Soil Fertility and Fertilizers
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Lecture: 26
Soil Testing and Soil Fertility Evaluation Methods

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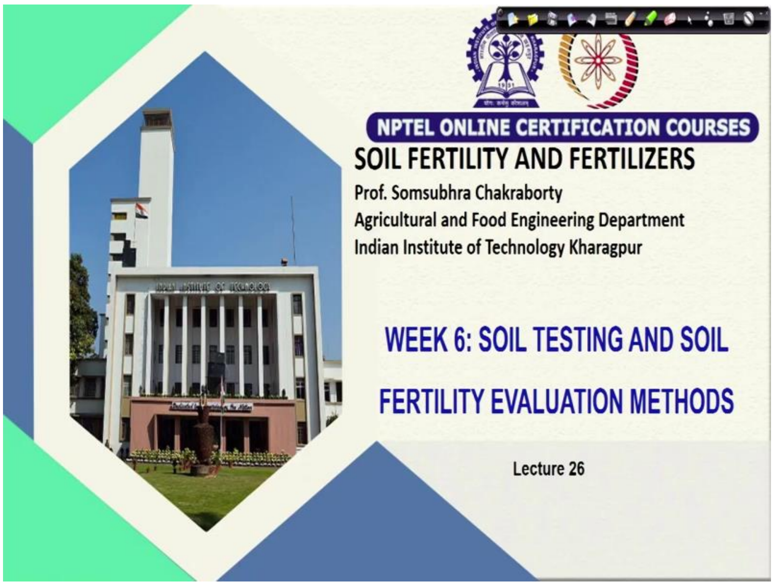

Welcome friends to this NPTEL online certification course of Soil Fertility and Fertilizers. And, we are going to start today week 6 and the topic of week 6 of lectures is soil testing and soil fertility evaluation methods. So, in our previous five weeks, we have discussed about the basics of soil fertility. We have discussed about soil health indicators and also we have discussed in details about several macronutrients and micronutrients, we have discussed their sources, we have discussed their roles and deficiency symptoms.

Now, in this week, we are going to discuss a very important aspect of how to determine or evaluate the soil and crop nutritional status using different methods, how to ensure that, we can recommend proper fertilization for maintaining the growth of the plant. So, in this lecture 26 that is first lecture of this week 6 we are going to discuss these following concepts.

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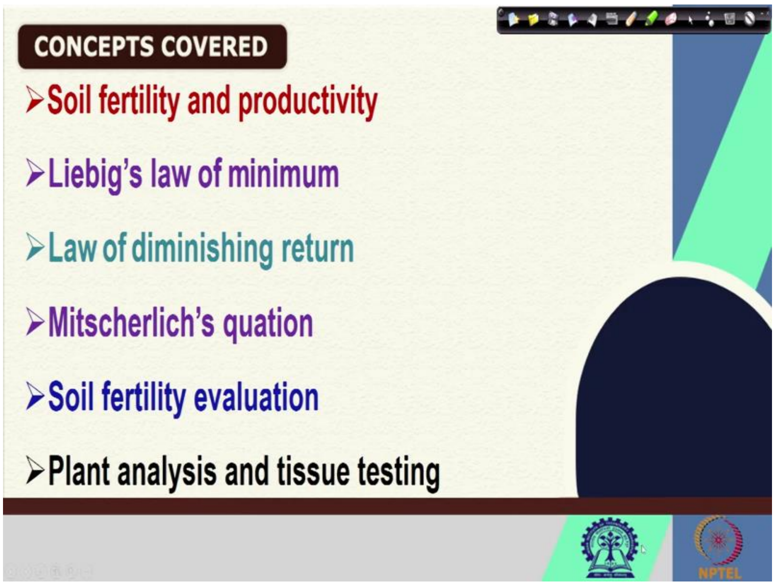

So, these are the following concepts of this lecture we are going to first cover soil fertility and productivity. Then we are going to discuss Liebig's law of minimum and then we are going to discuss law of diminishing return. Also we are going to discuss Mitscherlich equation and also we are going to discuss soil fertility evaluation methods and plant analysis and tissue testing. So, these are the concepts which we are going to cover in this lecture.

Remember this basics of soil fertility productivity Liebig's law of minimum, law of diminishing return, Mitscherlich's equation we have already discussed in our previous lectures, however, we will be doing a quick recap or quick recall of these concepts, before we discuss about soil fertility evaluation methods, because we need to remember these terms before we can understand different soil fertility evaluation methods.

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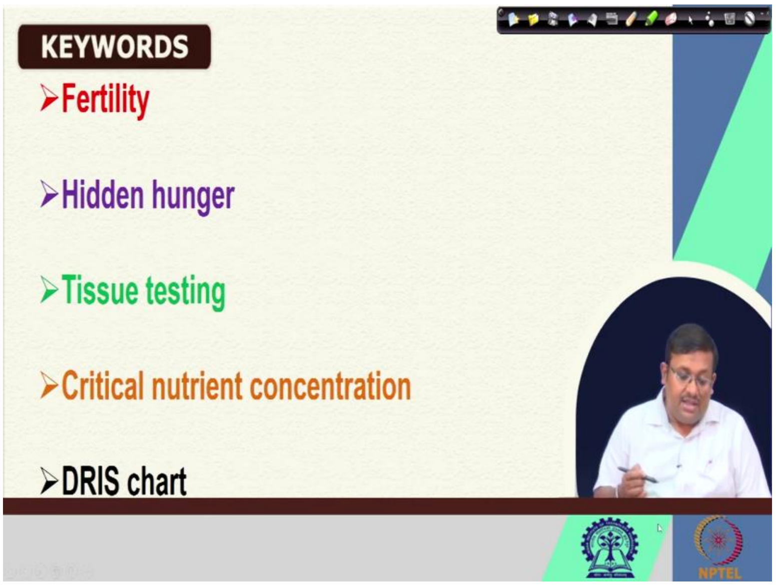

So, apart from these concepts, these are the following some of the keywords which we are going to discuss in this lecture of fertility, then hidden hunger, then tissue testing, then critical nutrient concentration, DRIS chart all these things are included in this lecture and we are going to discuss.

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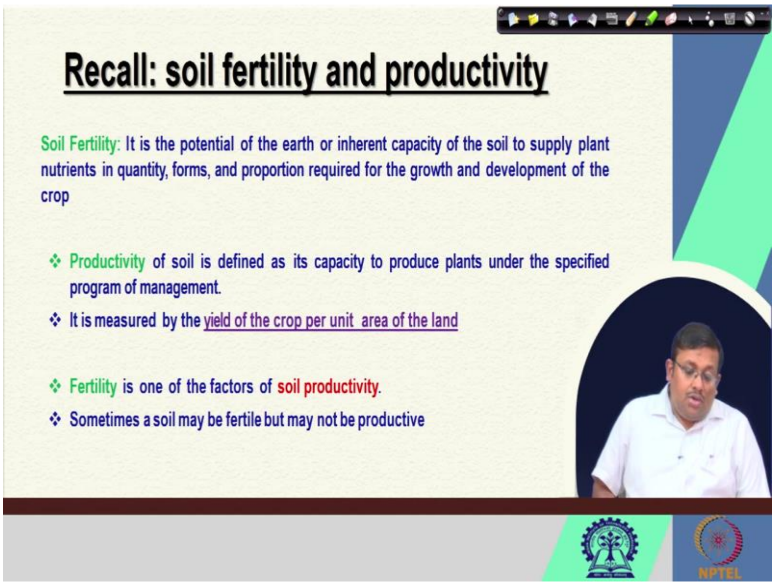

So, if we recall what is soil fertility and productivity and what is the difference between these two terms, you should remember or you should recall that soil fertility is the potential of earth or soil or it is an inherent capacity of the soil to supply plant nutrients in quantity forms and proportion required for the growth and development of the crop.

So, basically soil fertility defines the soil capacity to maintain the supply of essential plant nutrients. So, that for ensuring the growth and development of the crop. However, if we consider soil productivity, productivity is defined as the capacity of the soil to produce plants under specified program of management.

So, the basic difference between soil fertility and productivity is, productivity is measured in terms of produce or in other words crop growth or crop produce. So, in general productivity is measured by the yield of the crop per unit area of the land. However, soil fertility is the capacity of the soil to supply the plant nutrients in adequate quantity.

Now, remember that fertility is one of the factors of soil productivity not both these terms are same, because soil productivity also depends on climatic properties as well as management practices. Remember that sometimes soil may be fertile but may not be productive. There may be different types of abiotic stress that can result in unproductiveness of a soil or that can lead a soil to be unproductive.

So, it means that a productive soil is always fertile. However, a fertile soil may not be always productive this very important concept. So, we have already discussed this productivity and fertility however, this is we are discussing this again because this will be required for this lecture for understanding the concept of plant and soil fertility evolution methods.

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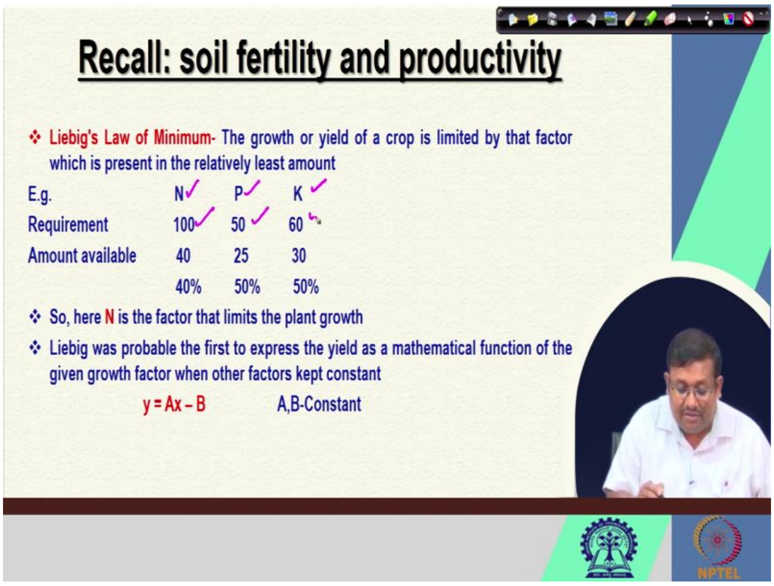

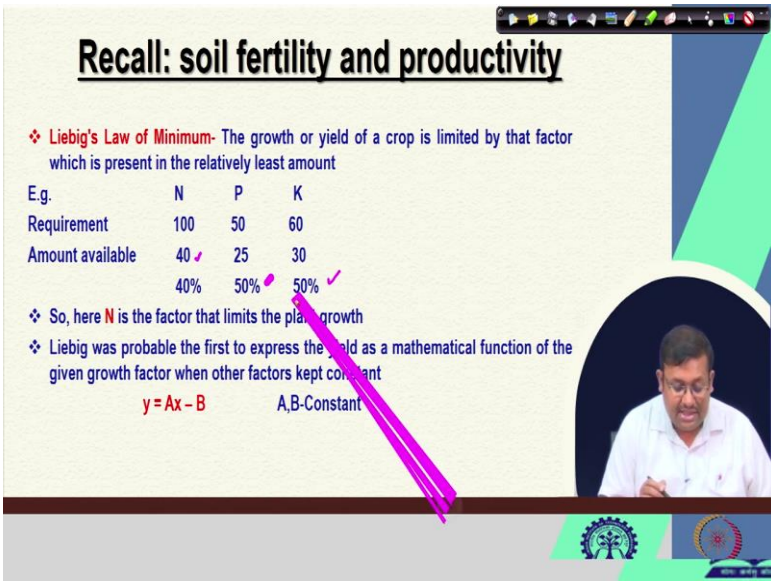

Also, if you remember Liebig's law of minimum which you have already discussed. The Liebig's law of minimum says that the growth or yield of a crop is limited by that factor which is present in the relatively least amount. So, when there are multiple nutrients or factor which are affecting the proper growth of the plant, then the growth of the plant will be governed by the least available factor or nutrient for example, here we can see a good example.

Suppose, here there are two different, three different nutrients nitrogen, phosphorus, potassium and requirement for growth of the crop is 100 units of nitrogen, 50 units of phosphorus and 60 units of potassium. However, if we see the availability of these nutrients, we can we can see that, we can see that the nitrogen is available in 40 percent.

So, we can see 40 percent availability of nitrogen and 50 percent availability of phosphorus and 50 percent availability of potassium. So, comparing all these three we can say that the nitrogen is the most limiting factor for the plant growth. So, in this condition nitrogen is considered as the most limiting factor.

Now, Liebig remember was the probably the first to express the yield as a mathematical function of the given growth factor when other factors are kept constant formula that is y equal to Ax minus B where A and B are constant. So, yield we can see this can be governed by this equation where A and B are constant.

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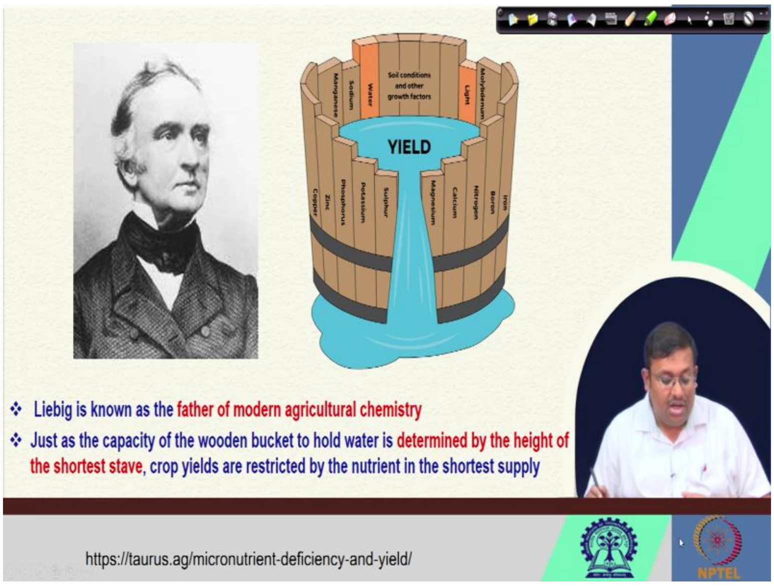

Now, Liebig is known as the father of modern agricultural chemistry and just as the capacity of the for example, here you can see that the yield is governed by if we consider the yield is represented by this bucket of water. So, the capacity of this wooden bucket to hold water is determined by the height of the shortest stave. So, crop yields are also restricted by the new trend in the shortest supply. We already know that, but just a quick recall.

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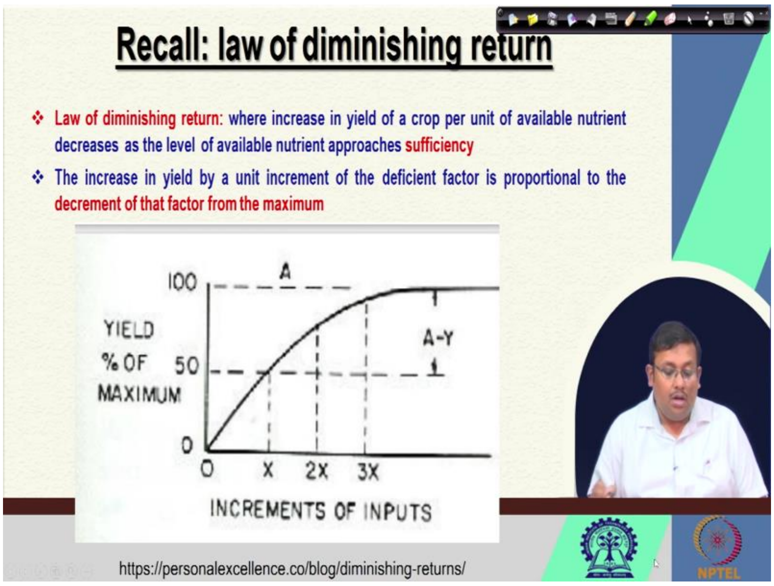

Now, also we know what is the law of diminishing return we know that law of diminishing returns says where increase in yield of a crop per unit of available nutrient decreases as the level of available nutrient approaches sufficiency. So, the increase in yield by a unit increment of the deficient factor is proportional to the decrement of that factor from the maximum.

So, we can see that when we are increasing the, when we are increasing the available nutrients suppose in the x axis from X to 2X to 3X the amount of increase in the yield of the crop per unit increase of these available nutrients will decrease as you can see, as a level of available nutrient approach sufficiency. So, this is the law of diminishing returns we have already known that.

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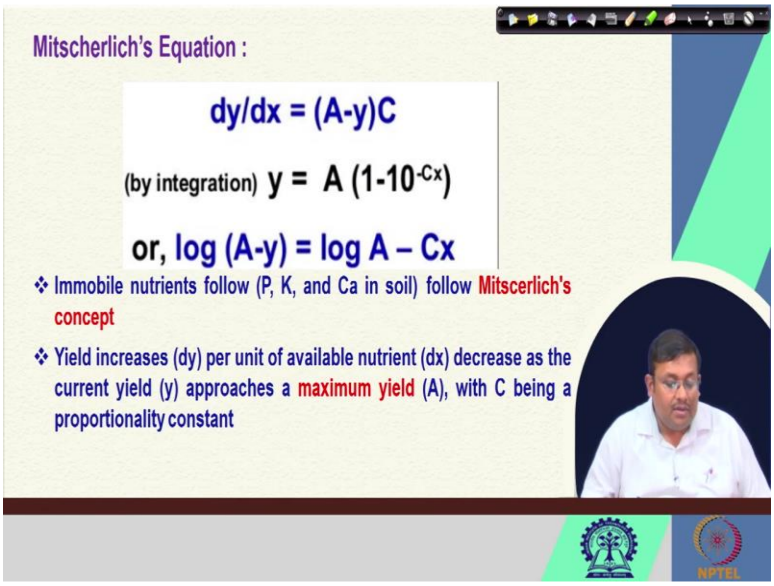

So, finally, we also know there is a Mitscherlich's equation where dy by dx equal to A minus y into C and by integration we can get y equal to A 1 minus 10 to the power minus Cx or log of A minus y equal to log of A minus Cx. Now, these immobile nutrients follow what are the immobile nutrients in the soil?

Phosphorus, potassium, calcium are the immobile nutrients in the soil. Those nutrients follow the Mitscherlich's concept and according to this Mitscherlich's equation, we can understand that the yield which is denoted by dy per unit available nutrient which is denoted by dx decreases as the current yield which is denoted by y approaches a maximum yield that is A with C being the proportionality constant. So, this is Mitscherlich's equation, we have already discussed this, so, I am not going to discuss this further.

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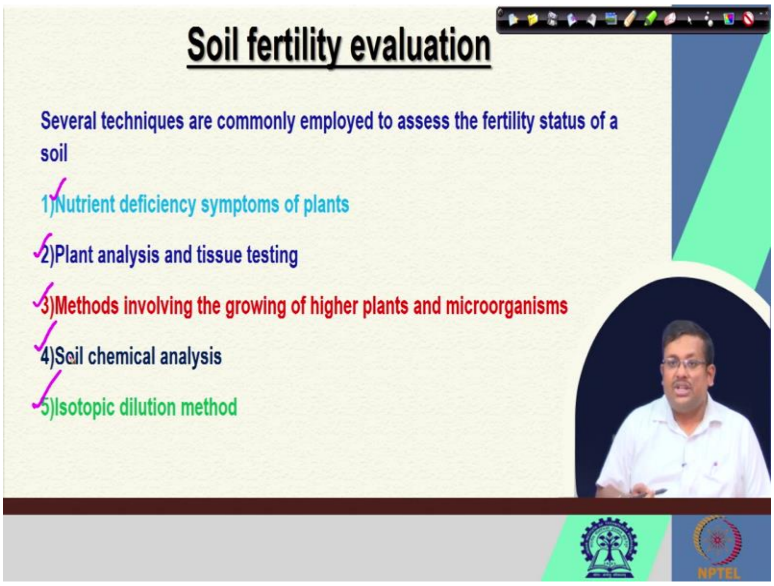

Now, let us discuss some of the important concept that is soil fertility evaluation. Now, there are several techniques, we generally employ to assess the fertility status of the soil, what are these techniques? There are 5 major techniques, first of all nutrient deficiency symptoms of the plant. Secondly, plant analysis and tissue testing, third is methods involving growing the higher plants on microorganisms, fourth one is soil chemical analysis and fifth one is isotopic dilution methods. So, we are going to discuss these, these evaluation methods.

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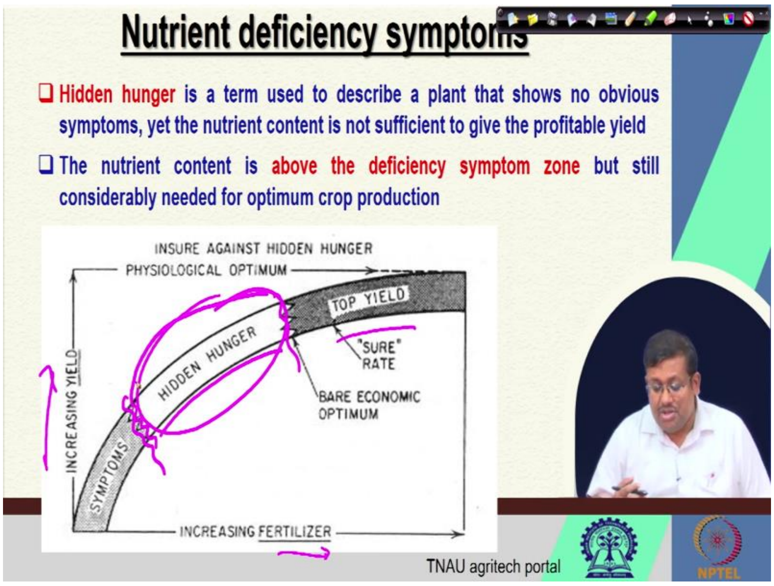

So, before we discuss the other methods, let us also discuss the nutrient deficiency symptoms. Now, you already know that there is all the crops when there is a deficiency of a particular nutrient they show not only the deficiency symptoms, but also subsequent yield reduction, we know that.

Now, there is a term called hidden hunger. So, this hidden hunger is a term used to describe a plant that shows no obvious symptoms see it the nutrient content is not sufficient to give the profitability. So, when the nutrient content is not sufficient, but still when the plant is not showing any visible symptom that is called hidden hunger.

Now, remember that in case of hidden hunger, this can be represented by this graph we can see, when we are increasing the fertilizer amount in the x axis and we can see the increase in the yield in the y axis, we can see up to a certain level we can see symptom this is a clear deficient symptoms. And of course, when there is insufficient amount of nutrient, we can see that there is an optimum growth.

However, in between these optimum nutrient concentration and the deficient nutrient concentration, these hidden hunger lies. So, these zone is showing the hidden hunger when the plant is not showing any visible symptoms, but at the same time, the nutrient content is less than the optimum content. So, these are the nutrient deficiency symptoms. So, why identifying the hidden hunger is a problem?

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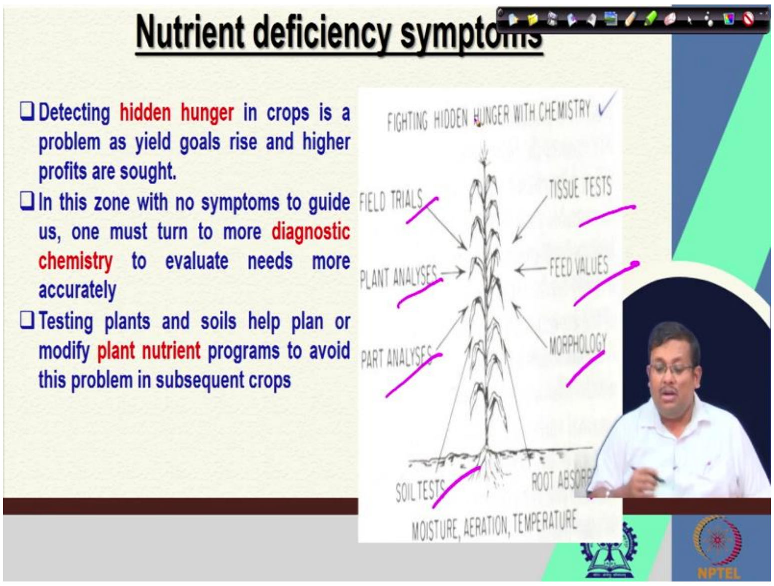

Now, detecting the hidden hunger for a crop is always a problem as yield goals rise and higher profits are sought. So, in this zone with no symptoms to guide us, one must return to more diagnostic chemistry to evaluate the needs for more accurate way. So, hidden anger detection is always a challenging method when higher profits are sought and when the goals of the yield I mean the when the yield goals the targeted yield arise. So, we need to go towards the diagnostic chemistry based methods. So, testing plants and soil health plan or modify the plant nutrient program to avoid this problem in subsequent crops. So, what are the ways to deal with this problem with hidden hunger?

You can see here we can go either with the field trials, we can go for the plant analysis, part analysis, soil test, root absorption and then morphological examination, field values and then tissue tests. So, all these different other tests are there are available when this when identification of the hidden hunger is a problematic issue. So, we will discuss them one by one.

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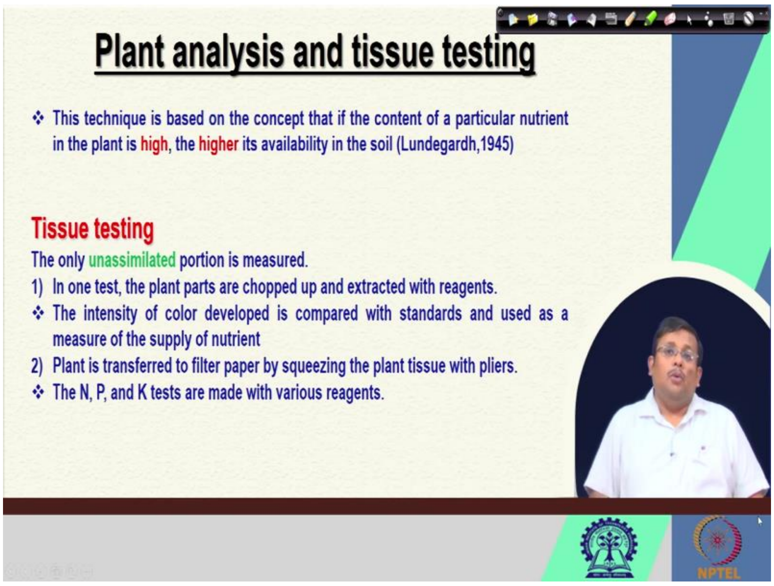

So, let us discuss the first one that is plant analysis and tissue testing. So, this testing is based on the concept that if the content of a particular nutrient in the plant is high, the higher its availability in the soil. So, when the concentration is high inside the plant, we assume that that nutrient may be present in higher quantity in the soil.

So, tissue testing in case of plant tissue testing, the only unassimilated portion is measured. So, in one case, there are two ways we want is the plant parts are chopped up and extracted with different reagents and then the intensity of the color developed is compared with standards and used as a measure of the supply of the nutrient.

So, what do you do? We chop this plant parts and then we digest on extract and then we develop the color and then we measure the intensity of the color as the to indicate the nutrient concentration this is one approach. Second approach is plant is transferred to filter paper, but you know transfer to filter paper by squeezing the plant tissue with pliers. And in this method, we can measure the nitrogen, phosphorus and potassium tests we can measure with various reagents. So, these are some of the ways to which we can do the tissue testing.

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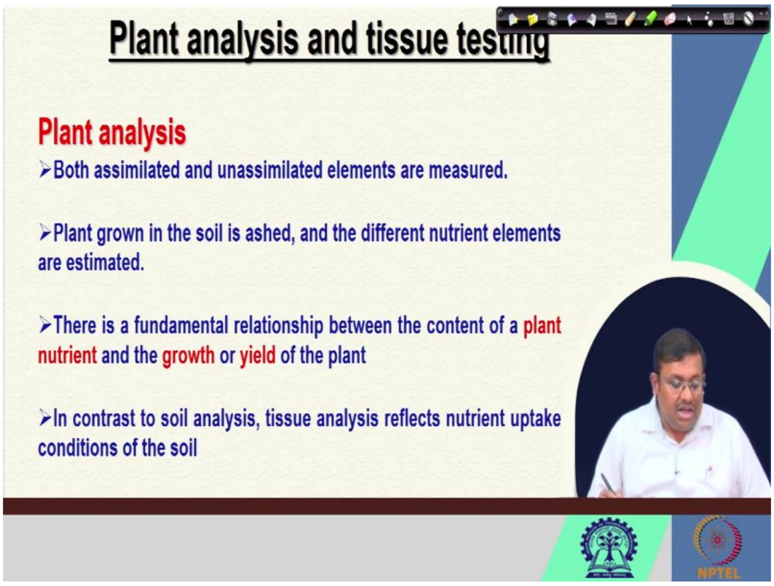

Now, in case of plant analysis, remember that both assimilated and unassimilated elements are measured and plant grown in the soil is first ashed and the different nutrient elements are estimated I told you that it has to be digested with different types of digestion mixture and then we measure the different elemental content in this in the plant part by different methods, there is a fundamental relationship between the content of a plant nutrient and the growth or yield of the plant. Now, in contrast to the soil analysis, tissue analysis reflects nutrient uptake conditions of the soil.

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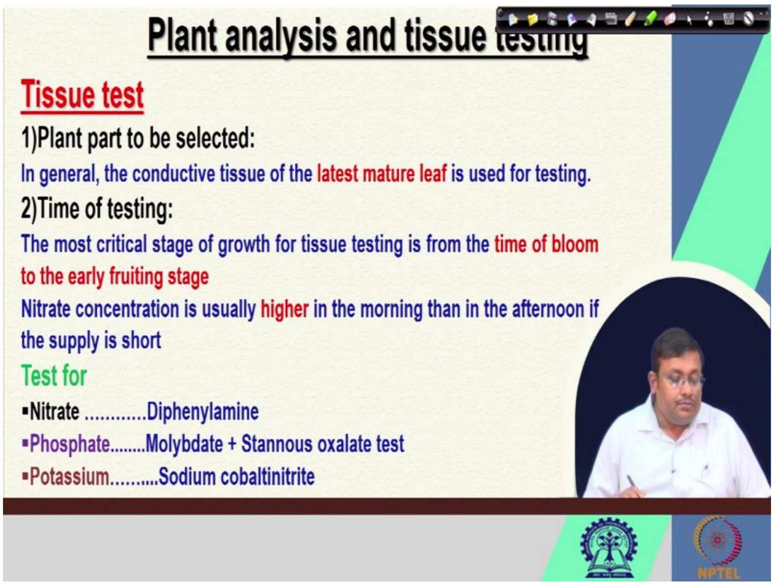

So, if we talk about the tissue test, what are the important consideration? The first important consideration is the plant part to be selected. In general, the conductive tissue of the latest mature leaf is used for testing when we are go for plant tissue analysis. So, we will take the mature latest mature leaf and the connective tissue from those mature latest mature leaf for plant tissue testing, what is the time of testing?

The most critical stage of growth for tissue testing is from the time of bloom to early fruiting stage. Remember that nitrate concentration is usually higher in the morning than in the afternoon if the supply is short. So, these are all important consideration when we sample the plant tissue for successive estimation of the nutrient.

So, what are the important test? For example, in case of nitrate, we go with the Diphenylamine based method, in case of phosphate analysis we go with the Molybdate plus Stannous oxalate test and in case of potassium we go with this sodium cobaltinitrite test. So, these are some of the tissue tests we generally measure the nutrients which are there within the plant body to assess the fertility status of the soil.

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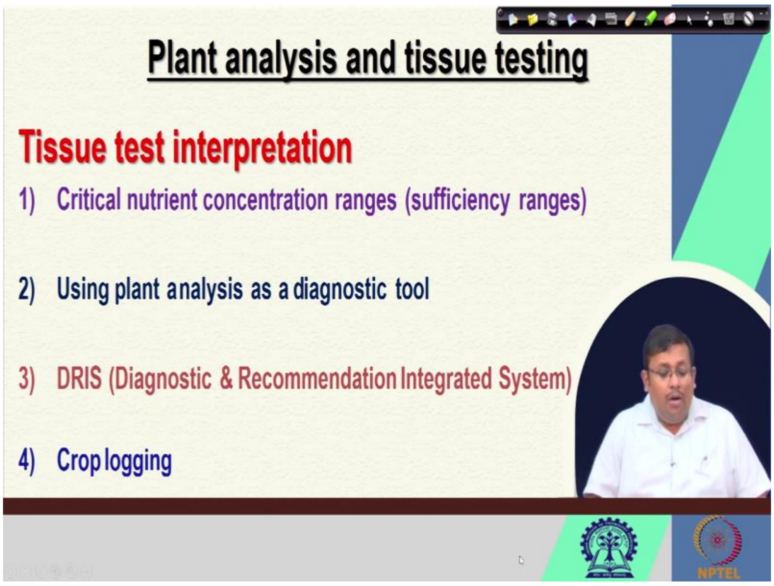

Now, how to interpret the tissue test results? Critical nutrient concentration ranges or sufficiency ranges you already know these concepts, the critical range concept and our critical nutrient concentration range or we call it CNC apart from that we can also use plant analysis as a diagnostic tool or we can use DRIS concept that is diagnostic and recommendation integrated system and fourth one is crop logging. So, these are the four methods we can use for interpreting the tissue test results.

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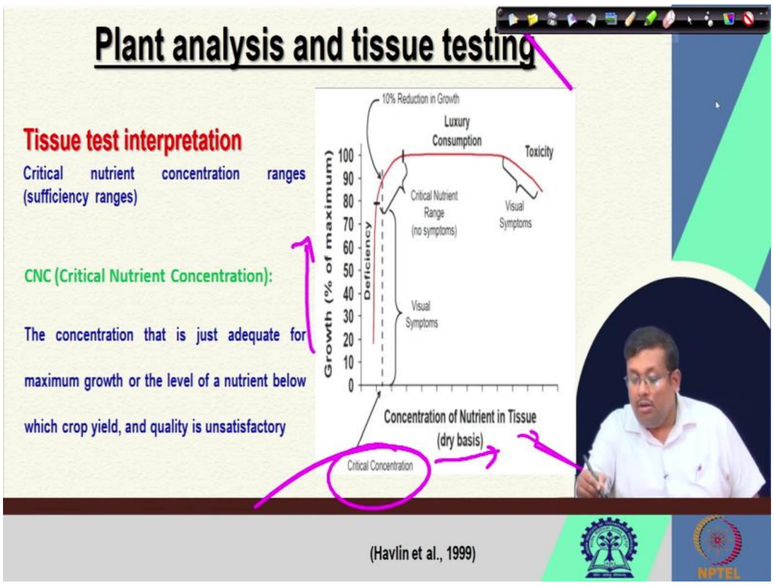

So, we all know that the CNC or critical nutrient concentration concept, we have already discussed this previously, but just for a quick recap, we can see in this graph in the x axis, we are putting the concentration of the nutrient in tissue in dry bases and in the y axis we are putting the growth in you know of the plant. So, we can see as the concentration of the nutrient is increasing, you will see there is an increase in the plant growth and there will be a threshold where after where you can see that there will be not much increase in the growth as you increase the concentration.

Now, the concentration that is just adequate for maximum growth or the level of a nutrient below which crop yield and quality is unsatisfactory is known as the critical concentration of the nutrient and this critical concentration of the nutrient is very important concept for developing the fertilizer recommendation because we want our you know soil fertility or the concentration of the nutrient in the tissue should be above this critical concentration to ensure the proper and optimum growth of the crop.

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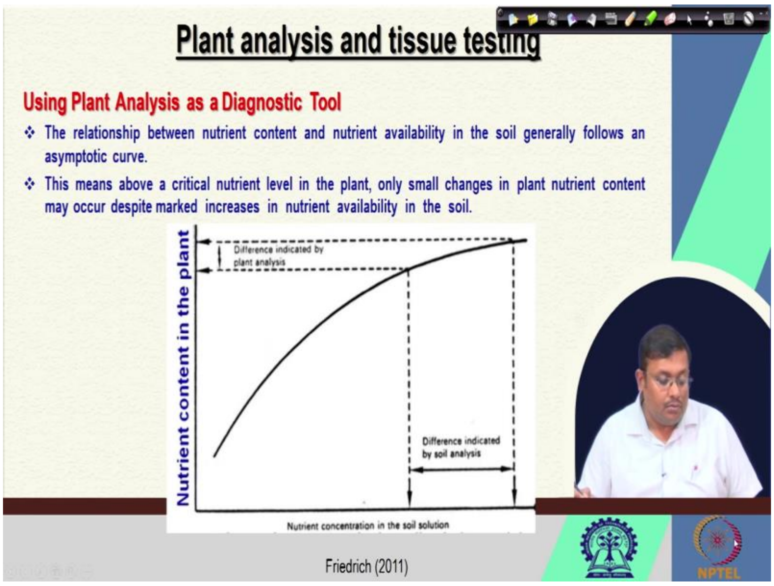

Now, the second way is the using plant as a diagnostic tool the plant analysis is a diagnostic tool. So, the relationship between the nutrient content and the nutrient availability in the soil generally follows an asymptotic curve, what is asymptotic curve? This means that above the critical nutrient level in the plant only small changes in plant nutrient content may occur despite marked increase in nutrient availability in the soil.

So, in this graph, you can see in the x axis we are putting the nutrient concentration in the soil solution and in the y axis we are getting nutrient content in the plant. So, if we consider this the critical level, so, you can see from this critical level to this content, when we increase the nutrient concentration in the soil solution.

So, this difference basically shows that the changes in the soil nutrient concentration however, the corresponding change in the plant nutrient content is comparatively small. So, that shows that it is an asymptotic curve.

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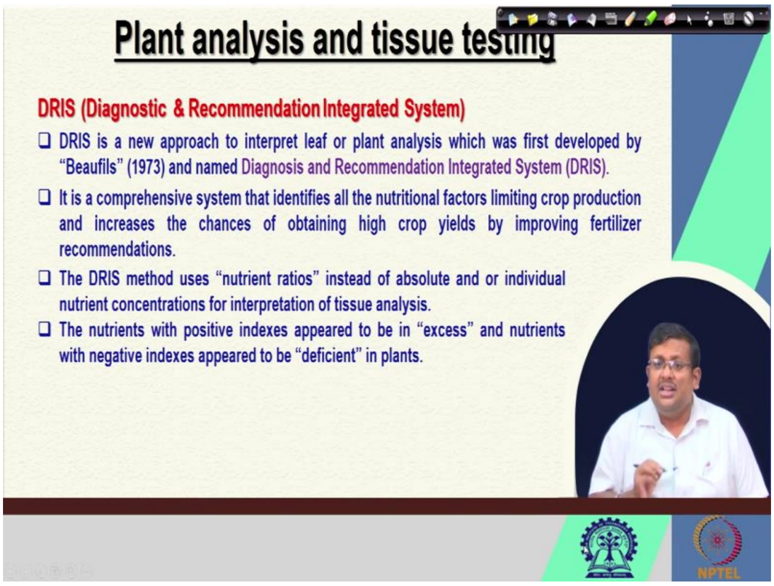

Now, the third concept is DRIS concept that is diagnostic and recommendation integrated system. Now, what is DRIS? In DRIS generally we consider not only the limiting nutrient but also their ratios. So, DRIS is a basically new approach to interpret leaf or plant analysis, which was first developed by Beaufils in 1973 and named as diagnostic and recommendation integrated system or DRIS.

So, what is DRIS? DRIS is basically a comprehensive system that identifies all the nutritional factors, limiting crop production and increases the chances of obtaining high crop yield by improving fertilizer recommendation. So, it consider all the important nutritional factors before going for the fertilizer recommendation.

Now, this DRIS method uses nutrient ratios instead of absolute and or individual nutrient concentration for interpretation of tissue analysis. So, here you will see, we are not using individual nutrient concentration rather we are using N by P, P by K, N by K ratios. So, the nutrient with positive in this index says appear to be in the excess and nutrients with the negative indexes appear to be deficient in plants.

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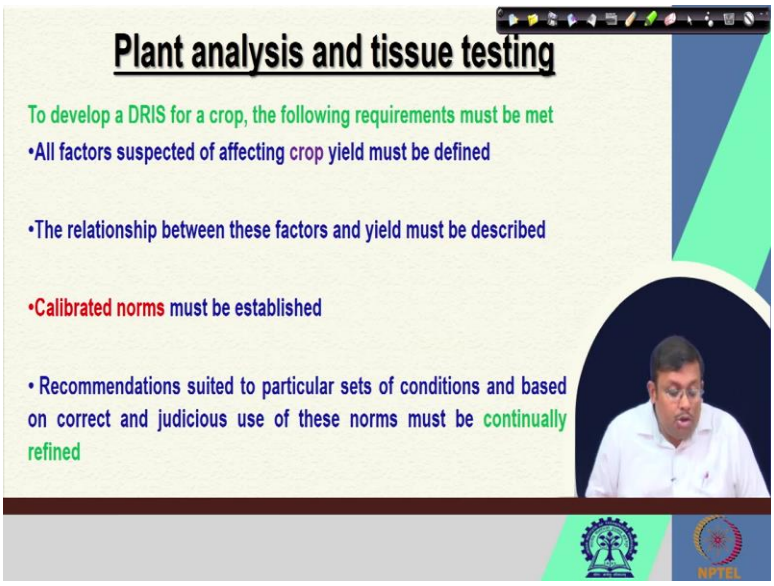

So, to develop a DRIS for a crop the following requirements must be made. So, all factors suspected of affecting crop yield must be defined and the relationship between these factors and yield must be described. And thirdly, we have to develop the calibrated norms and finally, recommendations suited to particular set of condition and based on correct and judicious use of this norm must be continually refined. So, these are the important concepts of DRIS.

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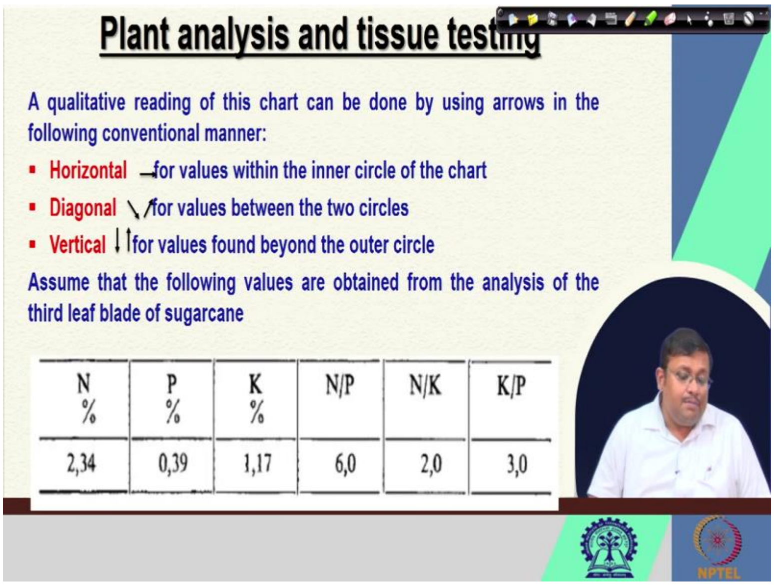

Now, let us see some examples. So, a qualitative reading, there is a DRIS chart we are going to see in this coming slide. So, in this DRIS chart the qualitative reading can be done by using arrows in the following conventional manner. So, you can see there is a horizontal arrow which shows the values within the inner circle of the chart.

Secondly, you can see some diagonal arrows for values between the two circles, we are going to see two circles, two concentrating readings and there will be vertical arrows for values found beyond the outer circle. So, let us see an example where we can see these falling values we got from the analysis of the third leaf blade of sugarcane.

So, we got 2.34 percent of nitrogen, 0.39 percent of phosphorus, 1.17 percent of potassium. So, obviously, we can get N by P ratio equal to 6, N by K equal to 2 and K by P equal to 3. So, how to use these N by P, N by K, K by P ratios in the DRIS concept.

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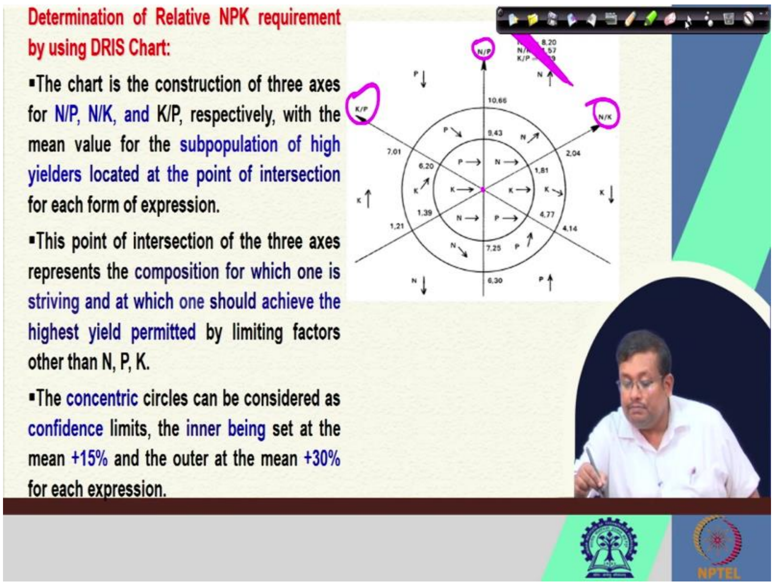

So, here this is the DRIS chart and you can see the chart is having three axis for N by P axis and then you can see N by K axis and K by P axis respectively with the mean value for the sub population of high yielders located at the point of intersection for each form of expression. So, this is a point of expression and the mean values you can see 8.20 for N by P ratio were N by K equal to 1.57 and for K by P equal to 5.39. Now, the point of, this point of intersection of these three axis that is N by P, N by K, and K by P represents the composition for which one is striving and at which one should achieve the highest yield permitted by the limiting factors other than N, P, K.

So, here you can see there are two concentric circles the first cycle or inner circle shows the 15 percent said the mean plus 15 percent zone and the outer ring shows mean plus 30 percent zone. So, based on these expression, we have to define what are the limiting nutrients in a particular case.

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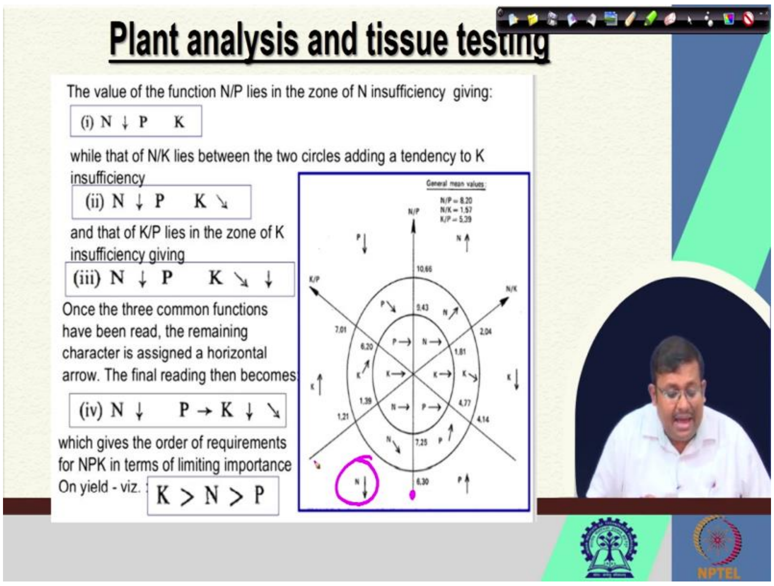

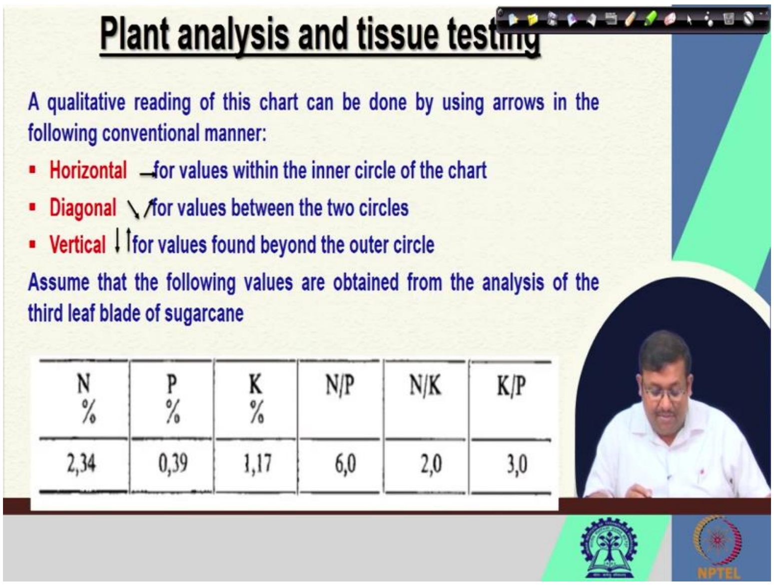

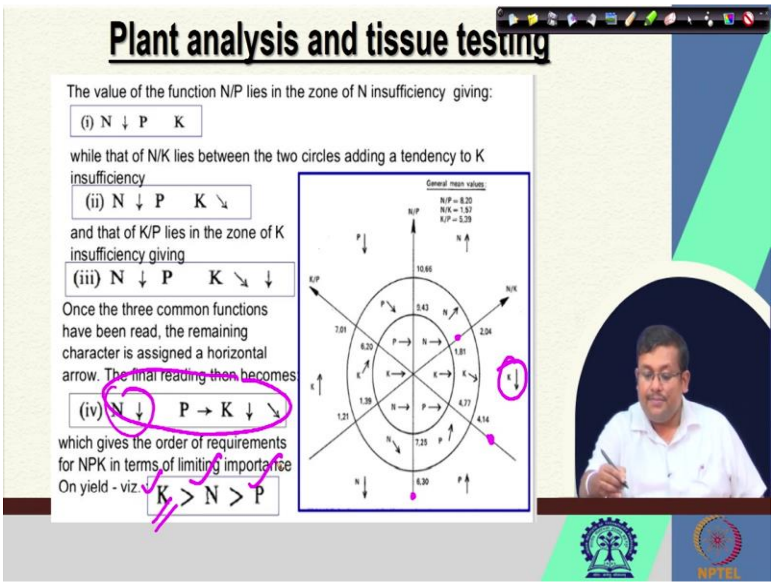

So, you if you see the value for the function N by P lies in the zone of N insufficiency. So, what was the value of N by P in our case, so, if we go back, we will see the N by P value was 6. So, it will come somewhere around. So, N by P it is 10.66, 9.43, 7 point, so, you can see it will be somewhere around here. So, that shows there is nitrogen insufficiency, because it is going down. Second is N by K. So, the N by K lies between what are the N by K values? So, N by K value let us go back and see what was our N by K values? So, our N by K values was 2 and K by P value was 3.

So, N by K value was 2. So, that lies. So, it is 1.81 and 2 point. So, that lies here, N by P lies here. So, that shows that the N by K lies between two circles, and here you can see a tendency for potassium insufficiency. So, you can see there is a tendency of potassium insufficiency and K by P equal to 3. So, it should be somewhere in these in this. So, that also shows lies in the zone of potassium insufficiency. So, you can see here.

So, once we have identified the location based on our nutrient concentration ratio, once all these three common functions have been read, the remaining character is assigned a horizontal arrow. So, we can see here, so, the final reading then becomes N will be decreasing phosphorus followed by potassium is decreasing.

So, here we consider all these things, we can see that, it gives the order of requirements for N, P, K in terms of limiting importance. So, we can see potassium is the most limiting condition, limiting nutrient here, followed by nitrogen, followed by phosphorus. So, this shows the order of the limiting nutrients. So, this is basically the crux of a DRIS system and based on these ratios, we can identify what should be the most limiting nutrient and thereby we can we can correct that deficiency of that particular nutrient. So, I hope that these this concept is clear to all of you.

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So, these are the references which are used for this lecture and let us wrap up this lecture and I hope that you have gathered some useful knowledge of course, so sum part of this lecture is a quick recap for understanding this critical nutrient concept and all other things. However, we have also discussed this Nobel concepts of plant tissue testing and also the DRIS concept. So, let us wrap up this lecture here and let us discuss more about soil and plant fertility evaluation in our next lectures. Thank you.