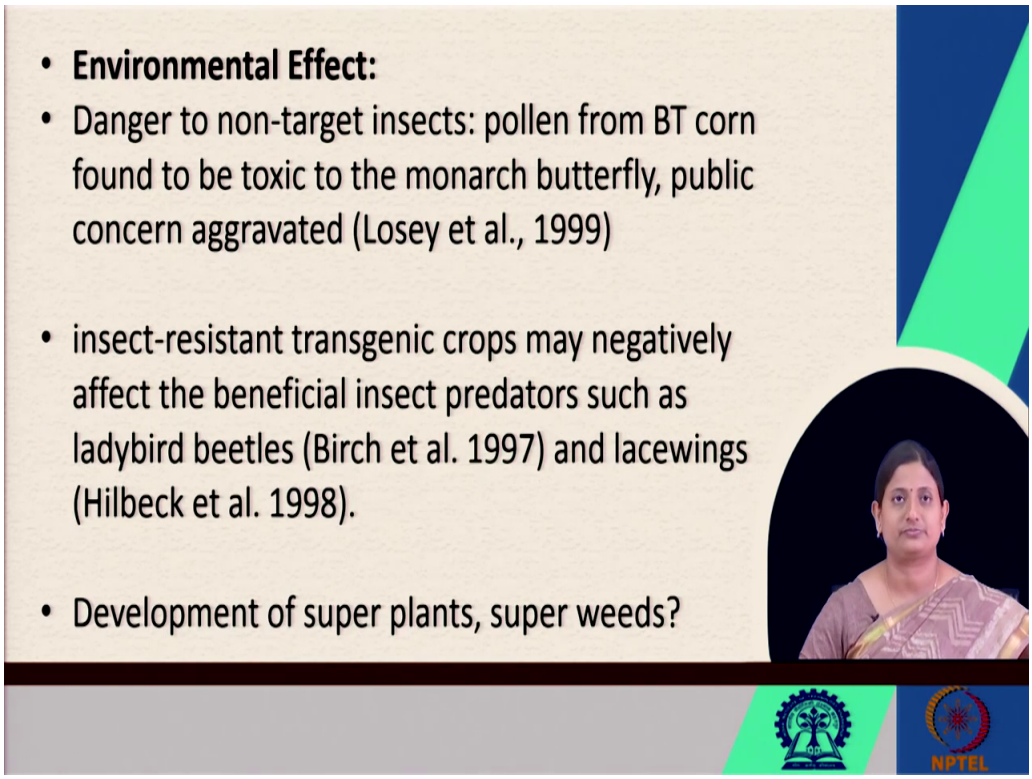

So, the first major issue is regarding the effect of the food on the health of the individual or the consumer; the second issue which comes with respect to the genetically modified plants is the environmental effect. When we are creating a variety, which has never existed on the earth; how will that affect our environment or the ecosystem.

That is a concern that has been again raised by many of the activists, especially the people who do not believe in this kind of technology. So, here is what happens, for example, in the case of the BT corn; the BT – 'Bacillus Thuringiensis'- is a kind of technology.

This BT gene when inserted into the cotton, it makes it resistant to a kind of pest, insect or lepida pet insect. So, it reduces the usage of pesticides; but, as per the studies the problem is that the BT corn while it has a desired effect on the target insect, but it has a certain undesired effect on the non-target insects.

For example, the monarch butterflies- it was seen that the monarch butterflies which peed on a particular tree when the pollens from this BT corn falls on that tree and monarch butterflies eat them. It was found that their larvae could not sustain that and it resulted in the decline of the population of the monarch butterflies in the area where the BT corn was cultivated.

So, while the study with respect to the BT cotton was being carried out, scientists have taken into the fact the target organism; but limited studies or no studies were performed with respect to the non-target insects. So, now it is an example that shows that genetically modified plants may have an undesirable effect on the non-target insect or any other animals in the ecosystem which may not be directly related to it.

So, it becomes important to particularly assess the risk-benefit analysis, of how the genetically modified plant will survive in an environment. And there may be instances where the transgenic crops may negatively affect the beneficial insect populations; like an example, this

ladybird beetles and lacewings, which are helpful in pollination or cross-pollination and other things.

So, they are preventing other kinds of the pest and helpful beneficial insects may also get affected by this. And there is another fear, that whether this kind of technology can have an undesirable transfer of the gene to maybe wild race that may result into a super plant or superweed, which again may have some effect which we do not foresee at this point of time.

Though the process of selection hybridization has been traditionally been used; but sometimes what happens, if there is a wild race and by cross-pollination or by some process, those genes are again transferred to the wild race, will that be a problem? So, we do not have a particular answer; it may be yes or it may be no, but again that is a risk or a concern for all of us.

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So, these are the few major issues with respect to the plant, GM plants. There are other issues like biosafety issues; how well they have been contained or the experiments have been taken in the field trial, so this is one of the issues. Moral perplexities like there is the technology called the GURT technology, where the terminator genes have been incorporated.

So, the terminator genes are the gene if, is inserted in a plant, the seeds will be unviable or infertile again. So, there are two issues with rest. first, can we stop the fertility of the seeds, so that the farmers who are cultivating them cannot re-sow them in the next generation?

But again it is an important technology in the sense that, issue of the cross-fertilization or development of the super plant or superweeds may be stopped. Because we are stopping it in one generation. In that way, scientifically it is a boon. But again can we accept this technology in a normal socio-economic environment, where the farmers depend on their seed produce from their land?

So, how that thing can be dealt with? There is a number of ethical dilemmas, scientific dilemmas, and technological dilemmas. Overall if you see in the area of biotechnology, the ethical dilemma takes the first place; but still, we have a number of issues with respect to plant biotechnology. So, surrounding all these issues, it becomes a challenge for the researcher or the company who is working on this biotechnology product.

So, to develop a product which is safe and effective as well approved by the compliances of the laws and the regulations, which are being developed by the regulators in the respective countries. This is all about the issues with respect to the GM plants. Now, in the next class, we will see what are the issues with respect to animal health and other things. So, thank you for watching this video. So, we will meet in the next class.

Thank you.