Soil Fertility and Fertilizers
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Lecture 52
Fertilizer Recommendation Approaches and Integrated Plant Nutrient Management (Contd.)

Welcome friends to this fifty second lecture of NPTEL online certification course of Soil Fertility and Fertilizers. And we are currently at week 11.

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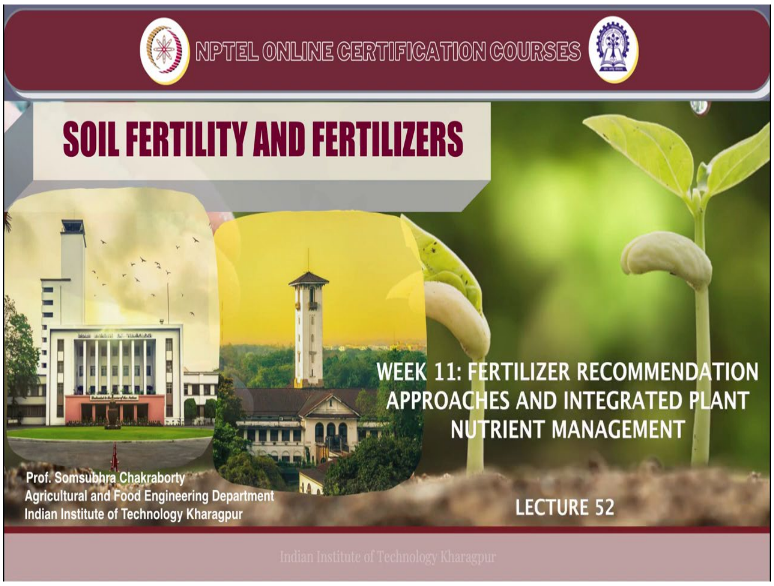

And in this week we are discussing about Fertilizer Recommendation Approaches and Integrated Plant Nutrient Management. Now, in our previous lecture of this week that is lecture number 51, we have discussed about the basic concepts of fertilizer recommendation approaches and we have also discussed the potential concept. Now, in this lecture we are going to focus on the following concepts.

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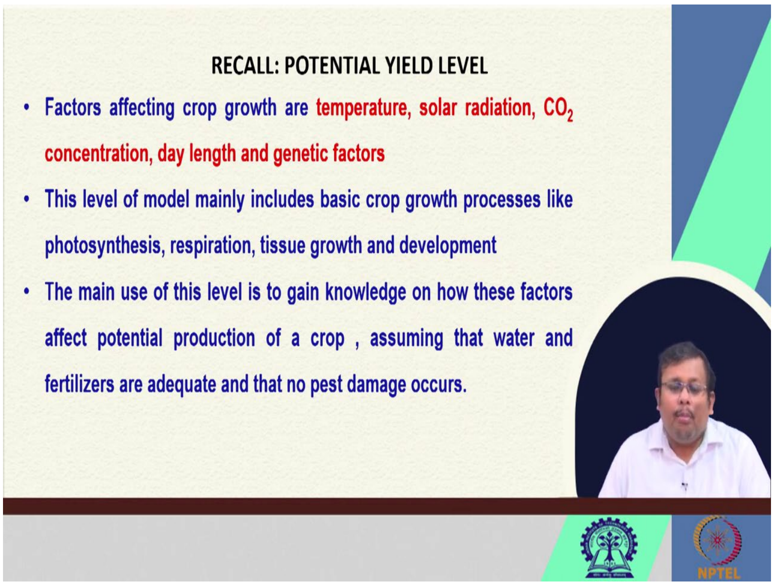

So, we are going to discuss this concept first of all, we are going to discuss the attainable yield level and actually level. What are the differences between these attainable yield and actually yield and how they differ from potential yield? And then there will be some recap of the previous some of the previous concepts which we have already discussed. These are soil fertility diagnostic techniques, then nutrient deficiency symptoms of plant and then soil testing interpretation techniques and then soil chemical test rating. So, we are going to discuss briefly those which we have discussed already in details.

We are going to discuss them or recap them briefly because these will be required for continuation of this week and this will need, we need a recap of this concept before we can discuss the nutrient recommendation approaches.

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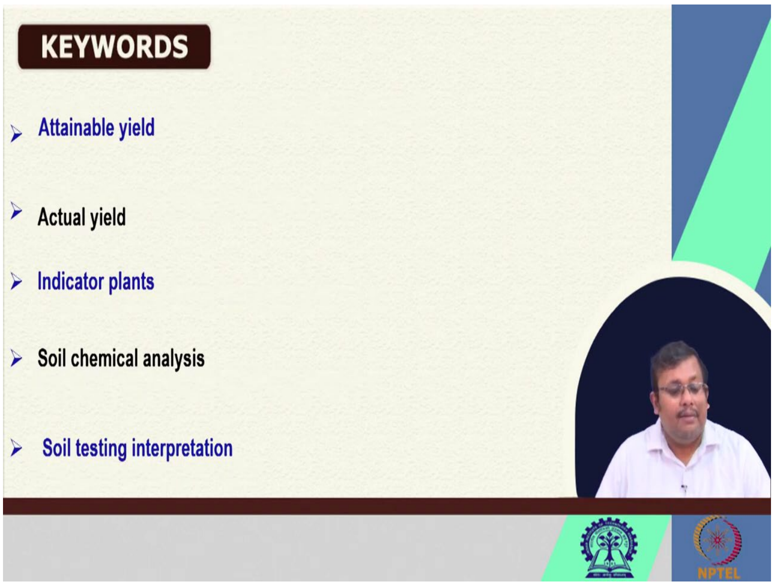

So, let us start with the keywords. These are the keywords like attainable yield, then actual yield, indicator plants, soil chemical analysis and soil testing interpretation. So, these are some of the keywords of this lecture. We are going to learn the definition of attainable yield, actual yield and we have already know what are the indicator plants and we are going to also discuss the summary of soil chemical analysis and how to interpret the soil test results.

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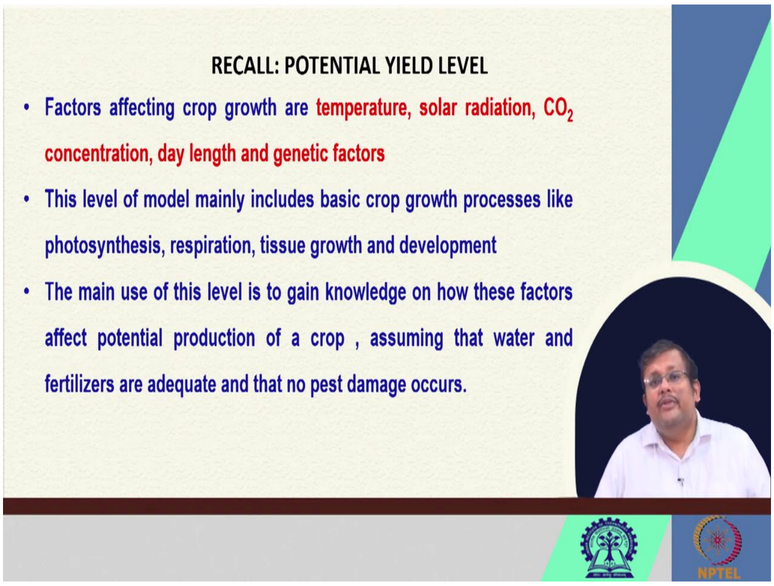

Now, if we recall our knowledge of potential yield from the fifty first lecture, that is the previous lecture of this week. We know that potential yield basically is the optimum yield for optimum management condition. And the factors which affect crop growth in potential yield level are basically temperature, solar radiation, carbon dioxide concentration day length and genetic factors.

Now, this level of model mainly includes basic crop growth processes like photosynthesis, respiration, tissue growth and development. So, these are the major factors while considering the potential yield. Now, the main use of this level is to gain knowledge on how these factors affect potential production of a crop assuming that water and fertilizer are adequate and that no pest damage occur.

So, basically in this potential level, we are not concerned about the management practices, variation in inputs and also the pests and disease attacks. So, potential yield level basically is the optimum growth or optimum yield of the plant considering all considering that other management and insect based factors are at optimum level and we are only considering the temperature variation, solar radiation, carbon dioxide concentration, day length and genetic factors which influence photosynthesis, respiration, tissue growth and development. So, basic physiological processes are only concerned while discussing the potential.

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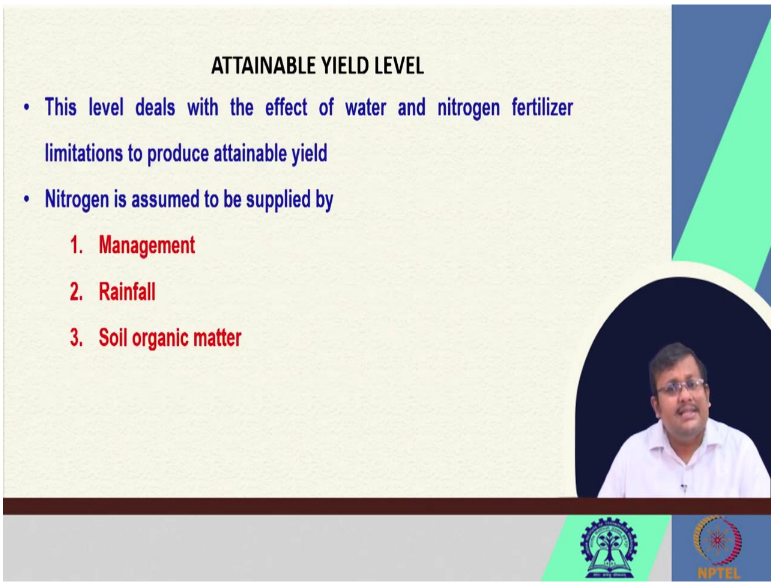

Now, let us see what is attainable. Now, this level deals with the effect of water and nitrogen fertilizer limitation to produce attainable yield. So, the basic difference between potential yield and attainable yield is in case of attainable yield we are also including the factors of fertilizer and also the water limitations. So, nitrogen is assumed to be supplied. We know that while we are discussing the nitrogen management, there are several ways of nitrogen inputs.

First of all, we can apply to the fertilizer management, nitrogen can be added through rainfall and also nitrogen can be added to soil organic matter.

So, these are some of the ways to which nitrogen can be managed, we have already discussed the nitrogen management previously, but, so, basically it is nitrogen management as well as water based limitations are the major controlling factors of attainable yield.

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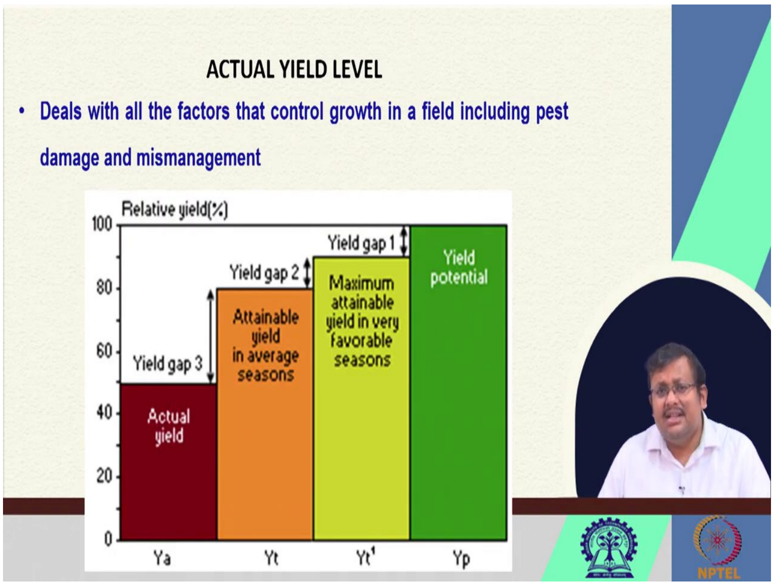

Now, the third yield is the actual yield. So, it deals with all the factors that control growth in a field including pest damage and mismanagement. So, in case of potential yield we are only considering the plant physiological factors, physiological processes, in the actual yield in the in attainable we are considering the variation due to nitrogen fertilizer as well as water limitation. And in case of actual yield level we are considering the factors including pest damage and mismanagement.

So, if we see that difference of potential yield to an attainable yield and actually yield these graph shows a good comparison. So, here you can see the highest yield or most optimum yield is the potential yield and of course, the attainability yield will be less than the potential because there is a variation due to the nitrogenous mentors and management and water management. So, we can see there are also two types of attainable. So, this yellow bar shows the maximum attainable yield in very favorable season whereas, this orange bar shows attainable yield in average season.

So, you can see there are yield gaps as we move from yield potential yield to maximum attainable yield and attainable yield and the final one is actual yield. So, this is the lowest one and here we are also including the impact of pest and disease attacks. So, these are the differences between potential yield and then attainable yield and actual yield.

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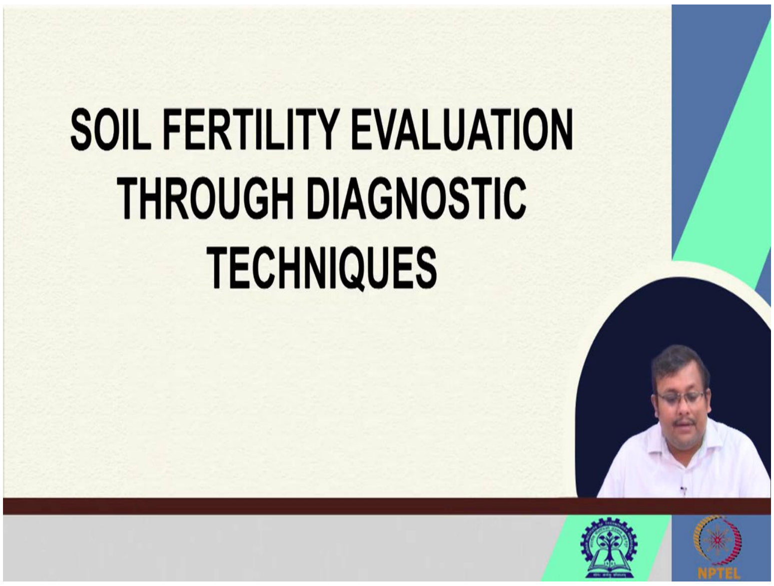

Now, let us discuss the soil fertility evaluation through diagnostic techniques and some of them we have already covered. Now, it will be a kind of a recap of those which we have already covered in details, so, that we can relate these to the upcoming discussion of nutrient management for plant growth or recommendation approaches.

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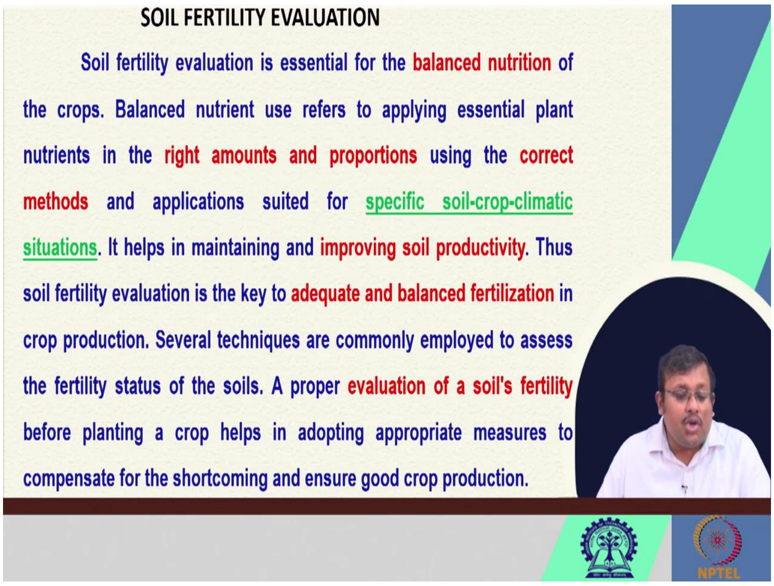

So, soil fertility evaluation as we know is essential for balanced nutrition of the crops. Now, what is balanced nutrition? Now, balanced nutrient use refers to applying essential plant nutrients in the right amount and proportion using the correct method. We are going to discuss the four concepts in upcoming lectures. But remember that not only the essential plant nutrients has to be applied, we have to apply them in the right amount and proportion using the correct method and application suited for specific crop and soil crop climatic conditions. So, it has to be used for specific soil crop climatic situation.

Now, balance crop or for balance fertilization for crops always helps us in maintaining and improving the soil productivity. The soil fertility valuation is the key to adequate and balanced fertilizer in the crop production. If we do not know what is the current nutrition status of the soil, we cannot formulate the balanced fertilization strategy for better and optimum growth of the plant. Now several techniques are commonly used to assess the soil fertility and now a proper evolution of soil fertility before planting a crop helps in adopting appropriate measures to compensate for the shortcoming and ensure good crop production.

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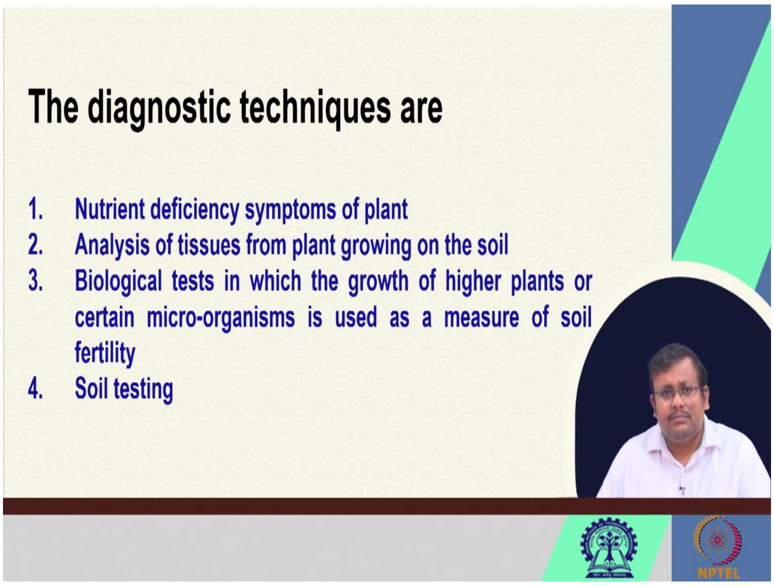

Now, we already know these concepts, what are the major diagnostic techniques. First of all nutrient deficiency symptoms of the plant, we have discussed them in details, while discussing different types of macro and micronutrients. And then tissue analysis from the plants which are growing in the soil. And then biological tests in which the growth of higher plants or certain microorganism is used as a measure of soil fertility. And finally, and most importantly, soil testing. We have already discussed those in details, we are just going to see the salient points so that we can relate them with the fertilizer recommendation strategies, which we are going to discuss.

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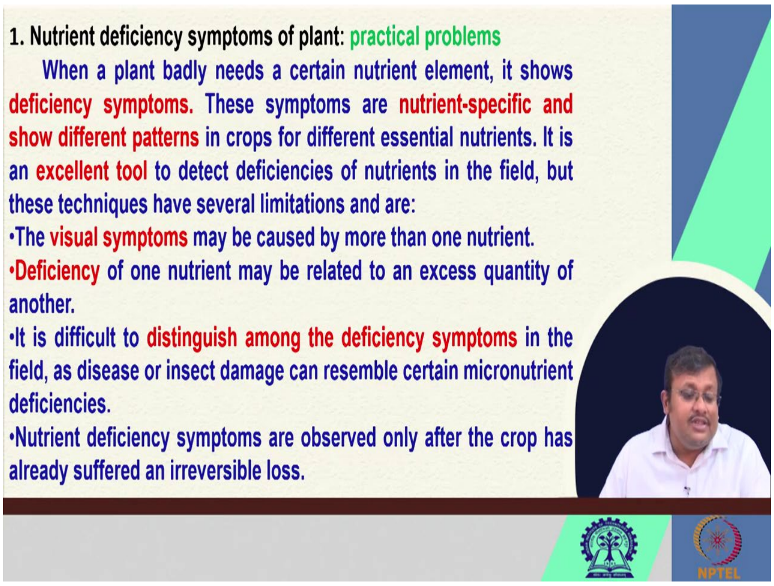

Now, if we see the nutrient deficiency symptoms of the plant, we have discussed them in details, already we have seen the visible symptoms of the plant, which they produce due to different types of nutrient states, either through nutrient deficiency or due to nutritional nutrient toxicity we have discussed. However, we have to also discuss some of the practical problems, while we use the deficiency visual deficiency symptoms to correct the soil fertility and deduce the balance fertilization dose. There are some practical problem.

First of all, when we know that when a plant badly needs a certain nutrient element, it shows the deficiency symptoms. So, these symptoms are very much nutrients specific we know and also shows different patterns in crop for different essential nutrients, we know that. For example, in case of nitrogen, we have seen yellowing of the leaves and also we have seen the stunting of the growth and also in case of phosphate, we phosphorus deficiency we have seen, reddish discoloration and all these different types of nutrients have their own deficiency visual deficiency symptoms.

Now, it is an excellent tool to detect the deficiencies of nutrients in the field, but these techniques have several limitations. What are these limitation? First of all, the visual symptoms may be caused by more than one in nutrient. So, there are some visible symptoms which may cause by more than one nutrient. So, there is always chance of confusion to identify what is the proper nutrition deficiency or deficient nutrient. Second is deficiency of one nutrient may be related to excess quantity of another. So, there are several nutrient antagonism we have already discussed or when there are nutrient antagonism that can also creates deficiency of a specific nutrient when there is an excess quantity of another nutrient. For example, phosphorus and zinc shows this type of relationship.

Now, it is difficult to distinguish among the deficiencies in terms in the field as disease or insect damage can resemble certain micronutrient deficiencies. So, when there are diseases or insect damages, you can see that some visual deficiency symptoms resemble with the nutrient deficiency visible symptoms. So, that also creates confusion. And another one is nutrient deficiency symptoms are observed only after the crop has already suffered and irreversible loss. So, if we want to take some PMT measure to correct the nutritional problem or nutrient deficiency in the soil, visual deficiency symptoms may not be the optimum solution.

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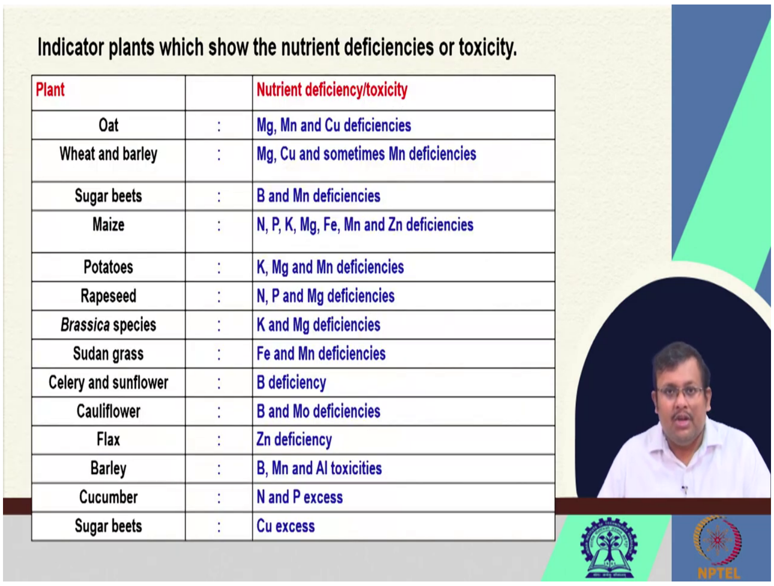

So, we also know there are several indicator plans, we know for Oat, Oat is can be used for identification of nutrient deficiencies toxicity or magnesium, manganese and copper deficiency. So, we can see the magnesium, manganese and copper deficiency by Oat. We can use wheat and barley for identifying the magnesium and copper and sometimes manganese deficiencies. We can use sugar beet to see the boron and manganese deficiency. We can use maize for nitrogen, phosphorus, potassium, magnesium, iron, manganese and zinc deficiencies. Potatoes can be used for potassium, magnesium and manganese deficiencies.

Rapeseed can be used for nitrogen, phosphorus and magnesium deficiencies. Brassica species can be used for potassium and magnesium deficiencies. Sudan grass can be used for iron and manganese deficiencies. Celery and sunflower can be used for boron deficiency. Cauliflower can be used as a indicator plant for boron and molybdenum deficiency. And then we can see flax can be used for zinc deficiency. Barley can be used for boron, manganese and aluminum toxicities. Cucumber can be used for nitrogen and phosphorus excess, and then sugar beets can be used for also we have seen. Sugar beets can be used for boron and manganese deficiencies. We can also use sugar beets for excess of copper in the soil.

So, these are some of the indicator plans. And so, we have this now, we know the what are the drawbacks of visual deficiencies in terms of the plant.

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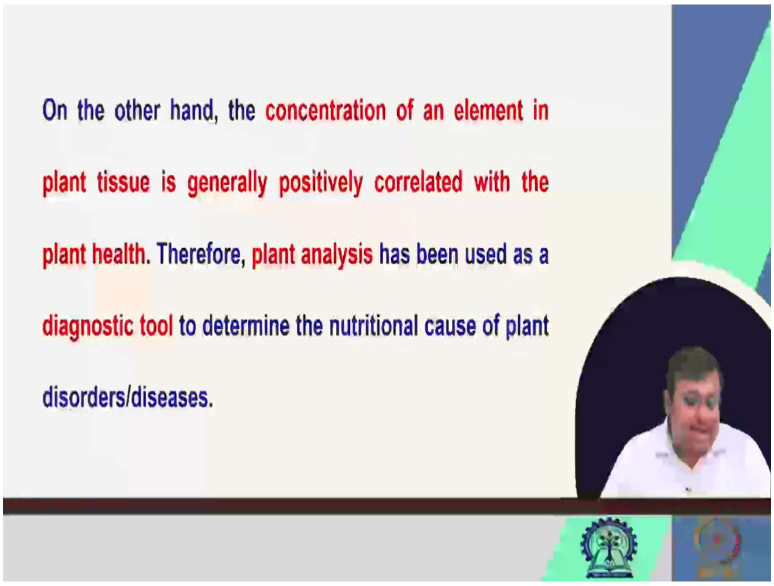

Now, on the other hand concentration of an element in plant tissue is generally positively correlated with the plant health. Therefore, plant analysis specifically tissue analysis has been used as a diagnostic tool to determine the nutritional cause of plant disorder or diseases.

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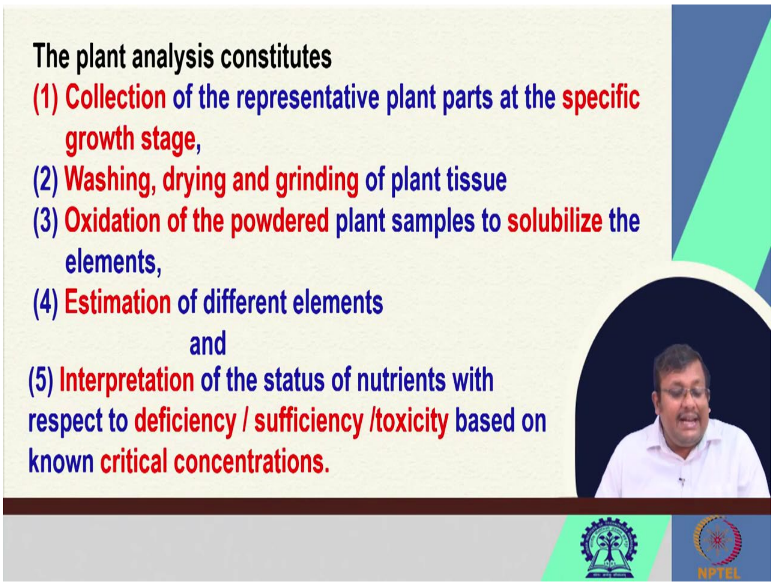

So, the plant analysis generally constitutes of several steps. We have already discussed just to recap a collection of the representative plant part at the specific growth stage. Then, we wash them, dry them and grind them and then oxidation of those powder plant samples to solubilize the elements which are there in the tissue. Their estimation of different elements and interpretation of the mutation status with respect to deficiencies, sufficiency, toxicity, and based on the non-critical concentration. So, these are the steps of plant tissue analysis.

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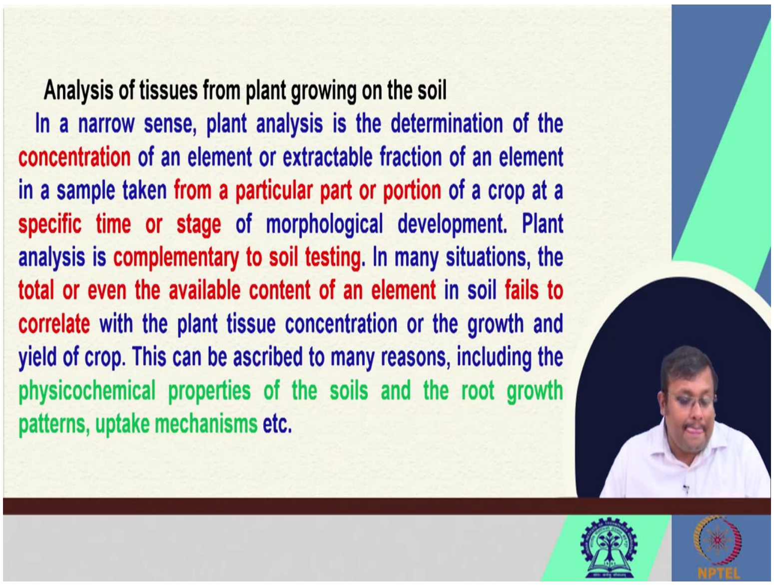

Now, in the narrow sense, plant analysis is basically the determination of the concentration of an element or extractable fraction of an element in a sample taken from a particular part or portion of the crop at a specific time or stage of morphological development we know that.

Now plant analysis is complementary to soil analysis or soil testing. Now, in many situation, the total or even available content of an element in soil fails to correlate with the plant tissue concentration or the growth and yield of the crop. These are several there are several reasons. First of all, for example, physiochemical soil physical chemical properties are so complex and they have so many interactions among them that can also influence the mismatch between the plant tissue concentration as well as the soil level of a nutrient.

And also due to the variation of the root growth patents and uptake mechanism there is also discrepancies between available nutrient content in the soil as well as the concentration of the nutrient in the plant tissue. Now, these are some of the reason where we can see some discrepancies between the plant tissue concentration as well and available nutrients in the soil.

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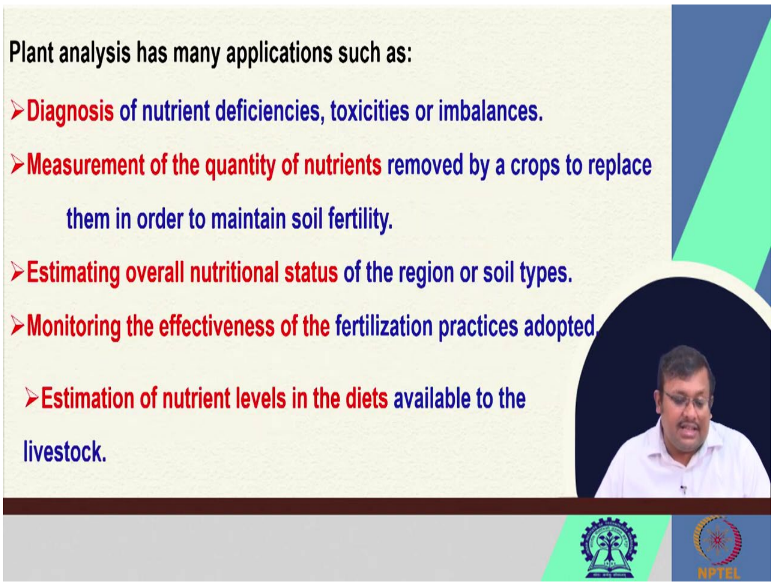

Now, in case of plant tissue analysis, they have different types of application. First of all, diagnoses of nutrient deficiencies, toxicities and imbalances and then measurement of quantity of the nutrients removed by the crops, to replace them in order to maintain soil fertility. Then estimation of overall nutritional status of the region or soil types and then monitoring the effectiveness of the fertilization practices adopted and then estimation of the nutrient levels in the diets available to the livestock.

So, these are some of the practical application, when it comes when we go in we discuss the plant tissue analysis for nutritional deficiency identification.

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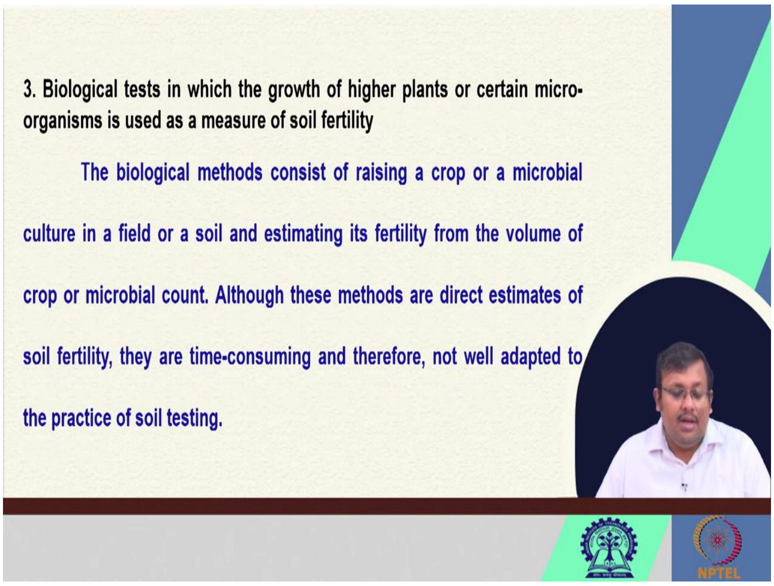

Now, the third approach for nutritional status of the soil for testing the nutritional status of the soil is a biological test using some higher plants are some specific microorganisms. Now, the biological we are also known as these are also known as the biological methods. Now, these biological methods are basically depends on raising a crop or in microbial culture in a field or the soil and estimating its fertility from the volume of the crop on that microbial accounts.

Now, although these methods are direct estimates of soil fertility, they are time consuming and therefore not well adapted to the practice of soil testing. So, these are some of the drawbacks of this biological test.

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Now, the absence of nutrients site, if we considered the biological pest in the absence of nutrients, certain microorganisms exhibit behavior similar to that higher plants. For example, if you see the growth of Azotobacter and Aspergillus niger those microorganisms or growth of those microorganism reflects nutrient deficiency in the soil. Now, the soil is rated from very deficient to not deficient in the respective elements depending on the amount of the colony growth.

So, basically those nutrients will be taken up by those microorganisms and they will develop the colony and based on the number of colonies, we can identify we can categorize the nutritional status of the soil or media. Now, in comparison with methods that utilize higher plants, microbiological methods are rapid, simple and require little space. So, these laboratory tests are however not very commonly used in India. In India, we generally use either deficiency symptoms as well as soil testing based to evaluation of soil fertility and to some extent plant tissue test.

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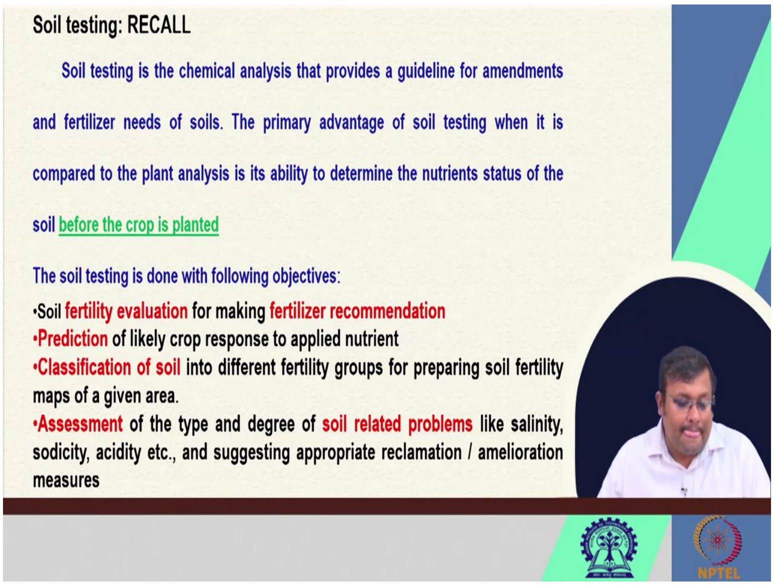

Now, soil testing again we have discussed in details. Now, we know that soil testing is the chemical analysis that provides a guideline for amendments and fertilizer need of soil. Now, the primary advantage of soil testing when it is compared to the plant analysis is its ability to determine the nutrient status of the soil before the crop is planted. Now, this is the method which we can use before the planting of the crop. So, the soil testing is done with the following objectives we already discussed the soil testing objectives but again that soil fertility evaluation for making fertilizer recommendations are first and foremost objective then prediction of likely crop response to apply nutrient.

Then classification of soil into different fertility groups for preparing soil fertility maps of a given area. And then assessment of the type and degree of soil related problems like salinity, sodicity, et cetera and suggesting appropriate reclamation and emulation measures. So, once we measure the soil fertility using soil testing methods, we will be able to see whether the soil is problematic soil or not. If the soil is problematic, that means if it is as highly acidic soil or alkaline or it is a kind of a saline soil then we can prescribe the appropriate amelioration measures like lime application, gypsum applications and then frequent irrigation application for reducing the salinity organic matter applications.

So, these are some of the remedial measures or amelioration measures to correct the soil fertility. So, these are very much important as far as the soil testing is concerned.

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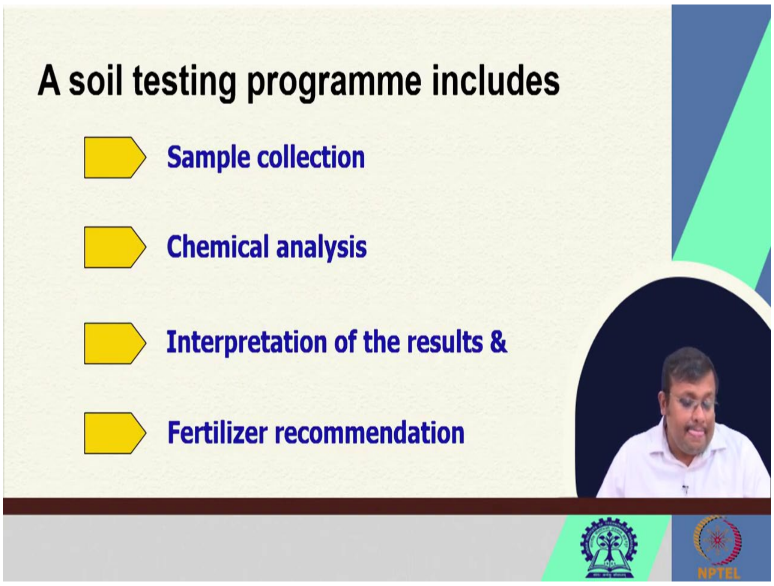

Now, a soil testing programmes, we know that is basically composed of several steps like sample collection, chemical analysis, interpretation of the results and fertilizer recommendation.

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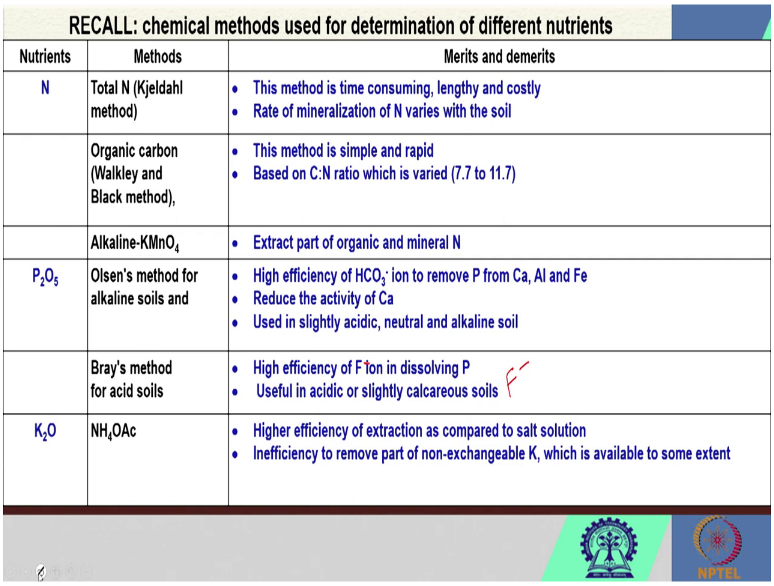

So, if we also recall the chemical methods which we used for determination of different nutrients, when we go for the total nitrogen estimation, we use a Kjeldahl method. Now, there are some merits and demerits. First of all, this method is time consuming, lengthy and costly. So, this is the major demerit and rate of mineralization nitrogen varies with the soil. Now, organic carbon we generally use by Walkley and Black method and this method is simple and rapid and based on the CN ratio, which is of course variable from one cell to another soil.

Then alkaline KMnO4. So, once we calculate this organic carbon from there, we can get these you can use the CN ratio to calculate the nitrogen. So, this is an another indirect way however, the CN ratio varies from one soil to another soil. Then alkaline KMnO4 method which is used for nitrogen and which extract part of organic and mineral nitrogen. So, this is the most widely used method alkaline KMnO4 to identify the available fraction of nitrogen.

Now Olsen’s method for alkaline soils for when we talk about the phosphate we use a Olsen’s method for alkaline and soils and Bray’s method for acid soils. Now, Olsen’s methods are highly effective for these alkaline soil because high efficiency of this bicarbonate ion which is also in reagent sodium bicarbonate, which you use this bicarbonate ion can remove the phosphorus from calcium, aluminum and iron and reduce the activity of the calcium and basically it is used in slightly acidic neutral and alkaline soil.

On the contrary, Bray’s method can be used to extract the phosphorus from the acidic soil. So, and for potassium that is K2O we can measure by neutral normal ammonium acetate which is showing the higher efficiency of extraction as compared to salt solution and it is inefficient to remove part of non-exchangeable potassium, which is available to some extent.

Now, here remember that these the high efficiency of this fluoride ion, which is F minus please, so, this F minus let me so, the fluoride ion is able to dissolve this phosphate from the soil specifically from the acidic soil condition and thereby they can measure the available phosphate and so, these are the basic methods for measurement of different nutrients available and total form of different nutrients.

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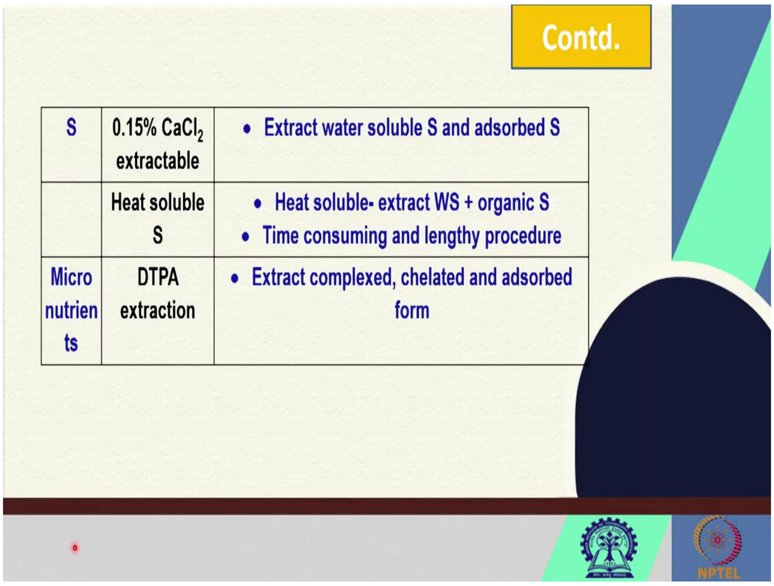

So, if we go ahead and see for Sulphur, we can see, we use the 0.15 percent Calcium chloride to extract the water soluble Sulphur and adsorbed Sulphur and heat soluble Sulphur can extract the water soluble Sulphur and organic Sulphur. It is also time consuming and lengthy procedure. And in case of micronutrients we use DTPA as the chelating agent and we extract the complex chelated and absorb. We can extract these nutrients in the complex chelated and adsorbed forms. So, these are the methods of soil testing.

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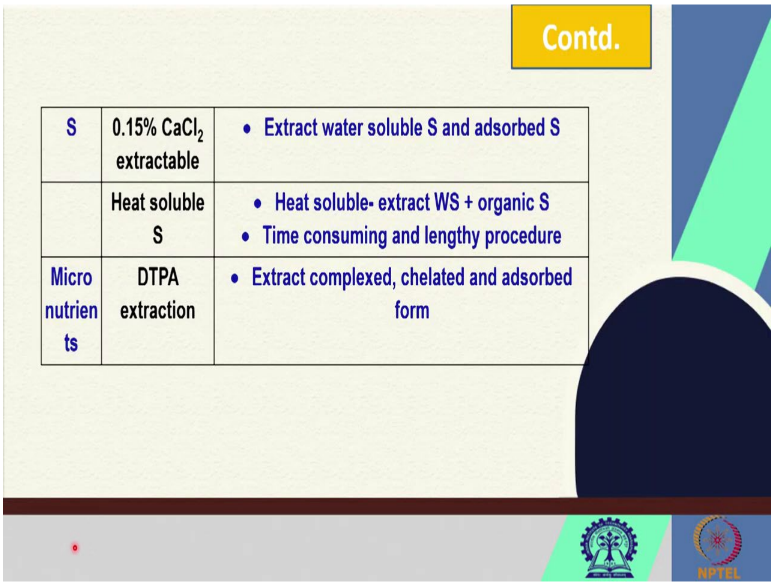

Now, the next is once we do the testing next is interpretation. Now, based on the nutritional status we can divide them into low medium and high and of course, we have to also consider the soil condition whether it is the acidic or alkaline or saline soil and of course, it has to be this interpretation has to be soil specific and crop specific.

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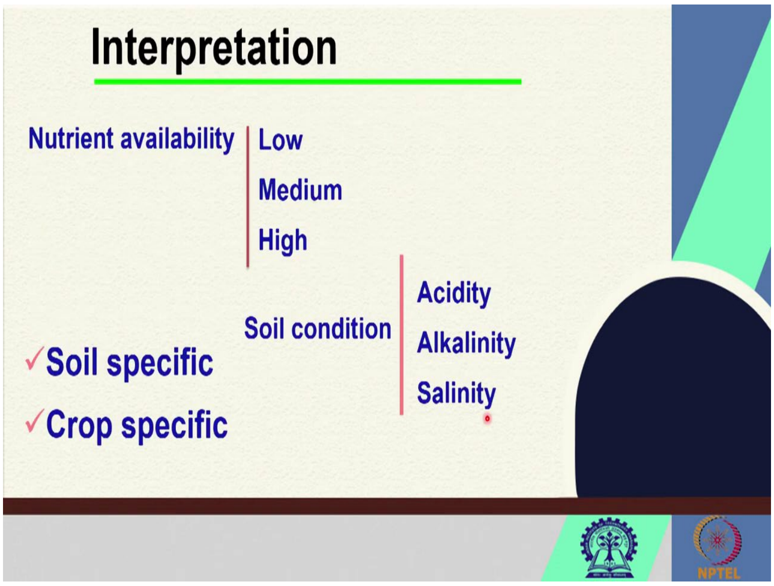

And the next is the recommendation. So, more fertilizer does not manifest more uptake or yield. So, this is very important and we can see these from the next couple of slides.

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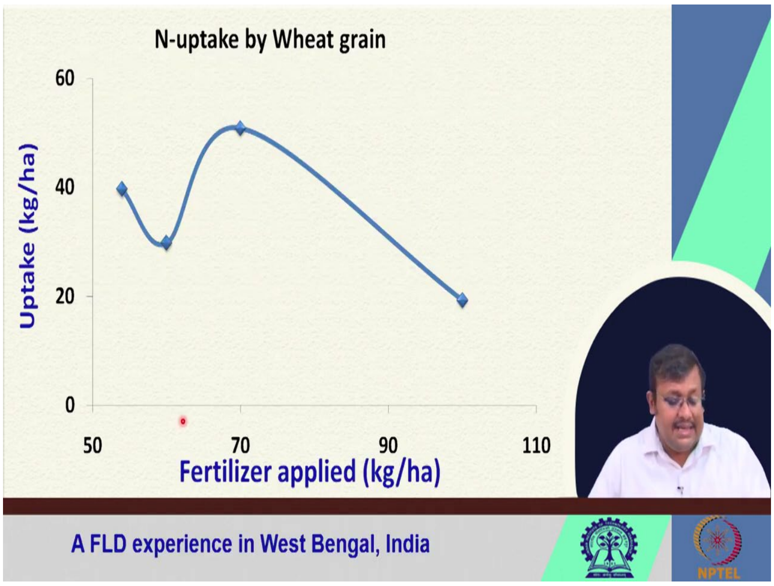

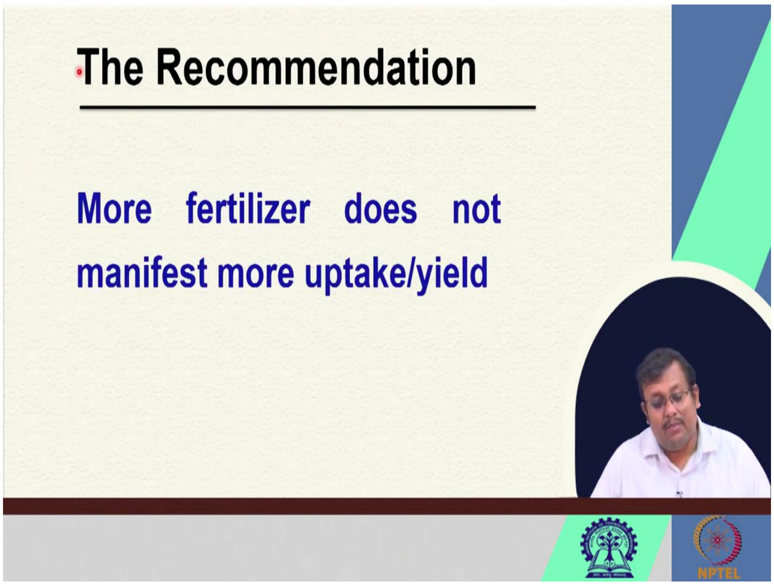

So, if we can see here this shows an FLD experience in West Bengal in India. So, as we increase the fertilizer application you can see the uptake of the nutrient is not increasing but it is decreasing and also it is increasing somewhat up to 70 kg per hectare and then it starts decreasing. So, we can see it is nitrogen uptake with grain is not always positive with the increasing amount of fertilizer, so, that shows that more fertilizer does not manifest more uptake or yield.

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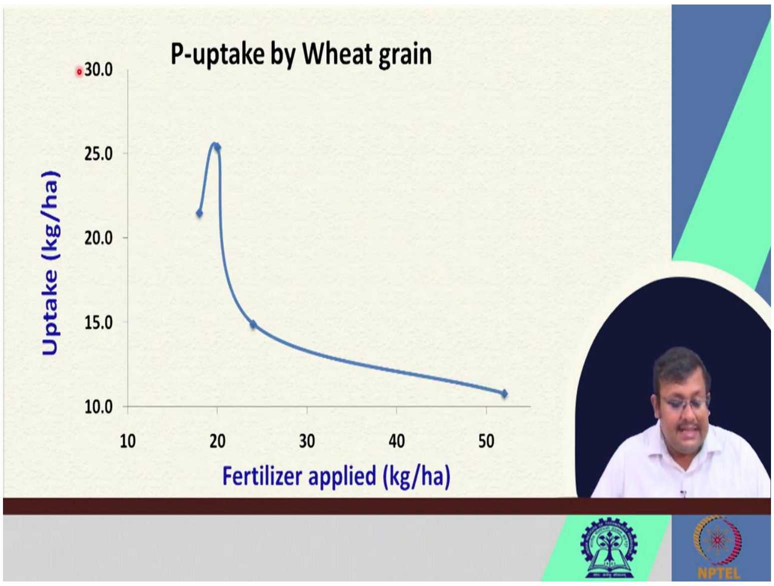

Similarly, if we can see phosphorus uptake by wheat grain when we are increasing the phosphate concentration in the fertilizer, we can see the yield is also decreasing after a certain level.

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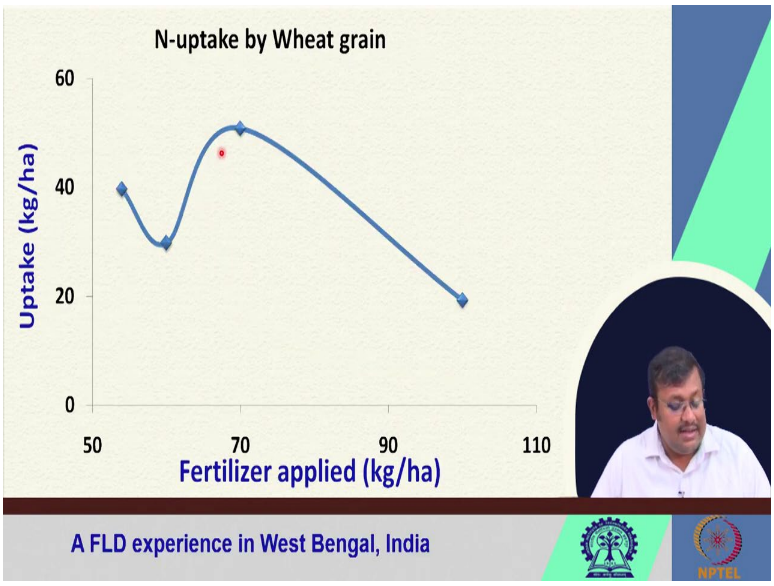

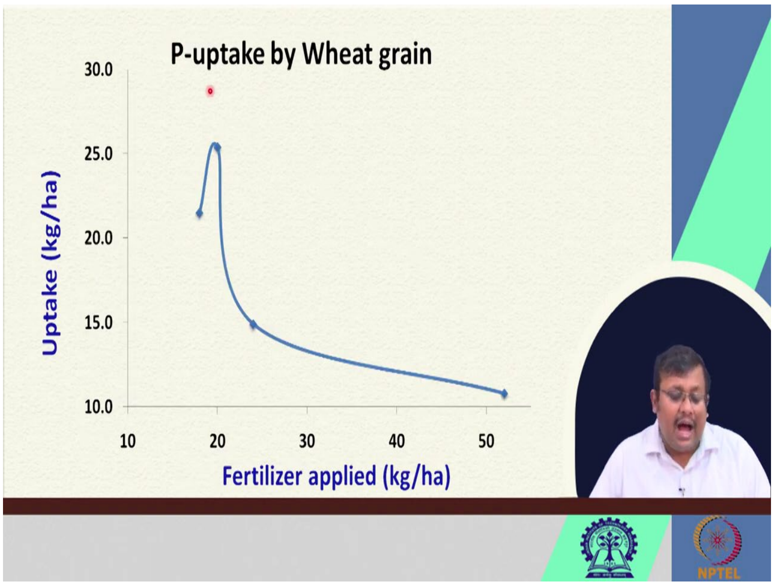

So, we can see for nitrogen and phosphate the higher fertilizer not always manifests the higher uptake or yield of the crop.

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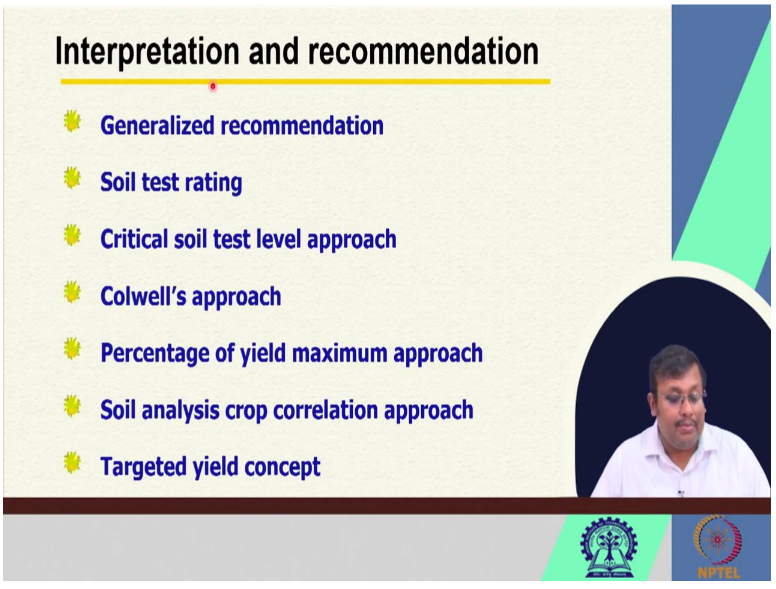

So, interpretation recommendation and of course, while you go for the interpretation recommendation, we use some general recommendation or generalized recommendation. We can use some soil test rating. We can use critical soil test level approach. We can also use Colwell's approach. We also use percentage of yield maximum approach and soil analysis crop correlation approach and then targeted yield concepts. So, these are some of the approaches which we use for interpretation and recommendation of the soil fertility status.

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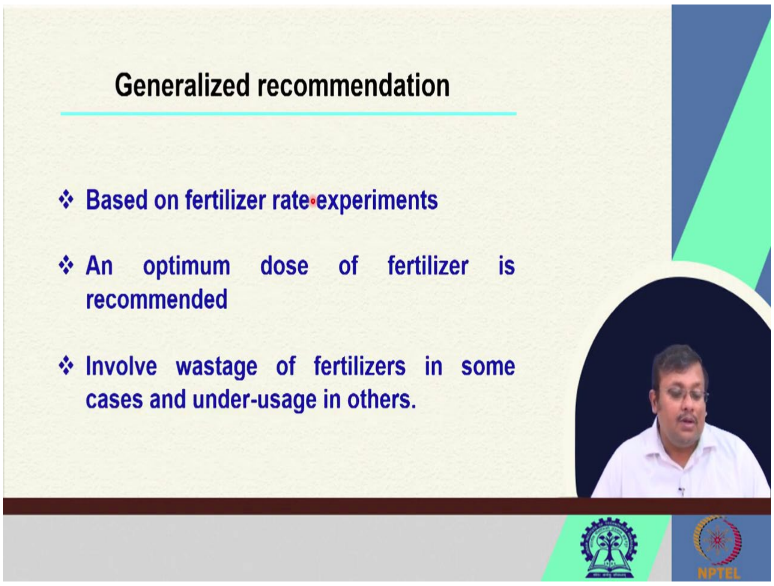

Now, generalized recommendation it is based on fertilizer rate experiments and it is an optimum dose of fertilizer is recommended and it the generalize, recommendation practices involve wastage of fertilizers in some cases and under usage in others. So, generalized recommendation processes can create a wastage of fertilizer in some cases and under usage in of some fertilizers.

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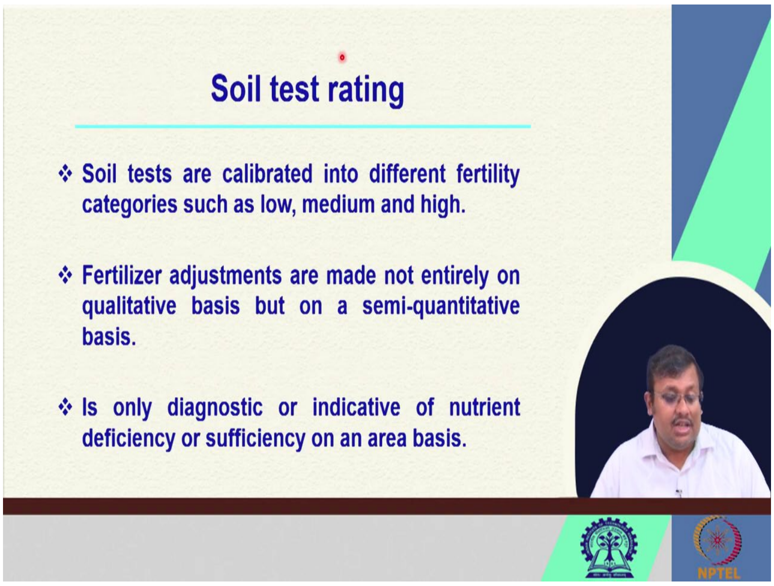

Now, the soil test ratings as a soil test are calibrated into different fertility categories like low, medium and high and fertilizer adjustments are may not entirely on quality business, but on a semi-quantitative basis and it is only diagnostic or indicative of nutrient deficiency or sufficiency on an area basis.

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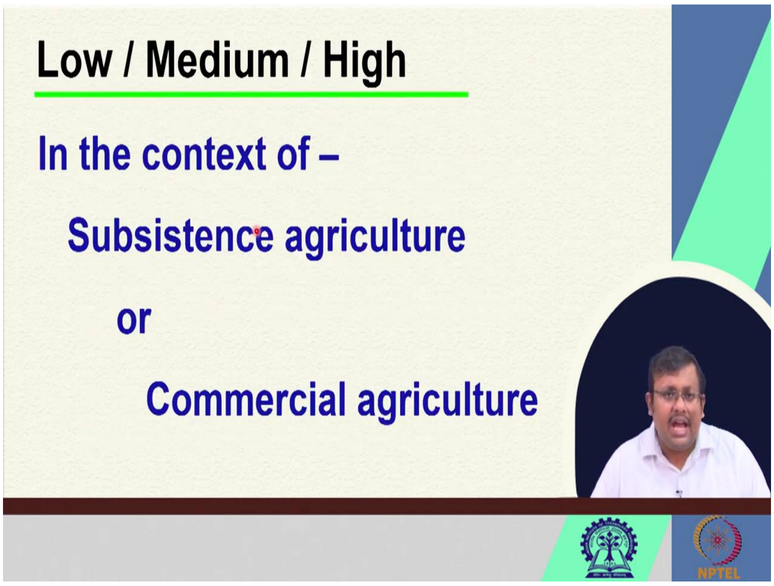

And this low, medium, high concept which we use for fertility status description it is in the context of subsistence of agriculture or commercial agriculture.

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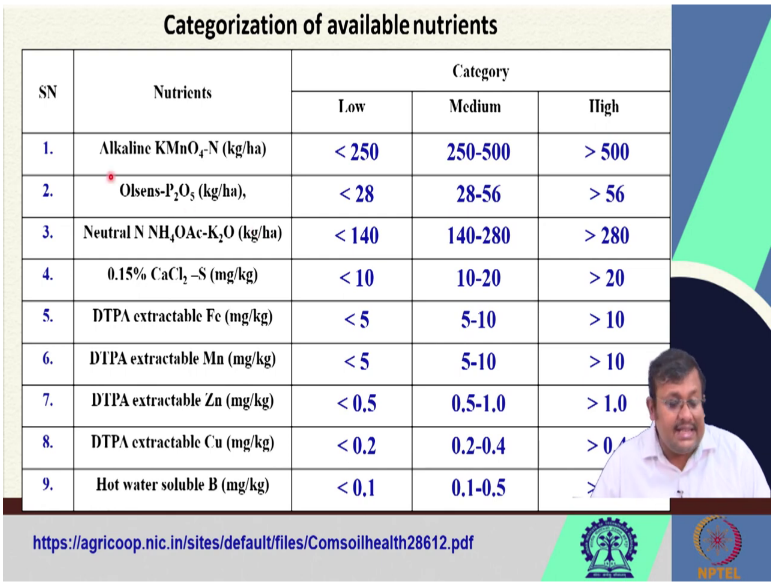
Categorization of available nutrients

SN	Nutrients	Category		
		Low	Medium	High
1.	Alkaline $KMnO_4$-N (kg/ha)	< 250	250-500	> 500
2.	Olsens-P_2O_5 (kg/ha),	< 28	28-56	> 56
3.	Neutral N NH_4OAc-K_2O (kg/ha)	< 140	140-280	> 280
4.	0.15% $CaCl_2$ –S (mg/kg)	< 10	10-20	> 20
5.	DTPA extractable Fe (mg/kg)	< 5	5-10	> 10
6.	DTPA extractable Mn (mg/kg)	< 5	5-10	> 10
7.	DTPA extractable Zn (mg/kg)	< 0.5	0.5-1.0	> 1.0
8.	DTPA extractable Cu (mg/kg)	< 0.2	0.2-0.4	> 0.4
9.	Hot water soluble B (mg/kg)	< 0.1	0.1-0.5	[illegible]

https://agricoop.nic.in/sites/default/files/Comsoilhealth28612.pdf

So, we can see if the categorization of available nutrients, we can see alkaline KMnO4 has a medium value range of 250 to 500 kg per hectare. In case of Olsen P2O5, we can see 28 to 56. Neutral normal ammonium acetate extracted potassium oxides, we can see 140 to 280. In case of Sulphur, 10 to 20 ppm. Then for iron, manganese, zinc and copper we can see 5 to 10 and then 0.5 to 1 and 0.2 to 0.4. And hot water soluble boron in ppm 0.1 to 0.5 ppm. So, these are the medium ranges and lower than that will be low category and higher than that will be higher category.

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So, guys, we have completed the discussing a discussion about the attainable concept as well as the actual concepts. And we have seen the salient features of the soil fertility evaluation methods and how we go for soil fertility interpretation and recommendation.

And let us wrap up this lecture here and in the next lecture we are going to discuss the other important concepts of fertilizer recommendation for optimum growth of the plant and we will see how we can use different other approaches for formulating a balanced nutrition for crop growth.

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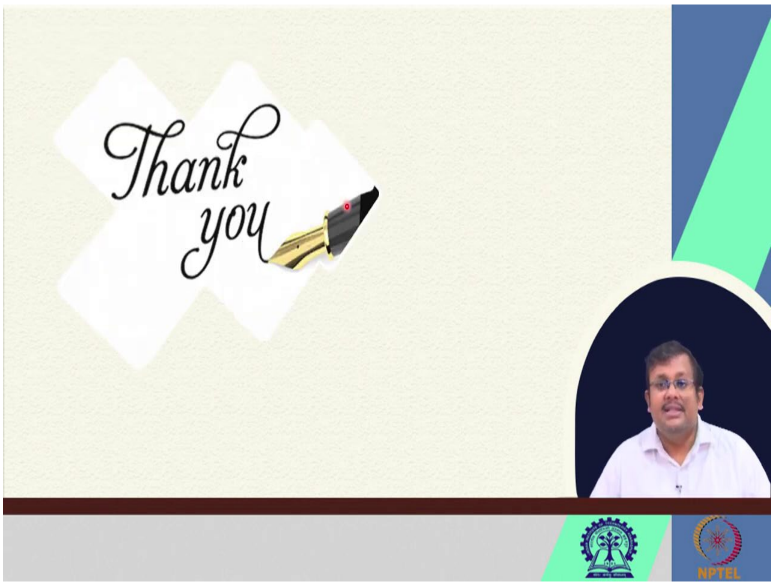

So, let us wrap up this lecture. Thank you. Let us meet in our next lecture.