Soil Fertility and Fertilizers
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Lecture: 30
Soil Testing and Soil Fertility Evaluation Methods (Contd.)

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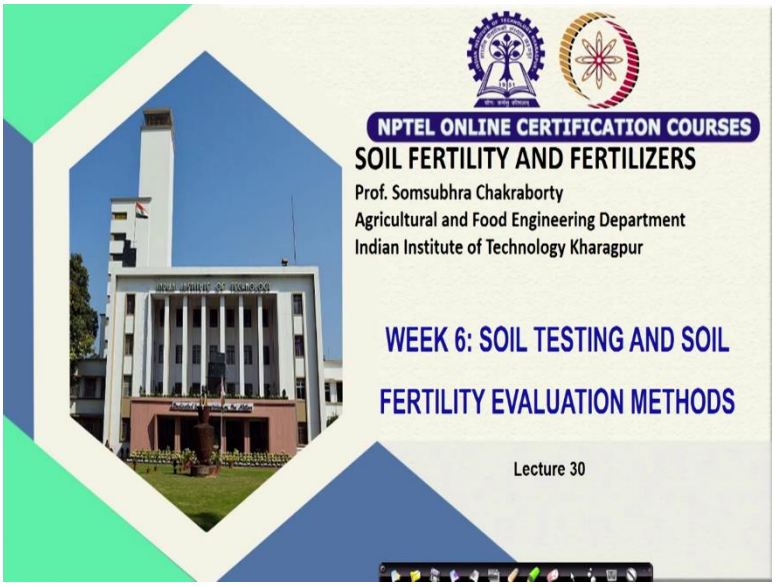

Welcome friends to this last lecture of week 6, lecture number 30. And in this week, we are discussing about Soil Testing and Soil Fertility Evaluation Methods. Now, in my previous lectures of this week, we have discussed about soil testing, the basics of soil testing, why we do soil testing, what are the advantages of soil testing and then we have discussed about how to do different types of plant analyses, plant indicate, you know plant based indication of fertility status, plant nutrition status, critical nutrient concept.

And also we have discussed about how to collect the soil samples, what are the different types of sampling designs and also we have discussed about sample preparation, sample storage, sample transportation methods and we have also discussed about how to determine soil pH, soil electrical conductivity and soil available nitrogen and phosphorus, we have started discussing soil available potassium, which we are going to continue today.

So, if you remember that these available nutrients are the indicator of soil fertility status and using these different types of extractants we measure the quantity of different elements or available nutrients, both macro and micronutrients in the soil.

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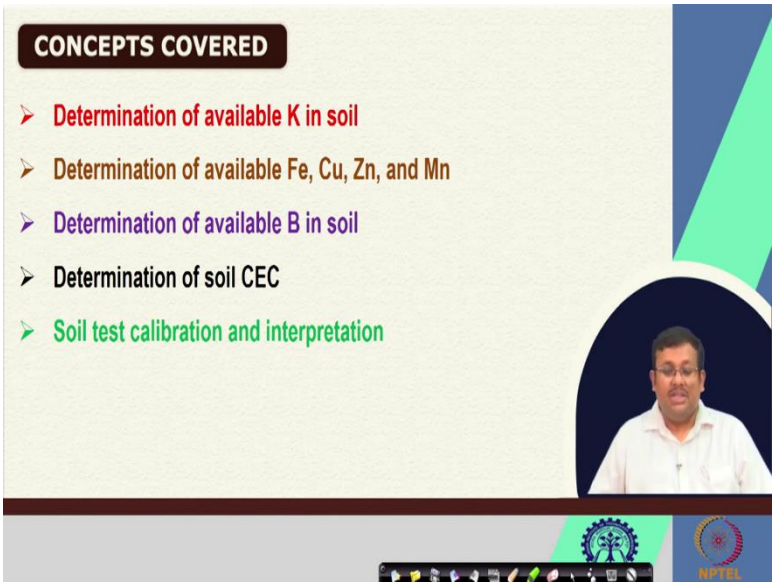

So, these are the concepts which we are going to cover in this lecture. First of all, we are going to cover determination of available potassium in soil and then we are going to discuss about how to measure the available iron, copper, zinc and manganese in soil and then how to measure available boron in soil. Then, we are going to see how to determine an important soil feature that is soil catenation capacity. And then finally, we are going to learn how to do soil test calibration and interpretation.

Now, these all are very important, apart from determination of pH, EC, organic matter and available nitrogen and phosphorus these are also very important soil fertility parameters. And we are going to discuss in brief about different determination methods for these macro and micronutrients.

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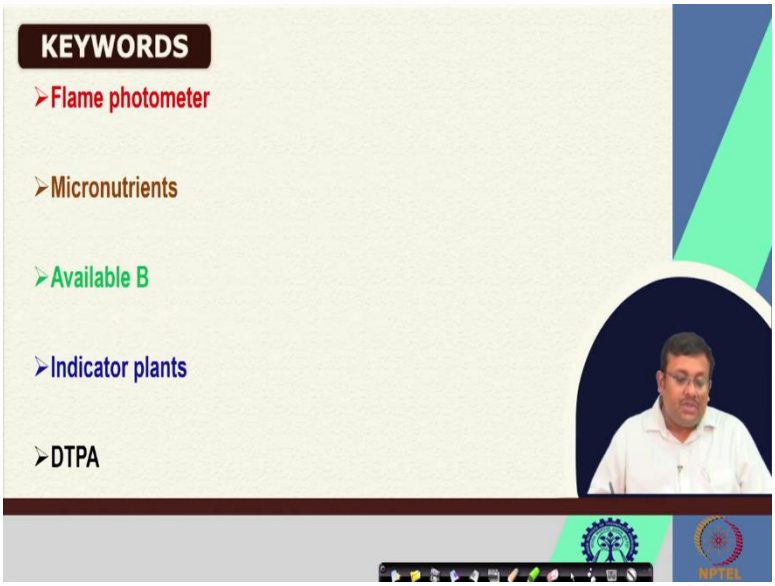

So, these are the keywords of this lecture Flame photometer, Micronutrients, Available boron, Indicator plants, DTPA these are some of the keywords for this lecture.

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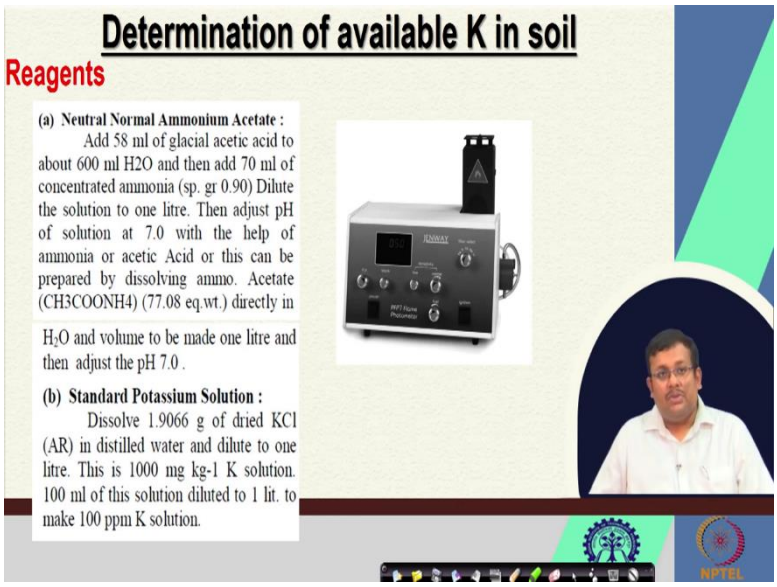

Now, we have already started discussing about available, determination of available potassium in soil which is one of the important soil macronutrient. Now, for determination of available potassium in soil we require two major nutrients, reagents. First of all is neutral normal ammonium acetate and this is the method of preparing the neutral normal ammonium acetate please go through it later if you are interested.

And secondly, the another important reagent is standard potassium solution for creating the standard potassium solution we need to dissolve 1.9066 grams of dried potassium chloride in distilled water and dilute to 1 liter and this is basically 1000 ppm potassium solution and 100 ml of this solution diluted to 1 liter to produce a 100 ppm potassium solution.

Now, why we require this? We require this 100 ppm potassium solution to create different standards for development of a standard, internal standard curve. Now, in the flame photometer you know, for standardizing the flame photometer, we require some standard solution, standard potassium solution. So, the standard potassium solution will be made from this 100 pm potassium solution.

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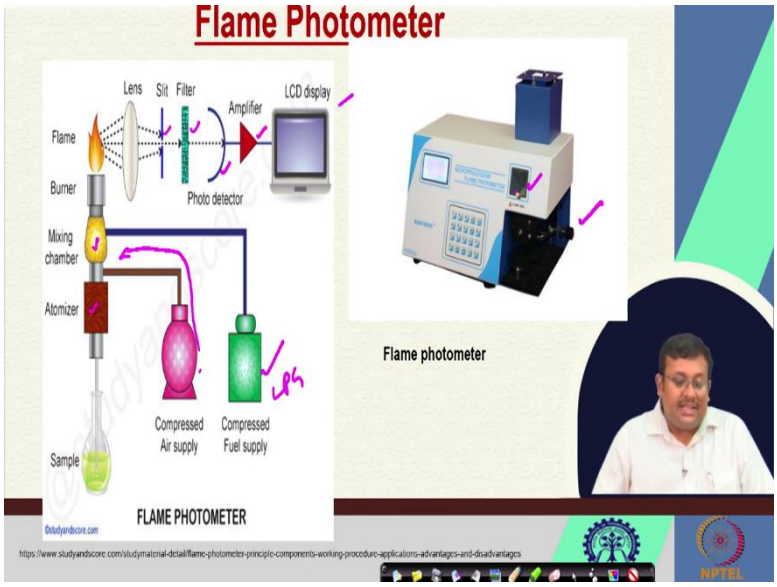

Now, this is a flame photometer and this is the schematics of flame photometer we can see that generally the sample is being aspirated in the atomizer and there is a air pump which, generates the compressed air and which supplies the compressed air and also the fuel supply, compress fuel supply in case of flame photometer we generally use LPG gas and then we you know mix the sample will be mixed with this air in this mixing chamber and it will go to the burner where the flame I mean where you know it will it will get the energy from the flame and this flame will be generated by this LPG gas.

Now, after these molecules or atoms will be energized, then they will release the characteristics, wavelength or characteristics light which will be focused through lens and which will go through slit and ultimately we will select the particular filter which is required

for particular element and then it will go to photodetector and will be for subsequently amplified to LCD display, which will give us the concentration of potassium.

So, this is how the flame photometer generally works and this is the you know actual you know image of a flame photometer and in this flame photometer there is an window which is called the flame view window. So, from this flame view window you can check the verify or check the color of the flame because for individual elements the color of the flame will vary. So, this is how this instrument basically works.

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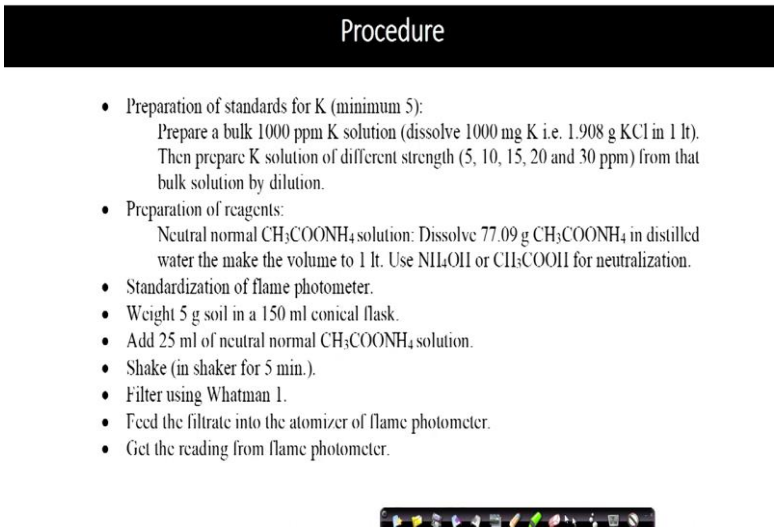

Now, if we go ahead and see the procedure of estimation of available potassium, first of all we have to create the standard for potassium as I have already mentioned, we have to prepare the standard for potassium at least 5 and then, you know, we have to prepare a bulk 1000 ppm potassium solution which I have already discussed, and then we have to prepare 100 ppm K solution from this 100 ppm K solution will produce the K solution of different strength like 5 ppm, 10 ppm, 15 ppm, 20 PPM and 30 ppm.

Now, also I have told you that we need to prepare these neutral normal ammonium acetate solutions. So, after we take these thing, after we create these standard from 5, 10, 15, 20 and 30 ppm, we need to first standardize the flame photometer after we standardize the flame photometer we need to weigh 5 gram of soil in 150 ml of conical flask and then we have to add this 25 ml of neutral normal ammonium acetate.

So, what will happen this ammonium acetate will dissociate to form the ammonium ion and these ammonium ions will replace the potassium which are adsorbed onto the clay surface, and this potassium will come into the solution and subsequently we will measure this potassium concentration in this extracted solution.

Now, once we add this 25 ml of neutral normal ammonium acetate solution, we need to shake it for 5 minutes and then we need to filter it using Whatman number 1, and then we need to fit the filtrate into the atomizer of flame photometer and then finally, we get the reading from the flame photometer. So, this is how we measure the available potassium in the using the flame photometer.

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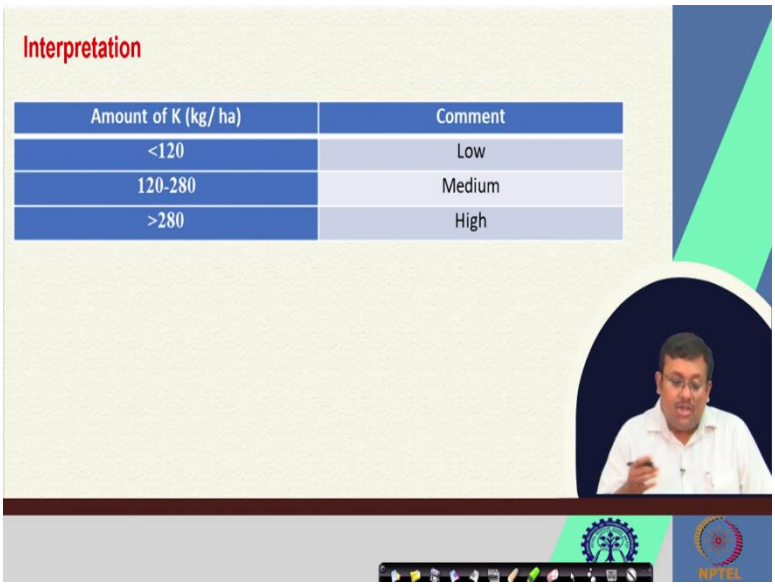

Now, how to interpret these results. So, there are some certain calculations I have not shown that calculation here, but the interpretation is based on the amount of potassium in kg per hectare, we can designate low medium and high content of course, when it is less than 120 kg we call it a low concentration, when it is 120 to 280 kg per hectare, then we call it a medium content and when it is greater than 280 kg per hectare, then we call it a high content.

Now, remember that just like phosphorus in case of potassium also we need to convert this K into K2O. So, for converting that K to K2O we need to multiply with a factor of 1.2. So, using that factor 1.2 We can we can mult, we can convert this available potassium to available K2O. Generally, for fertilizer calculation we use P2O5 and K2O. So, the availability of the nutrients are also sometimes interpreted in in terms of available P2O5 and available K2O. So, this is how we do the interpretation.

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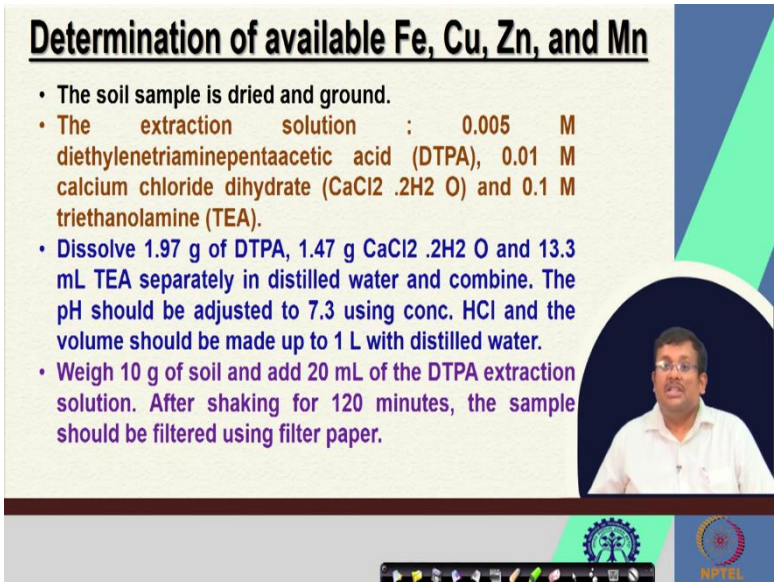

Next is the determination of available iron, copper, zinc and manganese. So, first of all we need to dry and ground the soil sample and here for extracting these iron, copper, zinc and manganese we will be using a DTPA solution. What is the full name of DTPA? DTPA is Diethylene Triamine Pantacetic Acid, so it is a chelating agent which will basically chelate all these micronutrients and then we will measure the concentration.

So, here in these extracting solution, it is basically a mixture of 0.005 Normal 0.005 Molar of DTPA then 0.01 Molar of calcium chloride dihydrate and 0.1 Molar of trithanolamine. So, we have to dissolve 1.97 gram of DTPA and 1.47 grams of calcium chloride dihydrate and 13.3 ml of triethanolamine separately in distilled water and then subsequently combine them and the pH of this mixture should be adjusted to 7.3 using concentrated HCL and the volume should be made up to 1 liter with distilled water.

So, this is about the extracting solution. Now, how to extract from the soil. So, first we need to weigh 10 gram of soil and then we need to add 20 ml of this DTPA extracting solution or extraction solution and then we need to shake it for 120 minutes after that the sample should be filtered using the filter paper.

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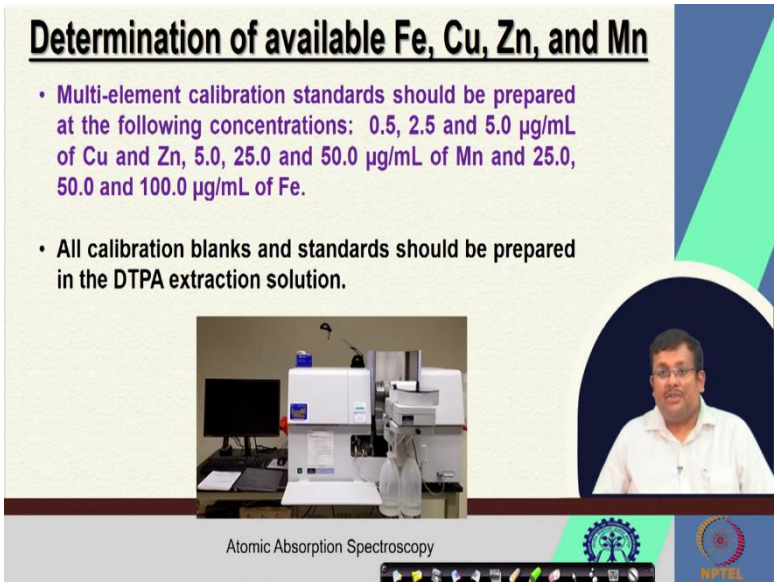

Once you filter that, then we need to develop a multi you know, we need to develop the we need to include the multi-element calibration standards for standardizing, the instrument. Now the instrument which we are going to use for determination of available for Fe, Cu, Zn and Mn is atomic absorption spectra photo meter and the principle is known as atomic absorption spectroscopy.

So, in this atomic absorption spectroscopy to standardize this instrument, we declare multi-element calibration standards for the following concentration what are those concentrations 0.5 ppm, then 2.5 ppm and 5 ppm of copper and zinc and then 5 ppm, 25 ppm and 50 ppm of manganese and 25, 50 and 100 ppm of iron.

So, once we standardize this instrument, all calibration blanks and standard should be prepared in the DTPA extracting solution. Remember that now, once we do that, then we can measure the concentration of these four micronutrients in the extracted solution and using these atomic absorption spectrophotometers.

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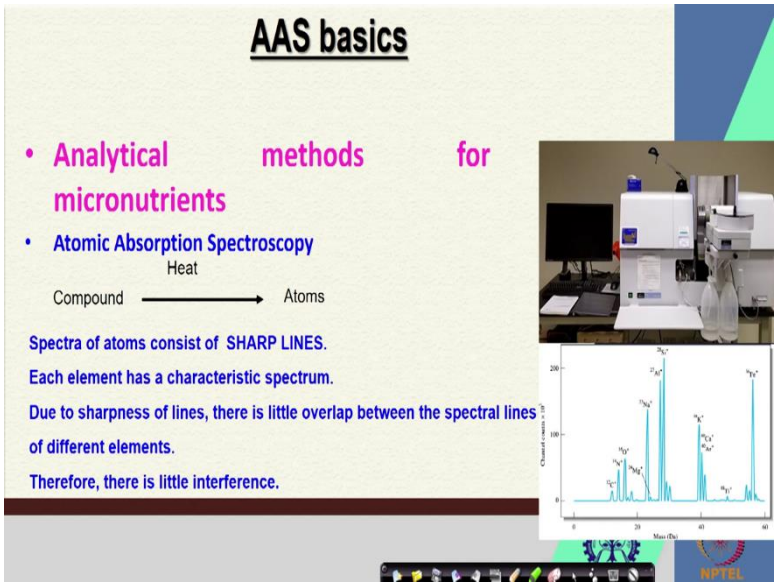

Now, to tell more about these atomic absorption spectrophotometers you know, in the basic principle of this, AAS that, these atomic absorption spectroscopy says that, when a compound is you know is heated by producing the temperature, it will be producing the atoms. Now, the spectra of the atoms consist of different types of sharp lines as you can see here, these are the sharp lines for different types of atoms. Now, each element has a characteristic spectrum. And due to sharpness of this line, there is little overlap between the spectral lines of different elements.

So, as a result, there is very little interference. So, this is how these atomic absorption spectroscopy basically works. This is a very important and widely accepted method and this instrument is being used for almost most of the soil testing labs for determination of available micronutrients specifically iron, copper, manganese and zinc.

Now, remember one thing apart from these atomic absorption spectrometer also we can also use ICP based methods. Now, for more details on the ICP based methods, you can follow the soil science and technology course, which I have offered previously in the NPTEL or there are plenty of materials available in the website which you can utilize to see the details of ICP.

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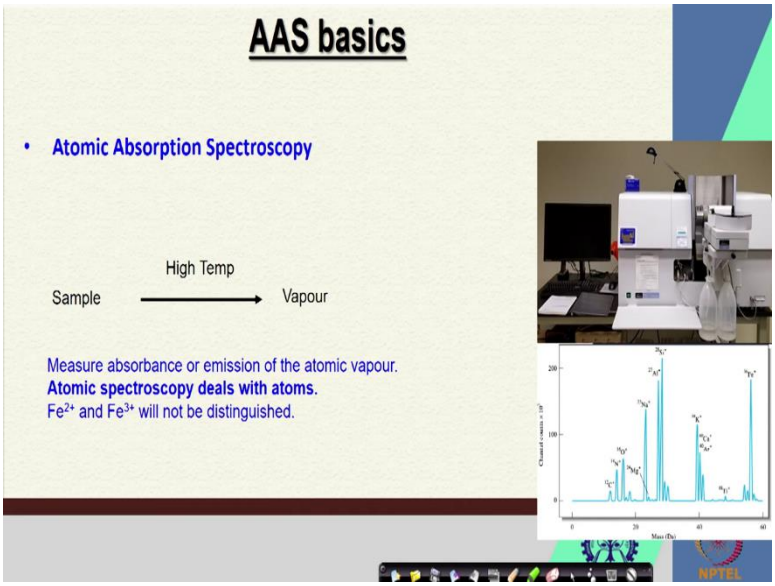

Now, to discuss more about these AAS remember that here in the AAS as we first inject the sample and using the high temperature it is converted into vapor and this instrument basically measure absorbance or the emission of the atomic vapor and the atomic spectroscopy, this is basically atomic spectroscopy. So, basically this atomic spectroscopy deals with atoms and Fe 2 plus and Fe 3 plus of course, here we cannot measure the ions in this method.

So, these Fe 2 plus and Fe 3 plus cannot be distinguished by the AAS instrument. So, atomic absorption spectroscopy can give you the total element content only, it cannot give you the ionic content. So, these is the these are the basics of atomic absorption spectroscopy.

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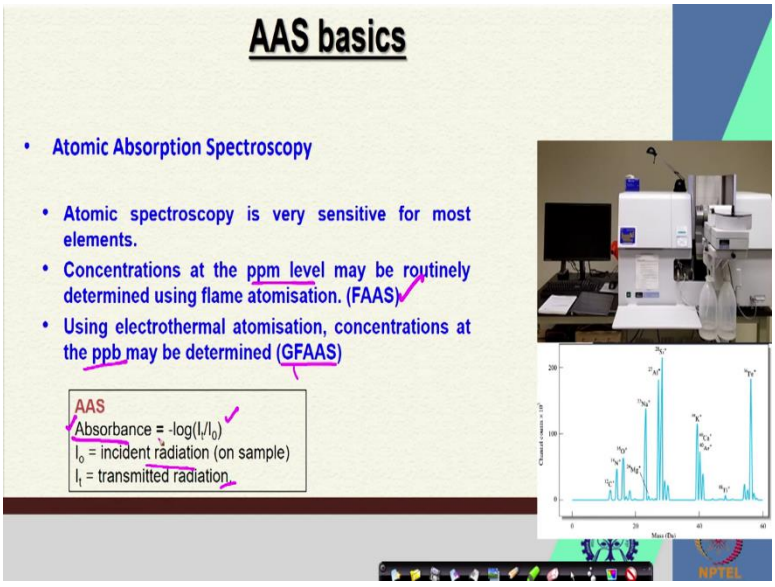

Now, I remember that these atomic spectroscopy is very sensitive for most of the elements and concentration at the ppm level may be routinely determined using flame atomization which also known as flame AAS or FAAS apart from that, we can also use electro thermal atomization we use a furnace called graphite furnace and this technology is known as GFAAS or Graphite Furnace Atomic Absorption Spectroscopy.

Now, what happens here, so, in the atomic graphite furnace atomic absorption spectroscopy using electro thermal atomization more higher temperature can be generated than FAAS now FAAS is good up to ppm level, however, using these graphite furnace atomic absorption spectroscopy we can go up to parts per billion levels, so, it will be more accurate.

So, this is the difference between flame atomic absorption spectrophotometer and graphite furnace atomic absorption spectrophotometer. Now, if you see the absorbance of you know the principle of AAS you can you know that absorbance is basically minus log of It by I0 where It is transmitted radiation and I0 is the incidence radiation.

So, basically these atomic absorption spectroscopy basically measure this absorbance which we can represent using this formula. So, this is how we measure the atomic absorption we measure the available iron, copper, manganese and zinc.

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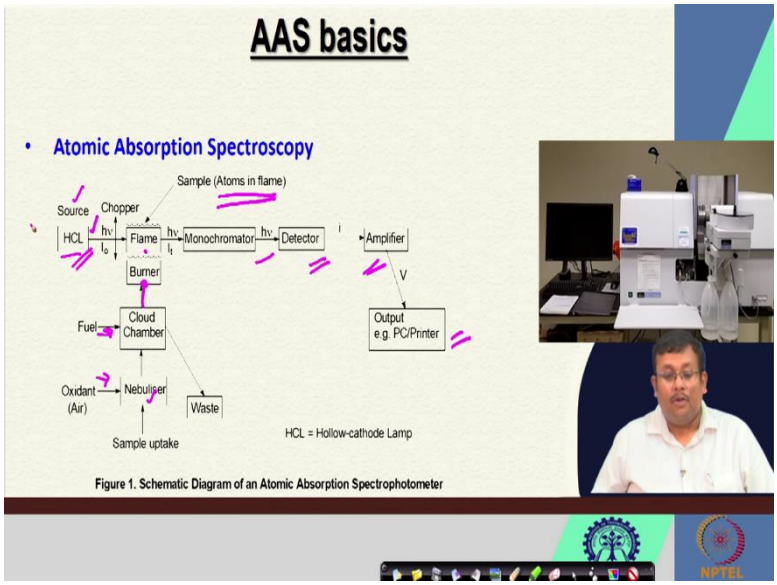

So, this is the schematics diagram of AAS in this schematic diagram it is quite clear that there is a you know light source which is known as the Hollow Cathode Lamp HCL. So, the hollow cathode lamp produces the light source and then the sample is being spirited and then

goes to the nebulizer and then we inject air which is, which acts as an oxidant and then it goes to the cloud chamber where we inject the fuel and then it goes to the mix goes to the burner and using the at using the energy of the flame you know it absorb the energy it observed the energy coming from this hollow cathode lamp and then these atoms.

Basically when the compound will go to the flame it will be converted into atoms in flame and these atoms will be absorbing this energy which is generated by this hollow cathode lamp and the rest of the energy will be transmitted and then it will be going through the monochromator and finally, it will be detected by the detector and then amplified by the amplifier where we can get the final output.

So, based on the absorption of the atoms we can measure the concentration of a particular element and these HCLs are elements specific and then it produce a specific energy which can be absorbed by a specific element. So, this is how these atomic absorption spectroscopy works.

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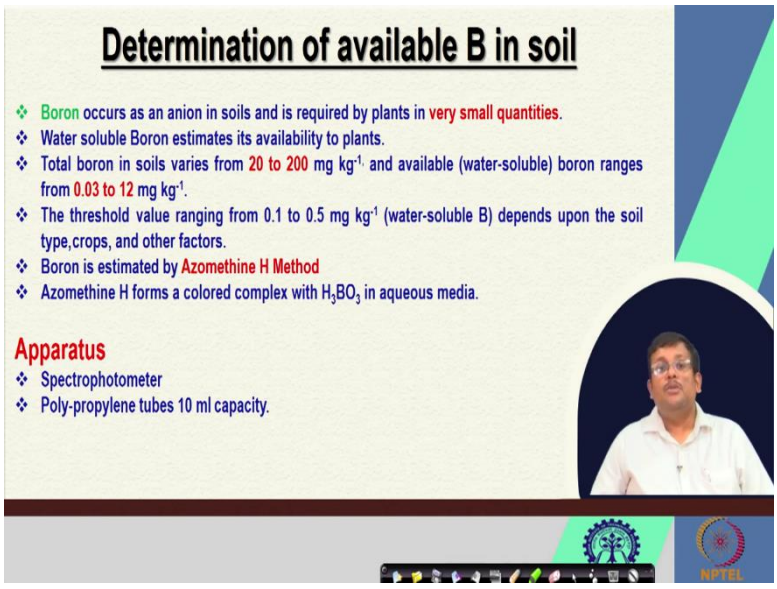

Now of the next one is determination of available boron. Now, boron occurs as an anion in soils and is required by plants in very small quantities. So, the sufficiency and deficiency difference of boron is very low. Remember that water soluble boron estimates its availability to plants. So, you know, water soluble boron basically indicates the available boron.

So, the total boron in soil generally varies from 20 to 200 ppm and available boron ranges between 0.03 to 12 ppm, that threshold value ranging from 0.1 to 0.5 ppm, which is water

soluble boron, and depends upon the soil, type, crops and other factors. How we measure the boron, we measure or estimate the boron using the Azomethine H method.

Generally, these Azomethine H forms a colored complex with H3BO3 in aqueous media what are the apparatus we required, we require spectrophotometer and also we require polypropylene tube of 10 ml capacity.

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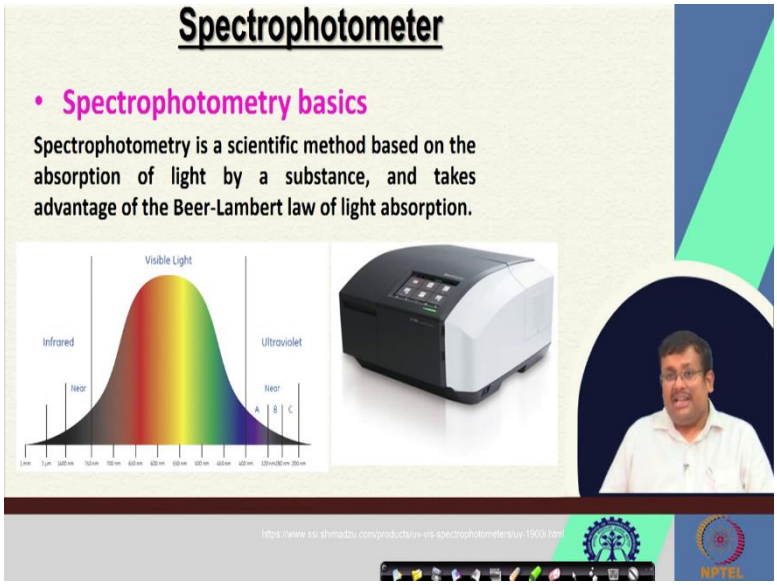

Now, let us very briefly discuss the basics of spectrophotometry. Now, spectrophotometry is a scientific method based on the absorption of light by substance and takes advantage of the Beer-Lambert law of light absorption. So, here we know that the visible light basically you know the electromagnetic spectrum can be divided into different zones we know that we can go from the ultraviolet region to visible light region to infrared region and infrared region is also differentiated into different other zones like near infrared, mid infrared, far infrared and so, on.

Now, the visible light generally you know goes from 400 nanometers to 700 nanometers. Now, spectrophotometry is spectrophotometer that is a you know is a meth is an instrument which basically use or which basically use the Beer-Lambert law of light absorption, this is a spectrophotometer let us discuss it.

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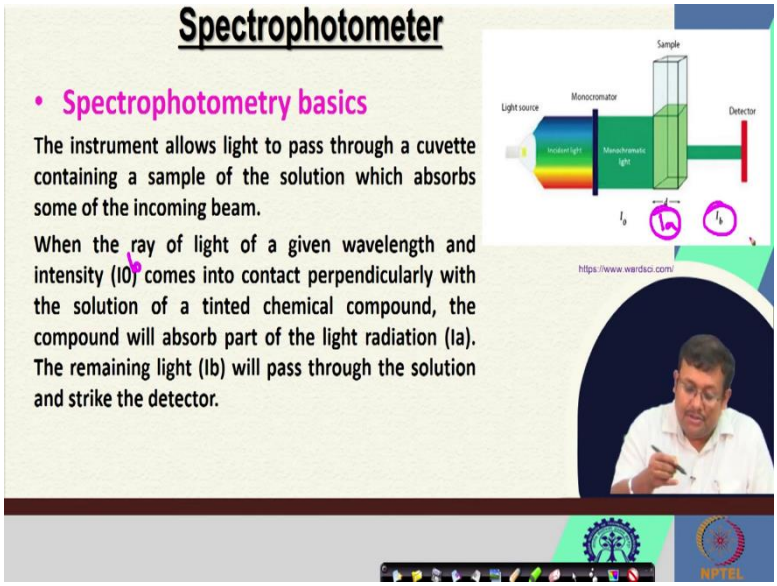

So, this instrument how it operates. So, this instrument allows light to pass through cuvette containing a sample of the solution which absorbed some of the incoming beam. So, here you can see these are cuvettes which is containing some samples and then here we are producing the incident light which is going through the monochromator filter and then a monochromatic light is going through the sample and then some amount will be absorbed in the rest of the amount will be detected by the detector.

So, I0 here is basically the incident light and Ib the you know transmitted light and d is that basically the width of the cuvette. So, the instrument basically allows the light to pass through a cuvette containing a sample of the solution which absorbs some of the incoming beam.

So, when the ray of the light of a given wavelength and intensity. So, generally this is I0 comes into the contact of perpendicularly with the solution of a tinted chemical compound here it is a tinted chemical component of color chemical compound, the compound will absorb part of the light radiation.

So, some amount of light will be absorbed which is denoted by Ia and the remaining light will pass through which is Ib will pass through the solution and strike the detector. So, this instrument basically works in this fashion.

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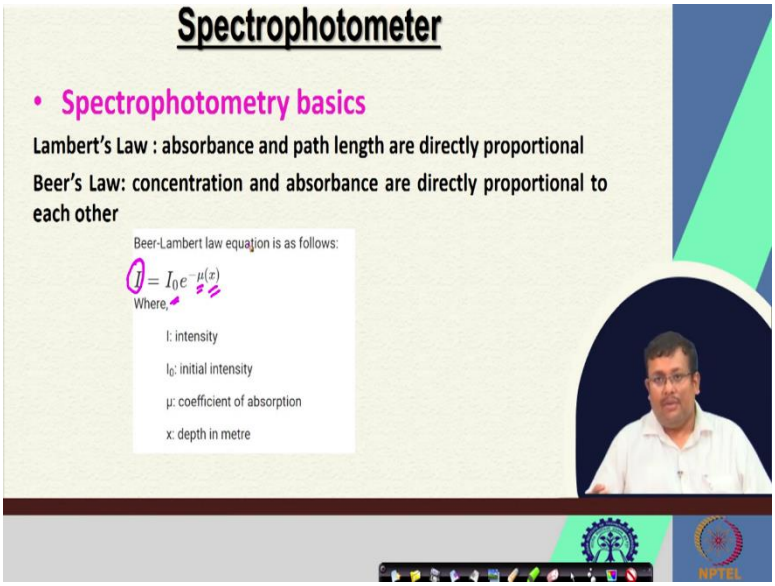

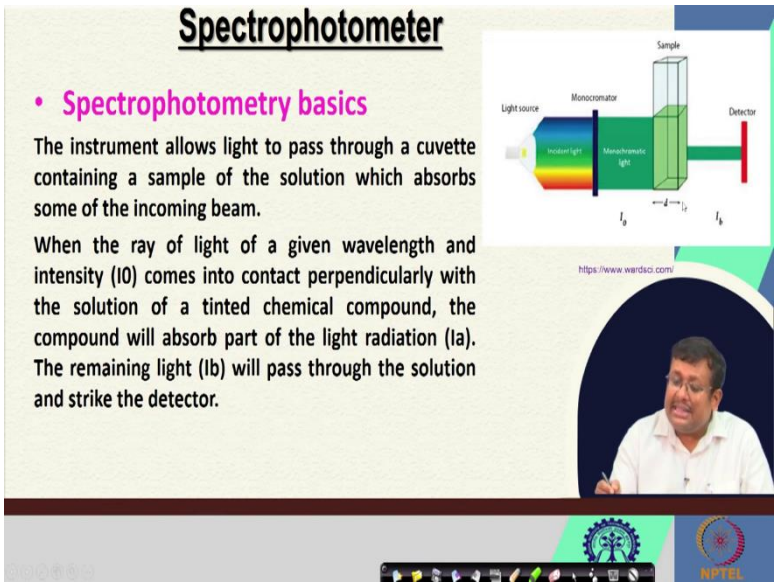

Now, we know that Lambert's law says that absorbance and path length are directly proportional. So, the absorbance that is the amount of light absorbed by the solution is directly proportional to the path length. So, if we go back here the path length is basically d because light has to pass this d distance through this sample solution. So, this is how these things goes and ultimately the Lambert's law says that absorbance and so Lambert's law says that absorbance and path length are directly proportional. And Beer's law says that concentration and absorbance are directly proportional to each other.

So, when we combine the Beer-Lambert law, the equation generally is as follows. So, we can see here I equal to intensity. So, I0 is the initial intensity or intensity of the incoming radiation and then mu is the coefficient of absorption and x is the depth in meters. So,

basically when we combine these two laws together basically it says that, that with the increasing concentration of the solution, there will be higher absorbance because, in our in this case, we are making sure by constant you know the d or let me go back to the previous slide. So, you can see in case of a cuvette the d is constant, so, the path length is a constant.

So, the concentration can only you know the absorbance can only vary due to changes in the concentration of the solution according to Beer's law so, when you combine both of them, we call it Beer's and Lambert's law and this is the mathematical form of these Beer's and Lambert's law.

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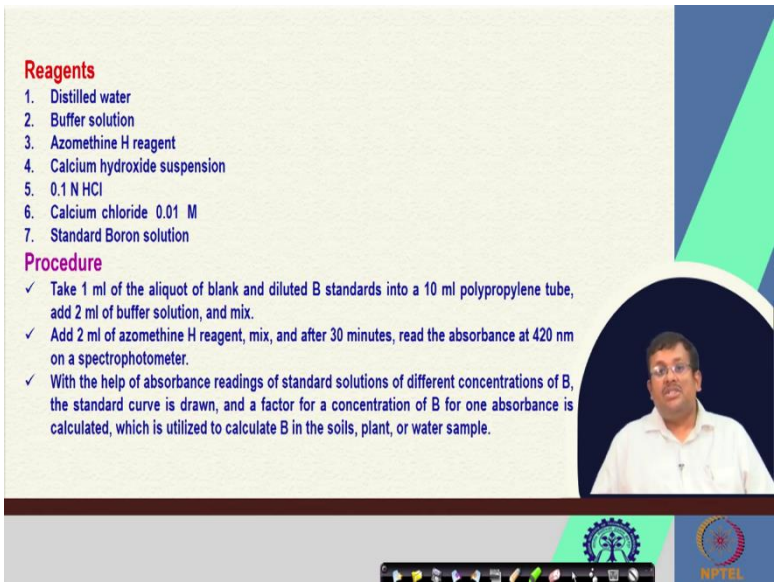

Now, what are the reagents we use for determination of boron, we generally use distilled water, buffer solution, Azomethine, H reagent, Calcium hydroxide suspensions 0.1 normal HCL, calcium chloride 0.01 Molar calcium chloride and standard boron solution.

So, this is the procedure we have to take 1 ml of aliquot of blank and dilute it with B standard into 10 ml of polypropylene tube and following the and we have to follow the rest of these things. So, first we have to take 1 ml of aliquot of blank and dilute the boron standards into 10 ml or polypropylene tube and 2 ml a buffer solution and then we have to mix them then we have to add 2 ml of azomethine H reagent then mix after 30 minutes, we have to read the absorbance at 420 nanometers on a spectrophotometer.

This is a monochromatic radiation remember that these Beer's and Lambert's law applies when there is a monochromatic radiation. So, with the help of the absorbance reading of

standard solution of different concentration of boron, the standard curve is drawn and a factor for a concentration of boron for one absorbance is calculated which is utilized to calculate boron in the soils, plant or water sample. So, this is how we measure the boron.

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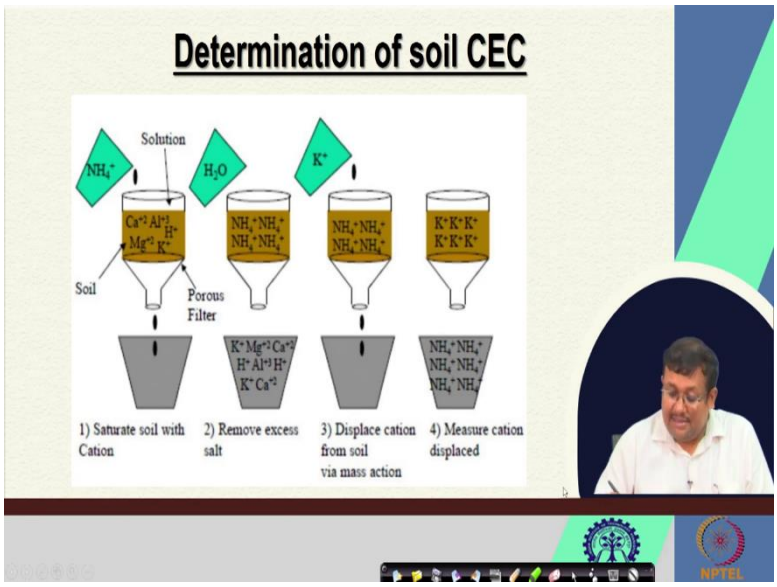

Determination of soil CEC basically these schematics shows the you know, these pic you know this this picture shows the steps of determination of soil CEC. So, first we take the soil and then we saturate it with ammonium acetate and then with a porous filter and then when this is totally saturated with ammonium we remove the excess water with the water and then once all the cations have been removed except for ammonium, then we leach this ammonium using potassium solution which will remove all the ammonium and these ammonium cation and replaced ammonium cation is basically measured subsequently to determine this soil CEC.

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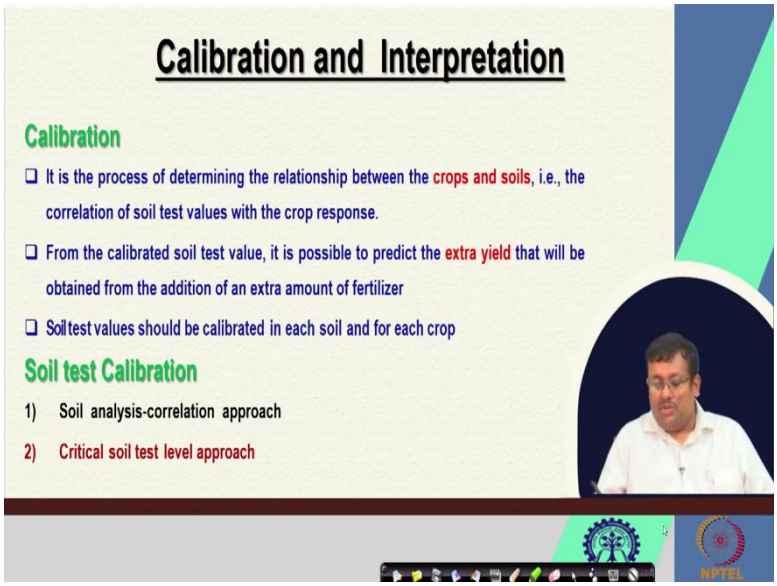

Now, how to calibrate and interpret the results, we have, we know now that how to measure different types of, how to measure different types of different elements, macro elements and you know and also micronutrients, macronutrients, micronutrients. Now, how to calibrate or interpret the results.

Now, it is the process of determining the relationship between the crops and soil that is the correlation of soil test values with the crop response from the calibrated soil test value it is possible to predict the extra yield and that will be obtained from the addition of an extra amount of fertilizer.

So, we have, using these calibrations we can predict the excess yield we can get by addition of extra amount of fertilizer and soil test value should be calibrated in each of the soil for each of the crop and soil tests calibration are of two types, one is soil analysis a correlation approach and critical soil test level approach.

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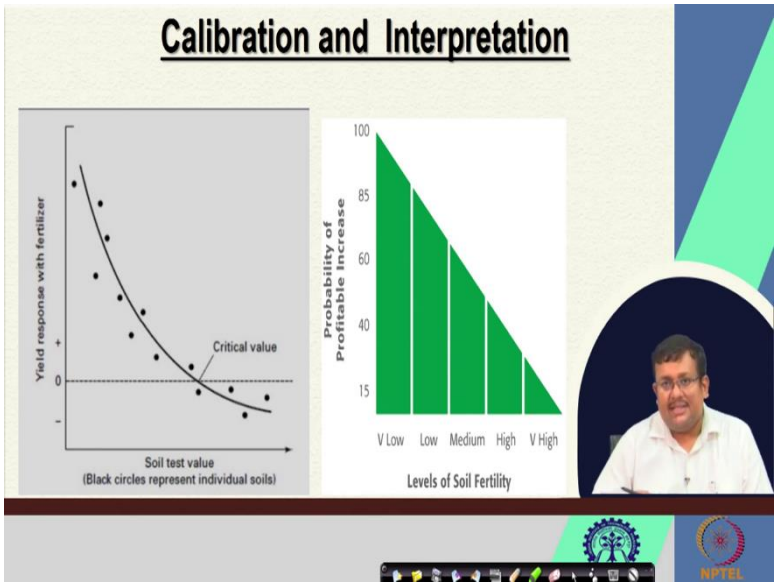

Now, if we see here, this graph basically shows that as the soil test values are continuously increasing, that means if the native content of nutrient in the soil is already high. That will give the least increase of yield with the fertilizer application. Of course, when there is a deficiency then only we apply fertilizer that and it will give us the more response. However, when there is a higher soil test value that will give the lowest yield response with the fertilizer.

Apart from that as we can see you know how to interpret the results. So, you can see there are different levels of soil fertility, very low, low, medium, high and very high and probability of profitable increase as you can see, if the soil you know levels of soil fertility is quite high, the probability of profitable increase with addition of fertilizer is quite less. So, this is basically the interpret, calibration and interpretation. So, the first one was a calibration curve and the second one is the interpretation.

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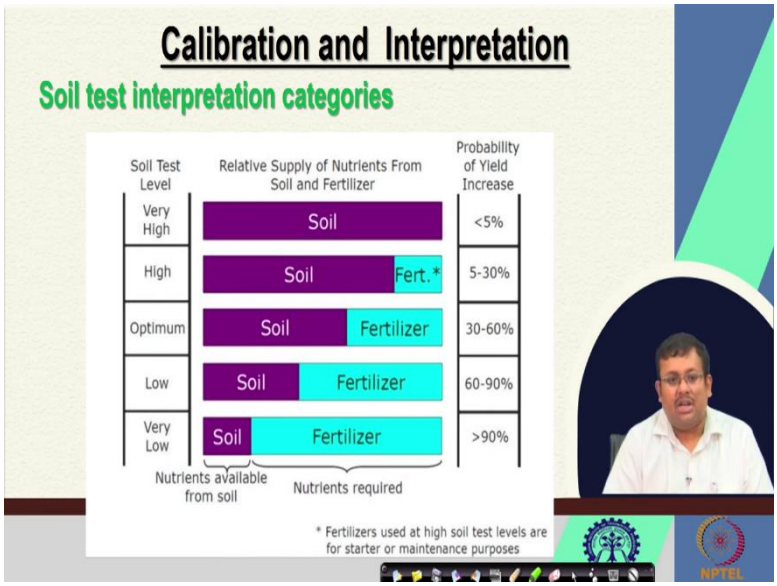

So, we can see here that soil test level if it is high, very high, so, the relative supply of the nutrients from the soil it will be maximum will come from the soil. So, probability of increase will be less than 5 percent, if it is high, soil test level is high then maximum is the soil and minimum is from fertilizer.

So, probability of increased 5 to 30 percent. So, as we go from these relative supply of the nutrients from soil to more to fertilizer, you can see the probability of yield increase continuously goes in you know goes up and of course, the soil test level will go down. So, that means, the fertilizer response to crop will be always high when the particular nutrient is deficient, when the nutrient is already there in a sufficient quantity, we cannot expect to have more yield increase with the addition of fertilizer.

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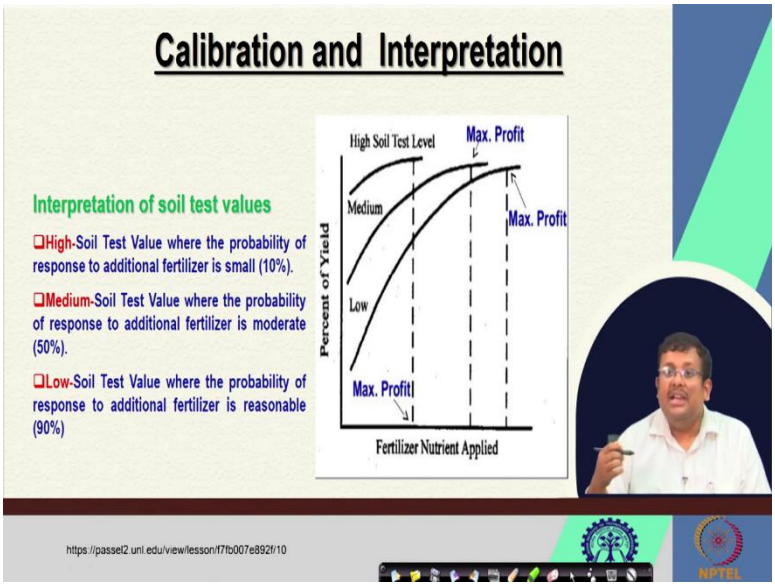

Also you can see here interpretation of the soil test values high medium and low and you can see fertilizer nutrient applied and percentage of yield you can see this is a high soil test level curve, this is the medium soil test level curve and this is the you know low soil test level curve.

So, what is high, high is the basically soil test value where the probability of response to additional fertilizer is small, which is 10 percent. And soil test medium is the soil test value where the probability of response to additional fertilizer is moderate that is 50 percent. And soil test flow is the soil test value where the probability of response to additional fertilizer is reasonably high which is 90 percent. So, this is the difference between low, medium and high level of fertility.

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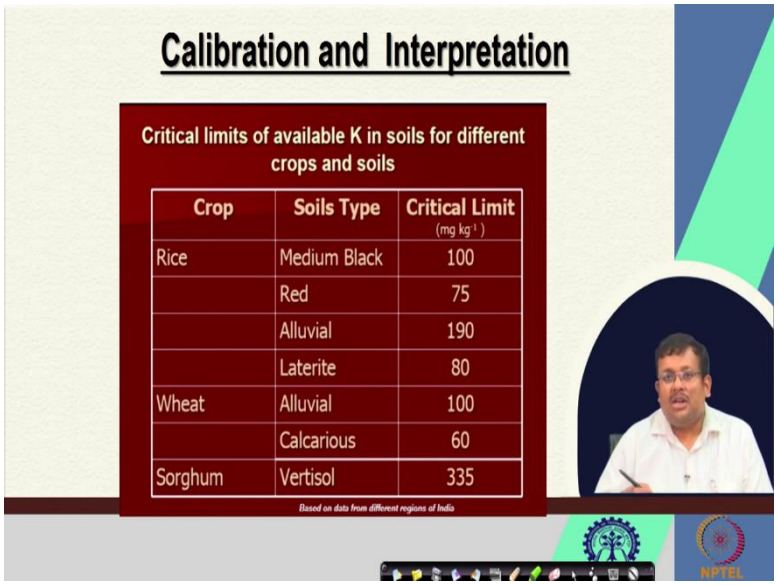

So, this is also you can remember that the critical limits of different nutrients and for different crops are region specific and soil specific. For example, you can see critical limits of available potassium in soils for different crops and soil you can see here in case of rice, medium black, the critical limit of 100 milligrams per kg and then for red soil it is 75 milligrams per kg. For alluvial it is 190 ppm, laterite is 80 ppm, wheat alluvial 100 ppm, wheat calcarious 60 ppm, sorghum vertisol 335ppm. So, this calibration and basically the critical limits of these nutrients vary from one crop to another crop and from one soil to another soil.

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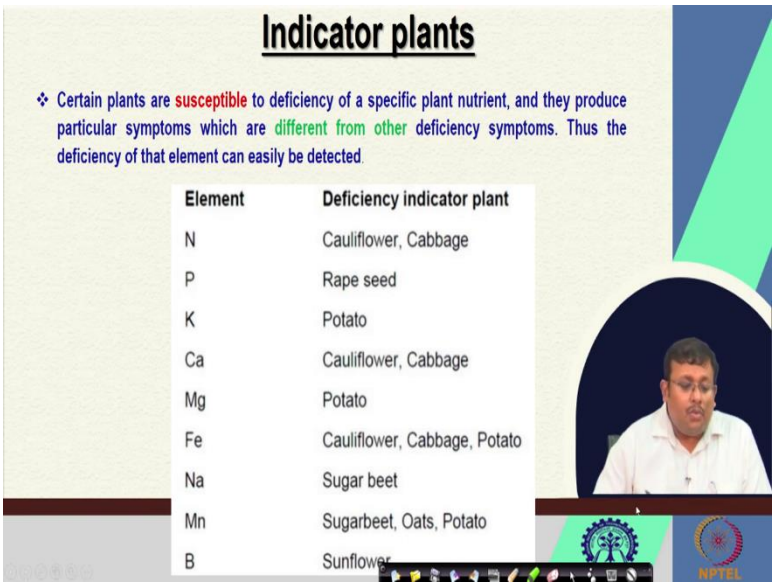

So, this is the last topic, there is an indicator plant. So, certain plants are susceptible to deficiency of a specific plant nutrient, and they produce particular symptom which are different from other deficiency symptoms. Thus the deficiency of that element can easily be detected.

So, there are certain indicator plant like for nitrogen, cauliflower and cabbage; phosphorus rape seed; for potassium potato; for calcium cauliflower cabbage; for magnesium potato; for iron cauliflower, cabbage, potato; for sodium, sugar, wheat; for manganese, sugar, wheat, oats, potato; and for boron, sunflower. So, these are the deficiency indicator plants.

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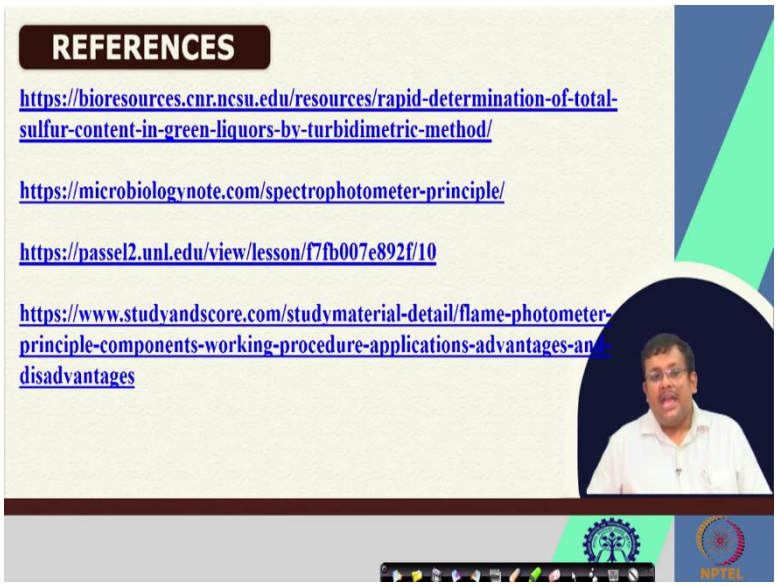

So, guys, this marks the end of this week 6 of lectures and I hope that you have gathered some good knowledges for the soil testing and determination of different types of soil fertility parameters and interpretation of those parameters. We will be discussing more about the recommendation in our upcoming lectures or upcoming weeks.

But if you have any queries regarding these lectures or regarding these topics, please feel free to email and post your questions in the forum. And we will start discussing soil degradation and also Land capability classification in our next week of lectures. And so if you have any difficulties, please let me know. And also please go through different literature for gaining more confidence on for these different types of you know soil testing methods. Thank you, let us meet in our next week.