Soil Fertility and Fertilizers
Professor Somsubhra Chakraborty
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Lecture 41
Fertilizer Quality Control, Fertilizer Adulteration and Fertilizer Testing

Welcome friends to this new lecture of week 9 of NPTEL online certification course of Soil Fertility and Fertilizers. In our previous week, we have discussed about different aspects of organic as well as inorganic fertilizers. We have discussed in details about the manufacturing process, we have discussed several important fertilizer terms; we have discussed how to calculate the fertilizer requirement. So, in this week we are going to focus on fertilizer quality control, fertilizer adulteration and fertilizer testing.

How we can control our fertilizer quality? How we can check the fertilizer quality? How we can test our fertilizer and how we can, what are the what are the ways through which fertilizer alteration are going, fertilizer can be adulterated? And how to test the fertilizer we are going to discuss in this week. But, before that we are also interested to know about the fertilizer consumption status of the world as well as in India. We want to see what is the present issues of fertilizer application; what are the ways to mitigate those problems? And also we are going to see some important fertilizer terms like slow release fertilizer, controlled release fertilizer.

What are their uses we are also going to discuss? Why they are important given the soil, soil conditions? I mean there are different types of soil conditions and according to those variation of the soil properties, what are the important factors we should keep in mind while applying the fertilizers? We are also going to discuss in this week. So, our first lecture that is lecture number 41 will focus on this following concepts.

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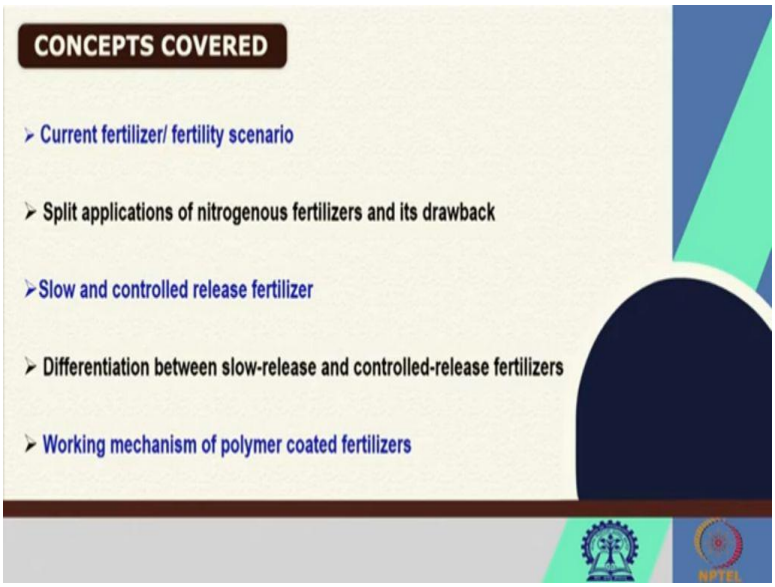

So, current fertilizer or fertility scenario, and then split applications of nitrogenous fertilizers and its drawback. And slow and controlled release fertilizer, then differentiation between slow release and controlled release fertilizers and working mechanism of polymer coated fertilizers. So, these are the concepts which we are going to cover in this lecture.

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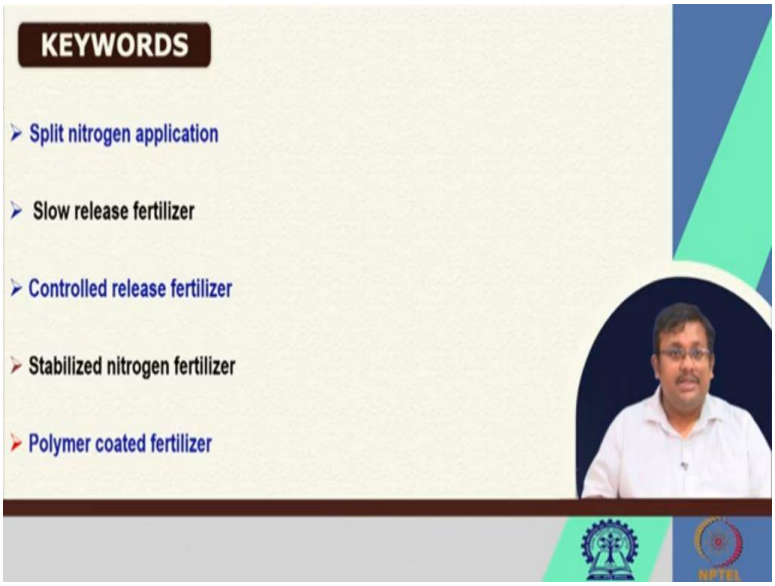

These are some of the keywords like split nitrogen application, slow release fertilizer, controlled release fertilizer, stabilized nitrogen fertilizer, and then polymer coated fertilizers. So, these are some of the keywords of this lecture.

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So, fertilizer application has initiated a huge progress in agriculture and that is why probably fertilizer revolution and fertilizer based increase in production has been termed as golden revolution. And subsequently fertilizer is called as a golden molecule. To improve the fertility of the soil and to increase the productivity, fertilizer has played a big role and which is undeniably very, we cannot we cannot deny its role. So, but we have to see the current status of fertilizer worldwide as well as in India; whether their consumption increase in consumption has increase in productivity continuously or not, or is there any other trends available?

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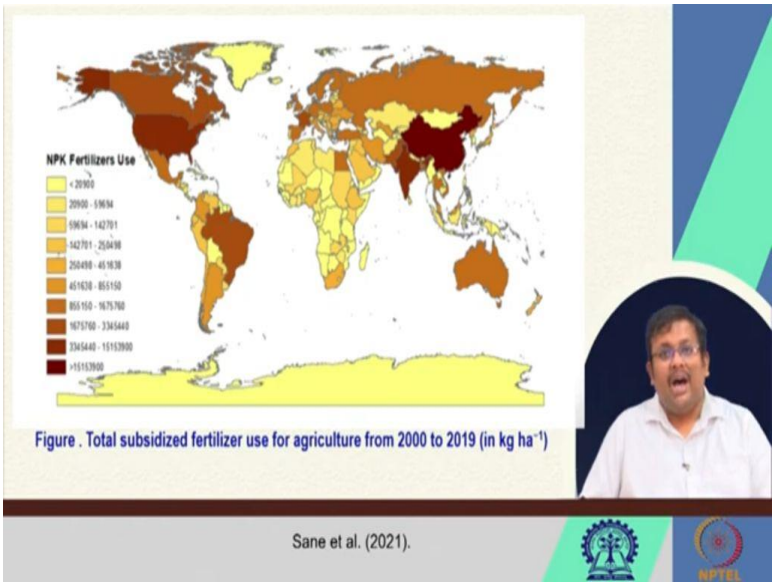

Now, if we see these worldwide NPK fertilizers use; that is this is remember that this is the scenario of subsidized fertilizer used for agriculture from the year 2000 to 2019 in kg per hectare. You can see the countries which are having the highest fertilizer subsidy are China; then you can see US or United States, and then Brazil, India. So, these are the countries where the use of subsidized fertilizer has been very high as compared to the other countries of the world.

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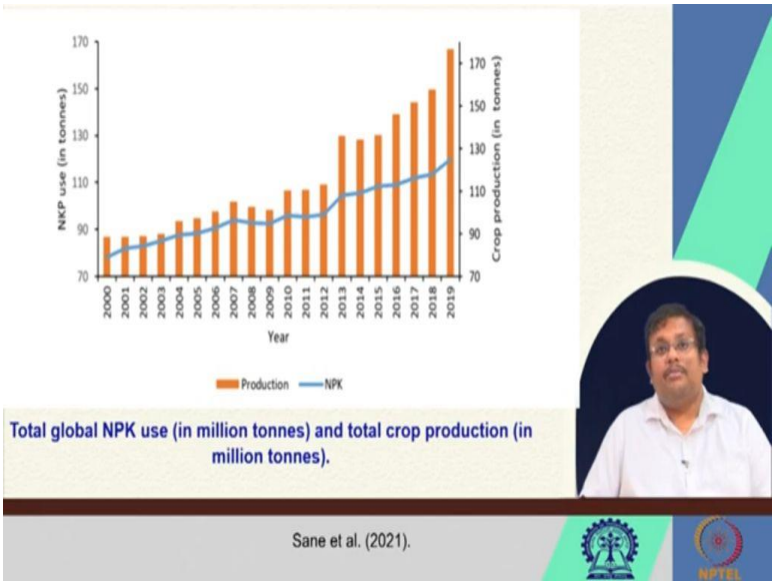

Now, if you want to see the total global NPK use in million tones and total crop production in million tones. From 2000 to 2019, you can see that there has been a steady increase in total production. Also we can see there has been a steady increase in NPK use that is NP and K fertilizer use in million tones from 2000 year 2000 to 2019.

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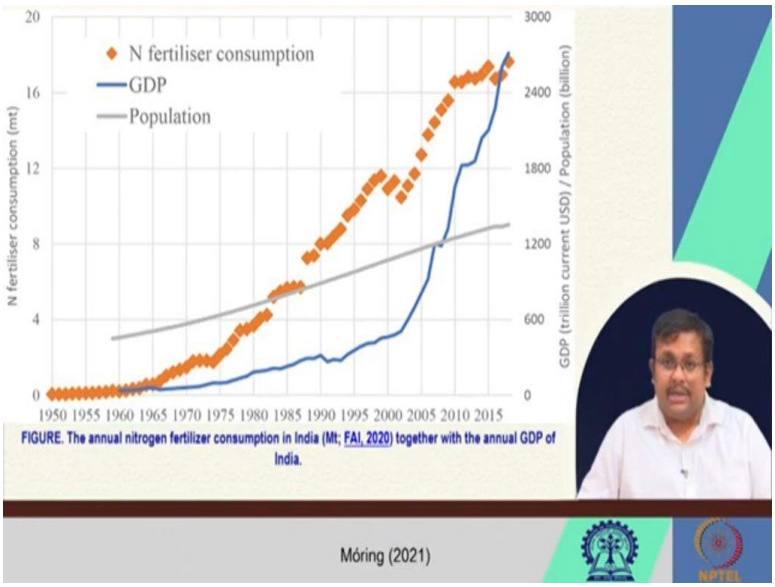

Now, also, from the Indian perspective, you see the annual nitrogen fertilizer consumption together with the annual GDP of India and population of India. You can see that as there is an increase in GDP, there is also an increase in nitrogen fertilizer consumption and also we can see there is a steady increase in population. So, it might be due to steady increase of population may may lead to higher production requirement and as a result, there may be higher nitrogen fertilizer consumption. And also maybe that lead to that leads to higher GDP. So, this is a condition of fertilizer consumption in India, specifically nitrogenous fertilizer.

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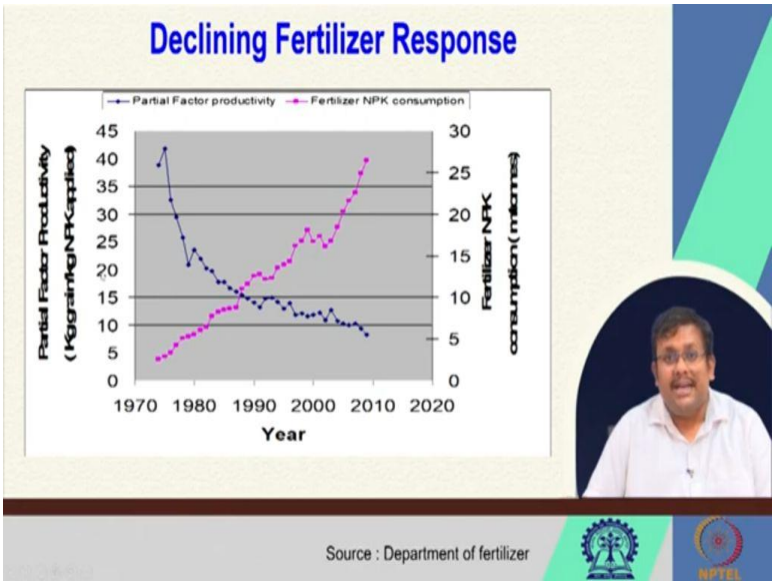

However, if we consider the overall scenario of the world, and if you consider the consumption of fertilizer NPK fertilizer; that means all the major micronutrients I mean

primary nutrients N, P and K, their fertilizer consumption from 1970 to 2010. And you can see also, you can if you if you check the partial factor productivity; that means kg of grain per kg of NPK applied. You can see there is a, there is an opposite trend. As you can see here from 1970 to 2010, as the fertilizer NPK consumption is continuously increasing.

The partial factor productivity that means, the kg of grain per kg of NPK applied is continuously diminishing. So, that means continuous use of this fertilizer can cause a deleterious effect in the natural productivity of the soil. And as a result, the kg of produce per kg of fertilizer consumption has gone down for last from 1970 to 2010.

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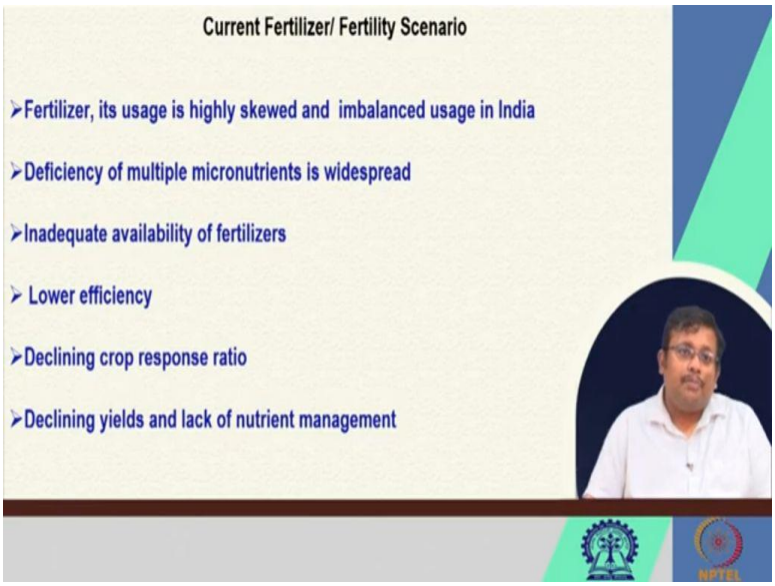

Now, if you see the current fertilizer or fertility scenario, you can see that fertilizer and its use is highly skewed; fertilizer use is highly skewed and imbalanced specifically in Indian condition. We can see deficiency of multiple micronutrients are widespread in India and the availability of the fertilizers are also quite inadequate. We can also see the lower efficiency of fertilizer elements, and then declining crop response ratio, and declining yields and lack of nutrient management. So, these are the major problems as far as the as far as the Indian soil fertility is concerned, and fertilizer application is concerned.

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So, what is the way forward? So, we need to do more research innovation, and promotion, and marketing of water soluble fertilizers. Fortified fertilizer, we have already seen some fortified fertilizer in our last week of lectures; for example, zincated fertilizers, boronated fertilizers we have seen. Then, also customized fertilizer, then slow and controlled release fertilizers, organic fertilizers; either they are liquid fertilizer or concentrated organic fertilizers; microbial fertilizer or bacterial inoculants; then soil amendments or additives and nano fertilizers.

So, these are the need of current agricultural practices and we are going to focus on specifically on slow and controlled release fertilizer in this lecture.

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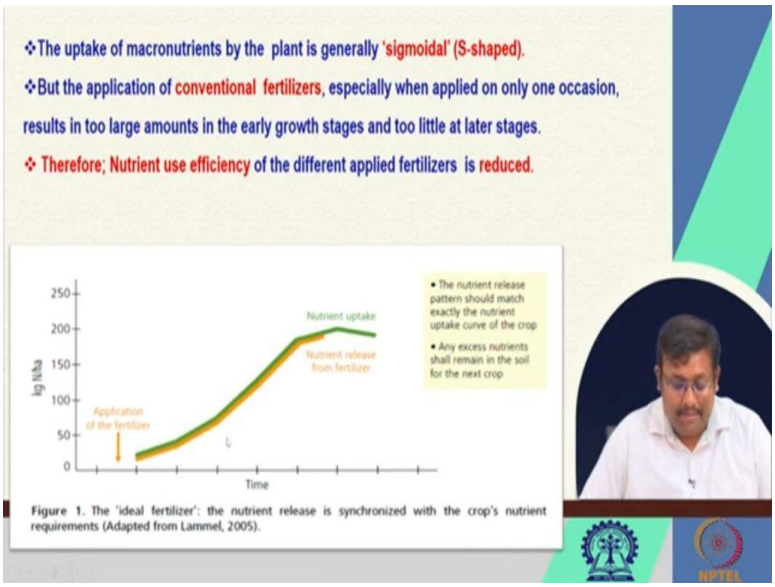

Now, if we see the uptake of macronutrients by the plant, it is generally sigmoidal or S-shaped. So, you can see that when we apply the fertilizer; so, in the x-axis this time and the y-axis it is nutrient uptake. So, this green line is showing the nutrient uptake. So, as the time progresses, the nutrient uptake is continuously increasing. However, the application of conventional fertilizer especially when applied on only one occasion here, results in too large amount in the early growth stages, and too little at the later stages of the growth.

Therefore, these nutrient use efficiency of the different applied fertilizer is reduced; because we are applying the fertilizer conventionally at one time. However, our fertilizer requirement or fertilizer nutrient uptake by the plant generally, generally takes a sigmoidal form or it is a form.

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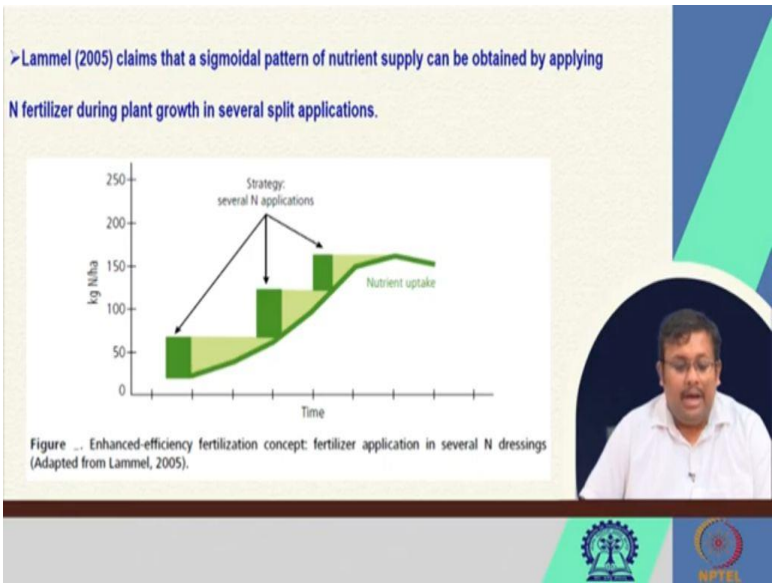

Now, Lammel claims that is sigmoidal pattern of nutrient supply can be obtained by applying nitrogen fertilizer during plant growth in several split applications. So, he suggests that if we apply the nitrogen at different splits; so one split is here, second split is here, and third split is here. These individual split will cover a portion of this sigmoidal curve of nutrient uptake. So, this split application can take care of these nutrient uptake as far as the nitrogen fertilizer is concerned.

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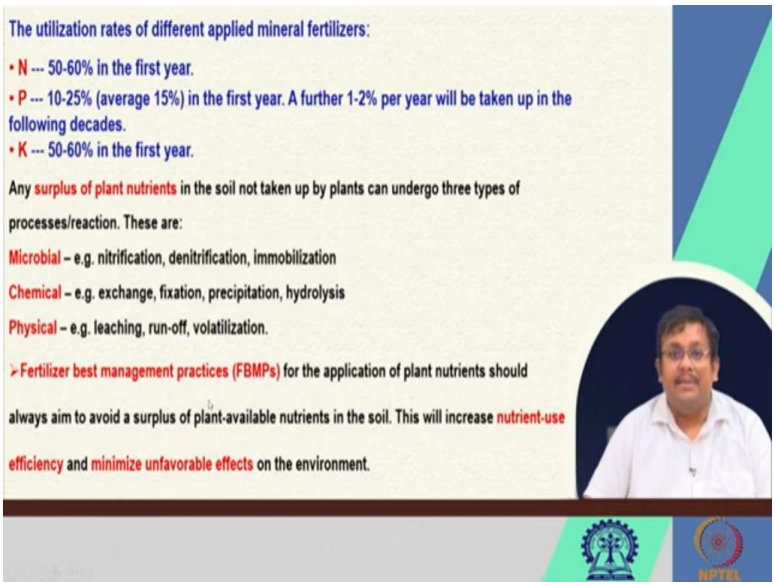

Now, the utilization rate, if we see the utilization rates of different applied mineral fertilizer; we can see in case of nitrogen 50 to 60 percent generally utilized in the first year. In case of phosphorus phosphorus 10 to 25 percent, average is 15 percent in the first year. A further 1 to

2 percent per year will be taken up in the following decades. And in case of potassium, 50 to 60 percent generally is taken up in the first year or utilized in the first year. Now, any surplus plant nutrient in the soil, not taken up by the plants can undergo three types of processes or reactions.

What are those? Microbial processes like nitrification, denitrification, or immobilization. Chemical processes like exchange, fixation, precipitation and hydrolysis and physical reactions like leaching, physical process like fill leaching, run-off and volatilization. So, to counter balance these loss of nutrients which are not being used by the plant, we need to use the fertilizer based management practices. Now, fertilizer best management practices for the application of plant nutrients should always aim to avoid a surplus of plant available nutrients in the soil. And this will increase nutrient use efficiency and minimize unfavorable effects on the environment.

So, these are the need of the hour. And we should always; we should always follow these fertilizer best management practices to increase the nutrient use efficiency.

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But, at the same time when you consider the split application of the nutrients, there are certain drawbacks of split application. First of all, multiple application when you go for multiple application that increase the cost of application or the total cost of operation. It can increase the fuel consumption and also it can increase the traffic and labor. Sometimes surface application also become inefficient due to volatilization and immobilization losses and they sometime remain on the soil surfaces.

And finally, there is a lack of foliar uptake; so, these are some of the drawback of split application. Soil application sometime also make may cause damage to the crop. And when we go for the split application that can enhance the risk of missing the proper window of application, if there is a time lag; so these are the drawback of split application. So therefore, there is a demand for a ideal fertilizer. Now, what is an ideal fertilizer? An ideal fertilizer should have a minimum three following characteristics. First of all, a single application should supply enough nutrients throughout the entire growth season to meet the plant demand for optimum growth.

Secondly, a maximum percentage recovery should be there to achieve the most significant return for the cost of the input. And thirdly, minimum detrimental effects should be there for soil at water and atmosphere. So, these are the three major characteristics of an ideal fertilizer.

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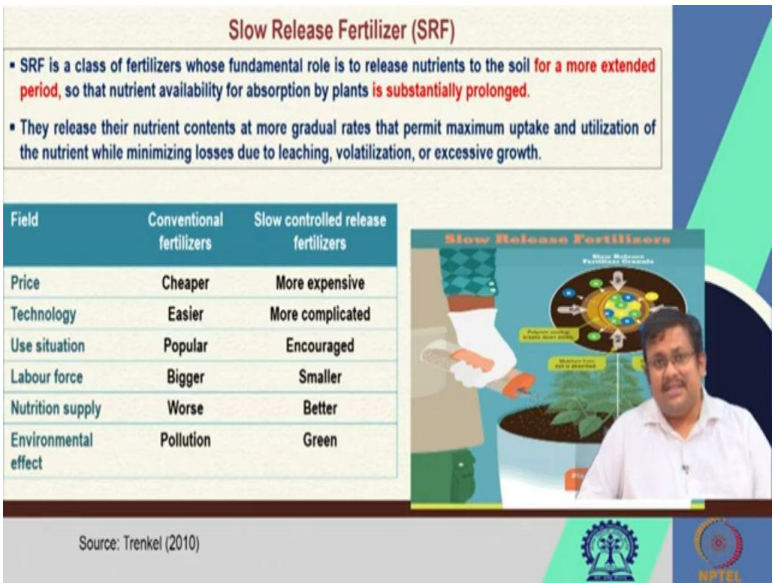

Now, let us discuss two important concepts; one is slow and controlled release fertilizer. So what is slow release fertilizer? Slow release fertilizer is a class of fertilizers, whose fundamental role is to release nutrients to the soil for a more extended period; so that nutrient availability for absorption of plant by plant is substantially prolonged. So, the slow release fertilizer generally release the nutrient for an extended period in a reduced rate than in normal condition; so that the the availability of these nutrients for plant absorption can be enhanced.

So, these slow release fertilizer release their nutrient content at more gradual rates that permit maximum uptake and utilization of the nutrient, while minimizing losses due to leaching, volatilization, or excessive growth. So, when there is excessive amount of nitrate, for example, that can leach down; so we can lose some amount of fertilizer element. It can release due to volatilization; or there maybe loss of nutrients by excessive growth, we do not require that. So, we require slow release fertilizer. Now, what are the differences major differences between these convention fertilizers and slow control release fertilizer?

So, the conventional fertilizers are relatively cheaper than slow and controlled release fertilizer, because they are more expensive. Technology for conventional fertilizers are easier; however, for slow release fertilizer, it is more complicated. Use situation for conventional fertilizer is popular; however we always encourage the slow control release fertilizer. Labor force is higher, labor requirement is high in case of conventional fertilizer. However, in case of slow release fertilizer (liquire) labor requirement is less. Nutrient nutrition supply is worse in case of conventional fertilizer this a major point.

And in case of slow release fertilizer, it is relatively better. As far as the environmental pollution or environmental effect is concerned, conventional fertilizer can cause pollution.

However, slow release fertilizers are environmental friendly. So, these are the differences between slow release fertilizer and conventional fertilizer.

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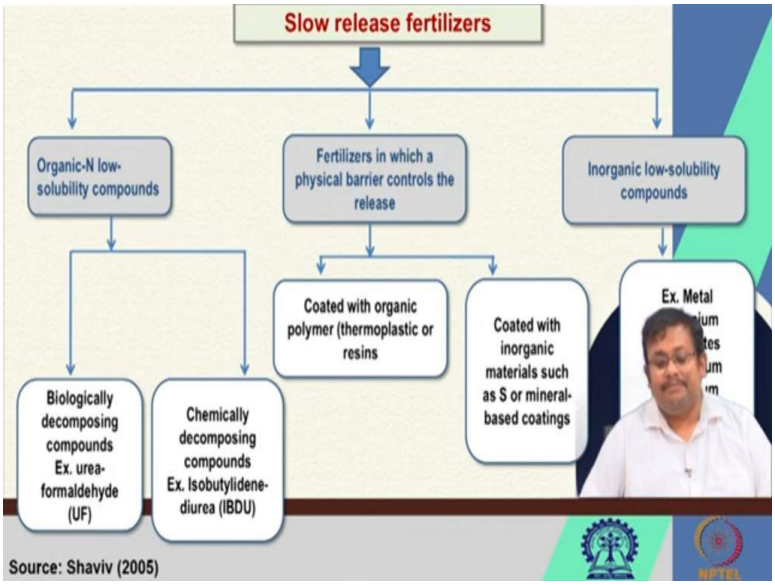

Now, if we see the subdivision of slow release fertilizer, we can see these are the major divisions. Organic nitrogen low solubility compounds, which are further divided into biologically decomposing compounds; for example urea formaldehyde or UF. And then chemically decomposing compounds like isobutylidene-diurea or IBDU. And second category is fertilizer in which a physical barrier controls the release. For example, the first one is coated with organic polymer. For example, thermoplastics or resin and coated with inorganic materials such as sulfur or mineral based coatings.

And third is inorganic low solubility compounds; for example, metal ammonium phosphate; for example, magnesium ammonium phosphate, and partially acidulated phosphate rock. So, these are the different types of slow release fertilizers.

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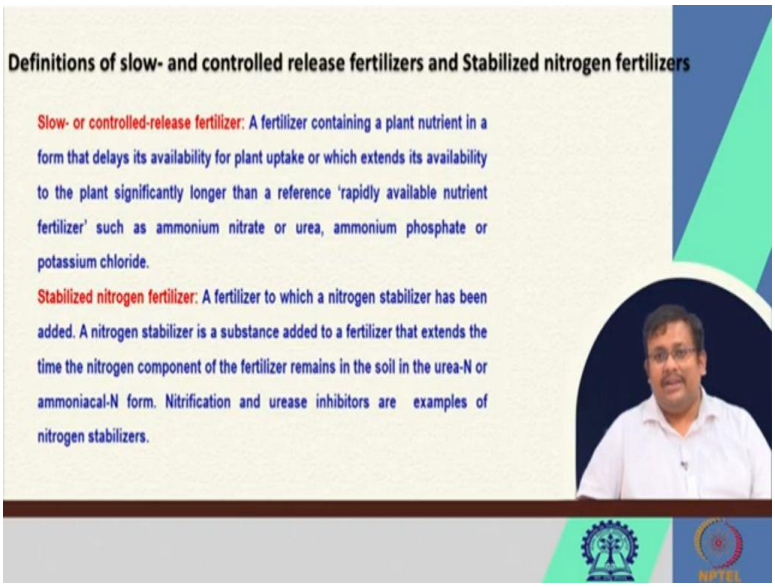

Now, what is the definition of slow and controlled release fertilizer and stabilized nitrogen fertilizer? Now, there is another term called stabilized nitrogen fertilizer. So, if you see the definition of slow and or controlled release fertilizer; so a fertilizer containing a plant nutrient in a form that delays its availability for plant uptake or which extends its availability to the plants significantly longer than a reference rapidly available nutrient fertilizer, such as ammonium nitrate or urea, ammonium phosphate or potassium chloride.

So, basically the concept is you the fertilizer release the nutrient in a slower rate than conventionally rapidly releasing fertilizer, nutrient releasing fertilizer is known are known as slow or controlled release fertilizer. Stabilized nitrogen fertilizer is basically fertilizer to which a nitrogen stabilizer has been added. So, a nitrogen stabilizer is a substance which is added to a fertilizer that extends the time, the nitrogen component of the fertilizer remains in the soil, in the either in the form of urea or in the form of ammonia, ammonical form. So, nitrification and urease inhibitors are example of these nitrogen stabilizers.

So, basically, you know that you urea is basically hydrolyzed in the presence of urease enzyme and nitrification is processed where these ammonium ions are converted into nitrate ion. Now, if we inhibit these two processes like nitrification and you and also we inhibit the urease activity that can severely hampered the nitrogen release from urea as well as nitrification process. So, that will stabilize the nitrogen release; so, that is why it is called stabilized nitrogen fertilizer.

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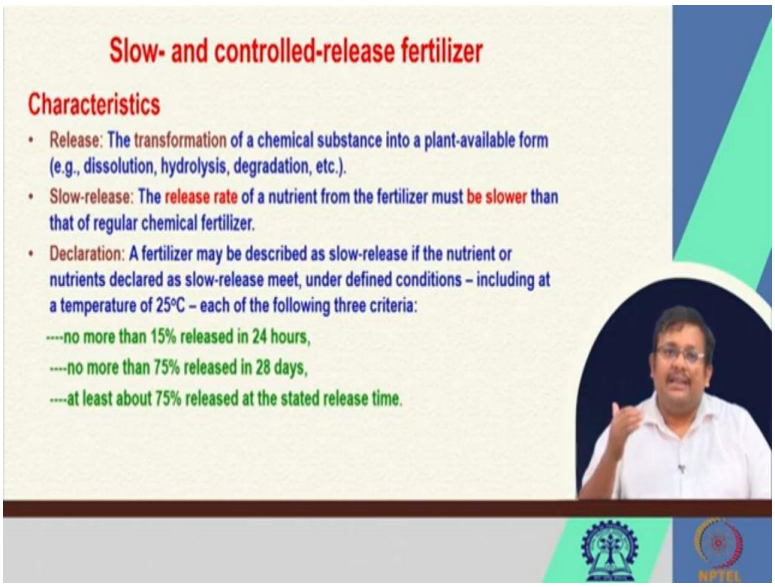

Now, what are the characteristics of slow and controlled release fertilizer? First of all, the release pattern. So, the transformation of a chemical substance into plant available form is very slow; so, slow release. So, the release rate of a nutrient from the fertilizer must be slower than that of regular chemical fertilizers; this is the first criteria. Second is a fertilizer maybe described as slow release if the nutrient or nutrients declared as slow release, meet these following criteria at a temperature of 25 degrees centigrade. So, what are these criteria? No more than 15 percent released in 24 hours; or no more than 75 percent release in 28 days.

And at least about 75 percent released at the stated release time. So, these are the conditions which these slow and control release fertilizer has to meet. And then only we can call them as slow and controlled release fertilizer.

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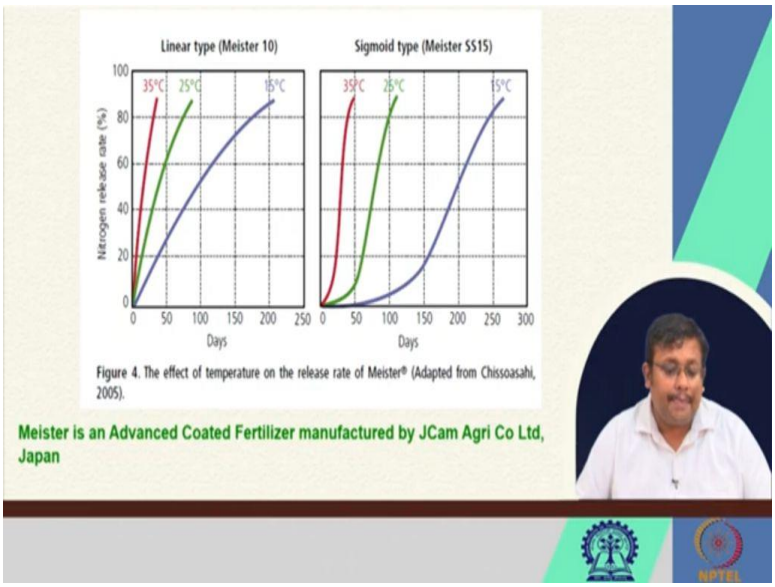

Now, here you can see this is a this is a Meister, we are we can see it is an advanced coated fertilizer which are manufactured; which is manufactured by these JCam Agri Company Limited of Japan. So, if we can see the nitrogen release in days of these Meister 10 and Meister SS 15, we can see that we can see the release pattern are for here in the, they are forming the linear pattern. And here you can see their sigmoid pattern of nitrogen release. And as the temperature increases, the nitrogen release is more steeper or the nitrogen release is higher; yes, we increase the temperature. So, this is an example of coated fertilizer and the nitrogen released from the coated fertilizer.

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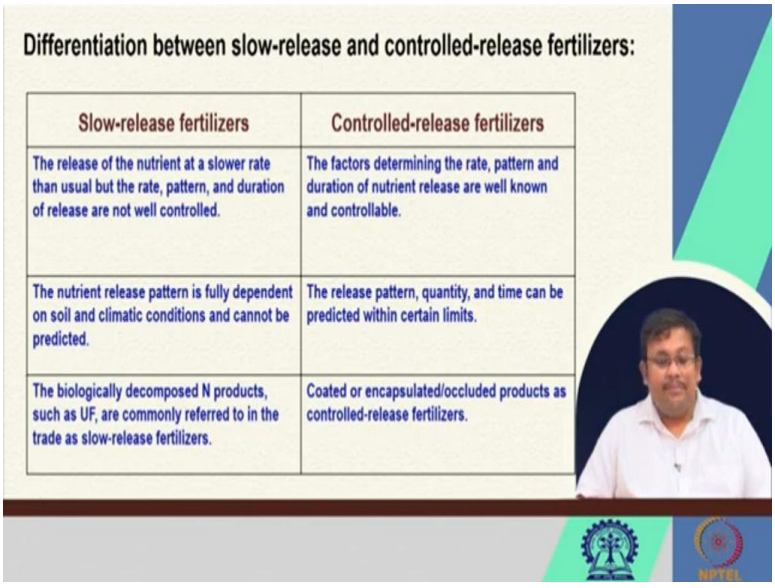

Now, what is the difference between slow release and controlled release fertilizer? So, slow release fertilizers are control release fertilizers. So, slow release fertilizers release the nutrient at a slower rate than usual but the rate pattern and duration of the release are not well controlled. However, in case of controlled release fertilizer, the factors determining the rate pattern and duration of nutrient release are well known and controllable. Secondly, the nutrient release in case of slow release fertilizer, the nutrient release pattern is fully dependent on soil and climatic condition, and cannot be predicted.

However, in case of controlled release fertilizer, the release pattern quantity and time can be predicted within certain limits. In case of slow release fertilizer, the biologically decomposed nitrogen products such as urea formaldehyde are commonly referred to in the trade as slow release fertilizer. However, in case of controlled release fertilizer, coated or encapsulated or occluded products are generally generally used.

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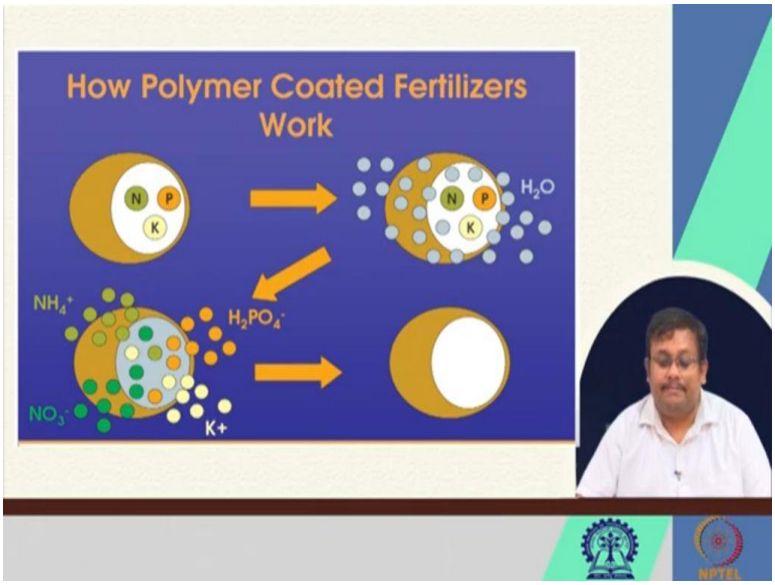

Now, if we see how these polymer coated fertilizer works. So, you can see these NPK fertilizers are basically coated with polymer. And when they come in contact with water, so water molecule basically enters here and they make a chemical reaction and this chemical in in in. As a result of this chemical reaction, there is a volume increase of this particle, and then there is chemical reaction. And as a result of this chemical reaction, we can see the release of different fertilizer elements like ammonium, nitrate, potassium, H two PO four minus and so on. So, this is how the polymer coated fertilizer generally work.

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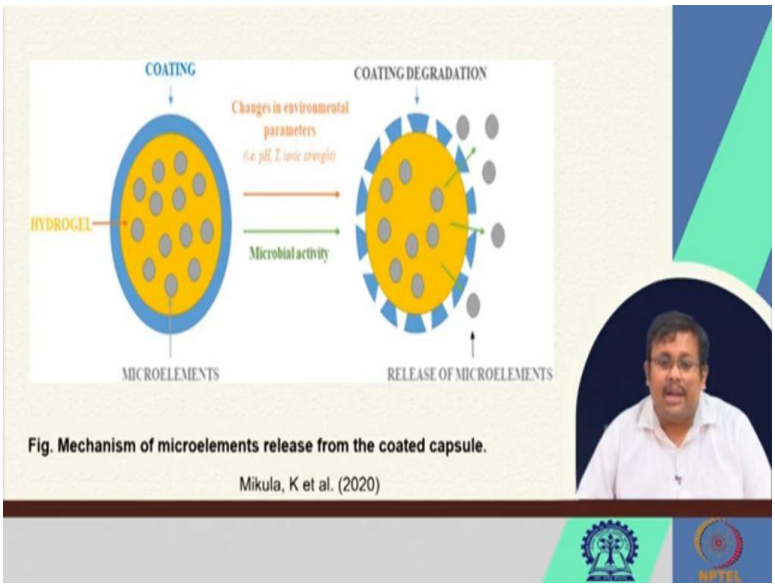

Also, you can see the mechanism of microelement released from a coated capsule. So, here you can see that these microelements which are surrounded by hydrogel and the whole thing is surrounded by a coating. Now, the release of these microelements is basically depends on the microbial activity. So, as a result of the change of environmental parameters, there will be microbial attack and as a result of this microbial activity, these coating degradation will occur and ultimately they will release these microelements for the plant uptake. So, this is how these microbes can help in the in increasing the availability of the elements from the coated capsule.

So, this is how we can we, there are different strategies, which we generally use to retard or control the release of fertilizer elements; so, that their availability can be prolonged in the soil for the plant uptake.

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So, the slow and controlled release fertilizer which are available for application. The two most important groups of slow and controlled release fertilizer according to their production process are mainly, first group is condensation products of urea-aldehydes which are known as slow release fertilizer. And second group is called coated or encapsulated fertilizer; these are controlled release fertilizers. So, nowadays, super granules are also there but they have only the regional importance.

So, you can see guys how these slow release fertilizer or encapsulated fertilizer, polymer coated fertilizer can help in slow and controlled release of nutrient, for prolonged prolonged; for prolonged uptake of those nutrient elements by the plant. So, guys we have completed this lecture. And, we will will go from here in our next lecture, and we will discuss more about these fertilizer quality control, and fertilizer adulteration, and the fertilizer testing in our upcoming lectures.

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And these are the references which I have used for this lecture. You are welcome to go through this literature, and enrich yourself with different aspects, and more comprehensive knowledge of fertilizer and slow release fertilizer and controlled release fertilizer. Thank you. Let us meet in our next lecture.