Soil Fertility and Fertilizers
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Lecture 02
Importance of Soil Nutrient Management and Basics Soil-Plant Relationship (Contd.)

Welcome friends to this NPTEL online certification course of Soil Fertility and Fertilizers. And we are at week 1, the topic of week 1 is the Importance of Soil Nutrient Management and Basic Soil Plant to Relationship. And today we are going to start our lecture 2 and in the first lecture we have discussed about the basic of soil fertility and then we have discussed about what is law of minimum, Liebig's law of minimum, we have also discussed the law of diminishing return and also, we have seen, we have briefly started the law of maximum.

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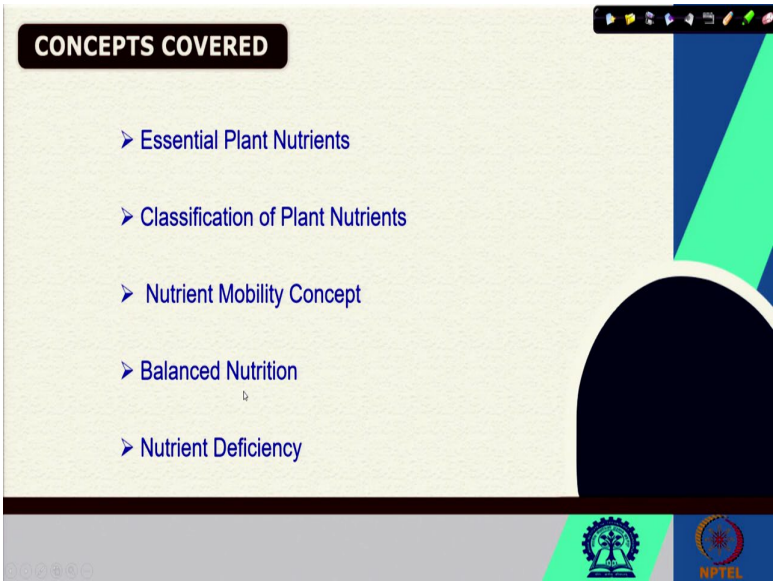

So, we will start from there and these are our the concepts which are going to cover in this lecture, we are going to cover the essential Plant Nutrients, then Classification of Plant Nutrients, their Nutrient Mobility Concept, then Balanced Nutrition and finally, we are going to see some Nutrient Deficiency symptoms.

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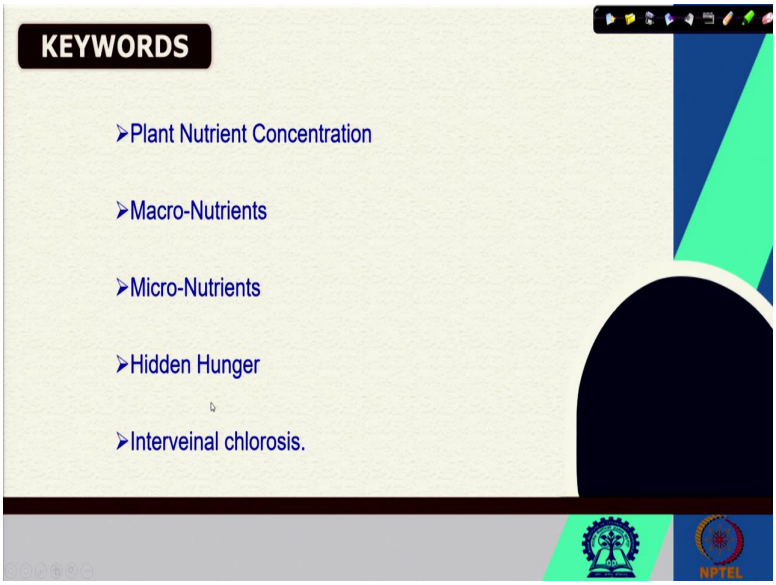

These are some of the keywords Plant Nutrient Concentration, Macro-Nutrients, Micro-Nutrients, Hidden Hunger and also Interveinal chlorosis these are some of the keywords for this lecture.

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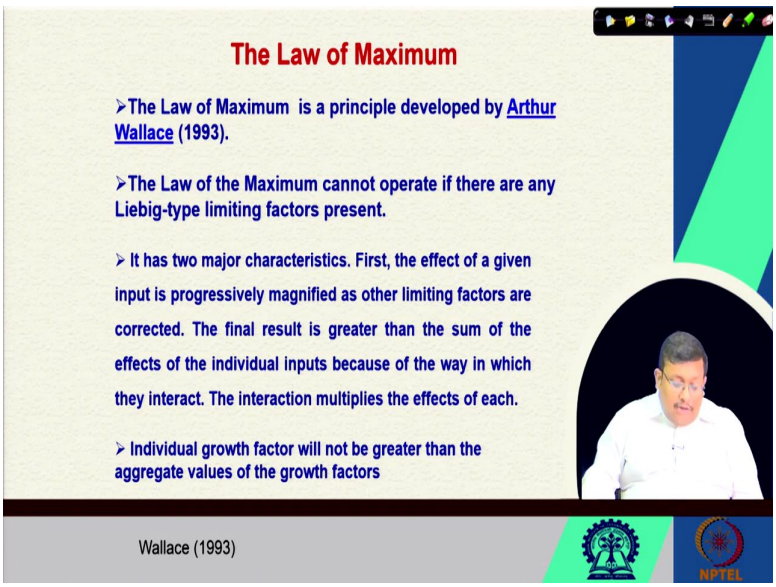

So, let us start from the Law of Maximum. So, you if you remember we have started discussing about the law of maximum it says that, it can… the effect of a given input is progressively magnified as other limiting factors are corrected. And of course, the final result is greater than the sum of the effect of the individual inputs because of the way in which they interact and the interaction multiplies the effect of each other.

So, individual growth factor will not be greater than the aggregate values of the growth factors, we will see some examples.

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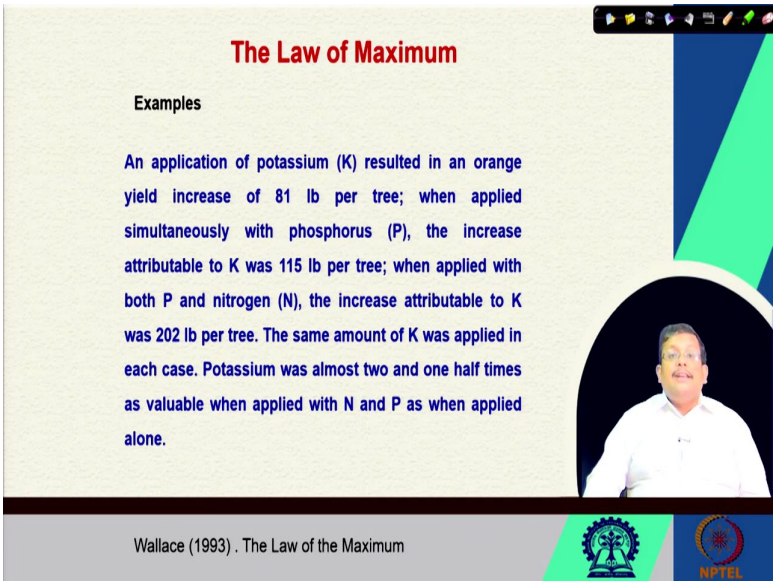

One example is given here suppose, an application of potassium resulted in an orange yield of 81 pound per tree. When applied simultaneously with phosphorus the increase attributable to potassium was 115 pound per tree. And when applied with both phosphorus and nitrogen, the increase attributable to K was 202 pound per tree.

So, the same amount of potassium was applied in each of these cases and the potassium was almost two and half times as valuable when applied with nitrogen phosphorus as when applied alone. So, that shows there is some synergistic effects. So, this is called… this is where you can see here we are applying the similar amount of potassium in each time however, due to the presence of phosphorus and simultaneous application of phosphorus and nitrogen, we are getting higher yield.

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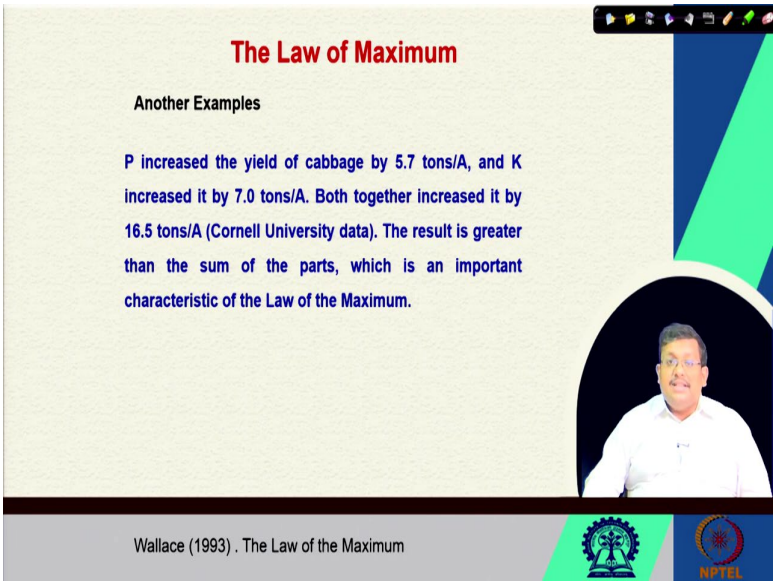

Another example you can see phosphorus increase the yield of the cabbage by 5.7 tonnes per acre and potassium increase it by 7 tonnes per acre individually. So, both together increase it by 16.5 tonnes per acre. So, this is the result is greater than the sum of the parts which is an important characteristics of the law of maximum.

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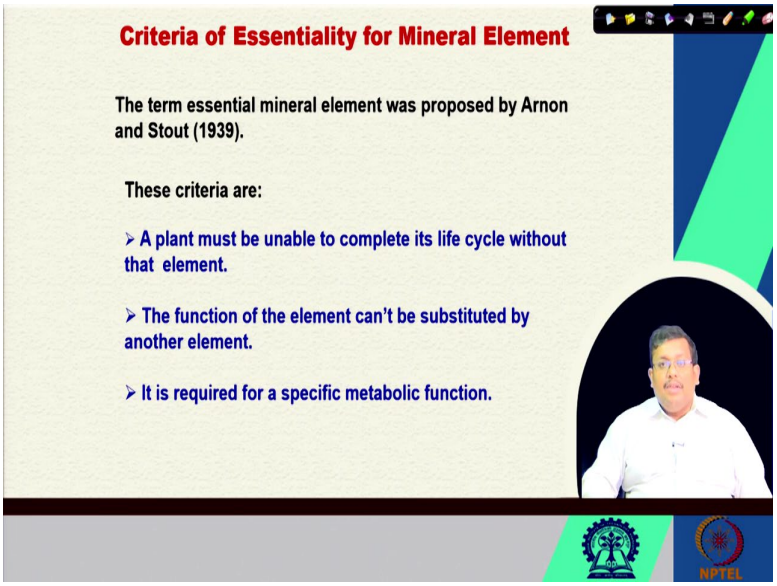

Now, let us see another important term that is essentiality criteria. Now, criteria of essentiality of mineral elements are this term of essential element was proposed by two scientists Arnon and Stout in the year 1939. And to become essential plant nutrients, a

element to be termed as an essential plant nutrient then element has to fulfil these three criteria. All these three criteria.

First of all, a plant must be unable to complete its lifecycle without that element and secondly, the function of the element cannot be substituted by another element. And third, it is required for a specific metabolic function. So, when one element will fulfil all these three important criteria, then only they will be considered as an essential mineral nutrient.

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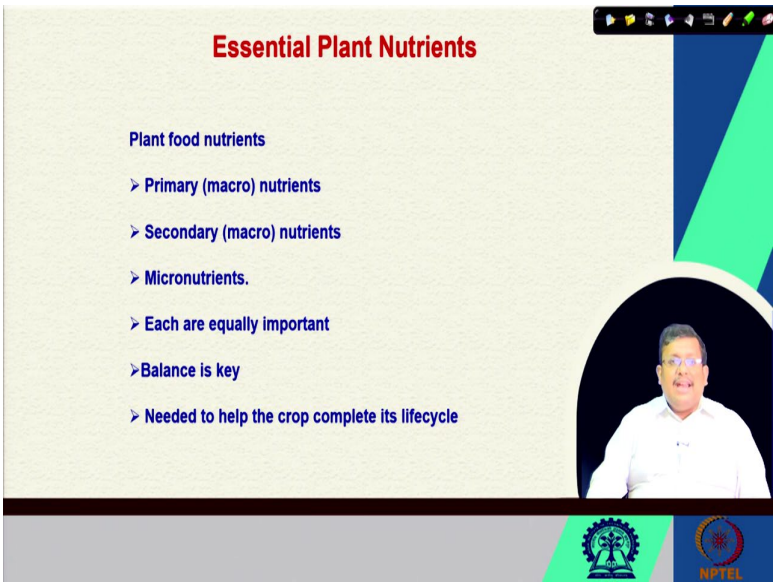

Now, what are the essential mineral nutrients? We can classify them into different categories like Primary (macro) nutrients, Secondary (macro) nutrients, Micronutrients, so these primary nutrients and secondary nutrients are grouped together in the macronutrients and of course, there are some micronutrients.

Remember that, these terms at given based on their relative quantity required by the plant not based on their importance, irrespective of their quantity, they are all equally important. If one of them is missing, then that will impact the plant growth. So, the balance of both macro-nutrients and micro-nutrients is key and it needs both of them are needed to help the crop complete this lifecycle. So, let us see some of the macro-nutrients.

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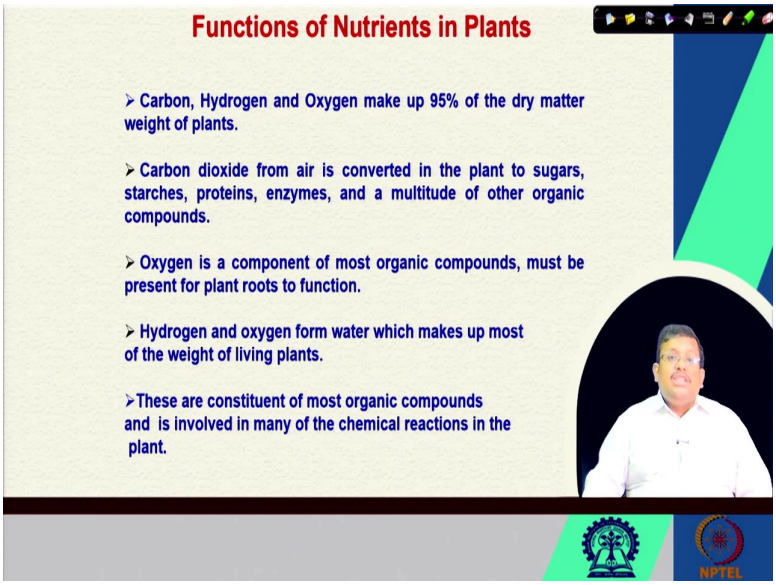

So, carbon, hydrogen, oxygen, they make up 95 percent of the dry matter of the plant parts and carbon dioxide from air is converted in the plants to sugars, starches, proteins, enzymes and multitude of other organic compounds and oxygen is a component of most organic compounds.

So, must be present for plant roots to function and hydrogen and oxygen from water you know, generally, plant grow hydrogen and oxygen from water, which makes up most of the weight of the living parts. And these are the constituents of most organic compounds and is involved in many of the chemical reaction of the plant. So, that is why these carbon, hydrogen and oxygen are also known as the structural elements for the plant.

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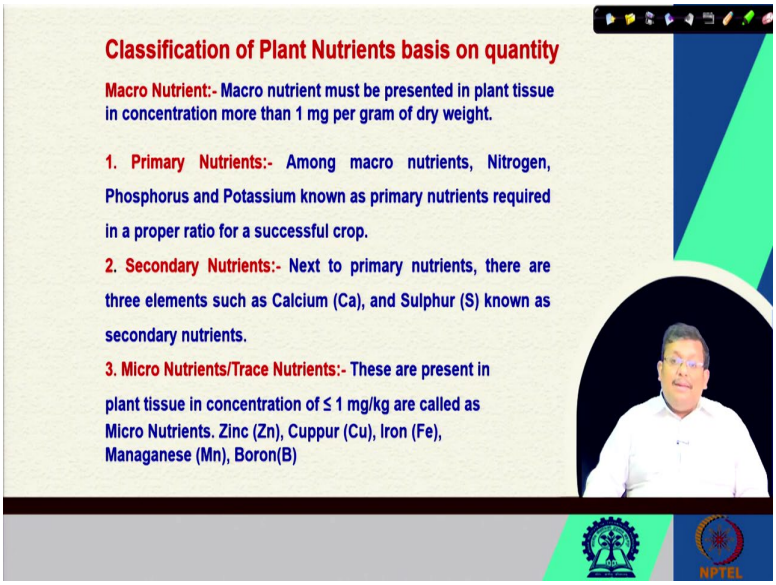

So, let us see the Classification of Plant Nutrients based on the quantity required, macro-nutrient, macro-nutrient must be present in plant tissue in concentration more than one milligram per gram of dry weight, and in these macro-nutrients there are two categories one a primary nutrient and the secondary nutrients.

So, the primary nutrients are also among the macronutrients. So, these nitrogen, phosphorus potassium are known as primary nutrients required in a proper ratio for a successful crop. So, and secondary nutrients are next to the primary nutrients they are calcium, sulphur, and calcium magnesium is also there. So, please include magnesium.

So, calcium, magnesium and sulphur, they are also known as the secondary nutrients and micro-nutrients or trace elements are present in the plant tissue in concentration of less than 1 ppm. So, these micro-nutrients are zinc, copper, iron, manganese, boron.

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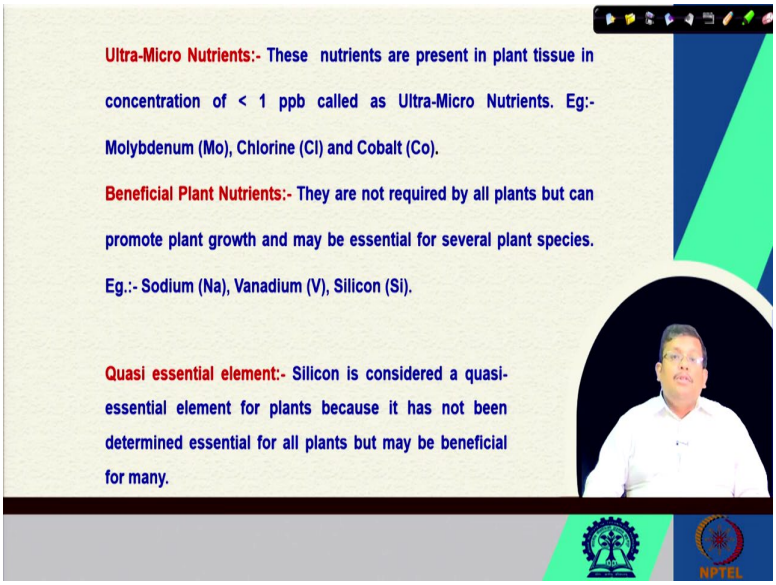

And there are some ultra-micronutrients. So, these are also coming under the micronutrients. So, you can see here. So, these nutrients are present in plant tissue in concentration of less than 1 ppb. So, they are known as the ultra-micronutrients like molybdenum, chlorine and cobalt, there are some beneficial plant nutrients also.

So, they are not required by all plants, but can promote plant growth and may be essential for several plant species like sodium, vanadium and silicon. There is a term called Quasi essential elements. So, silicon is considered as a quasi-essential element for plants, because it has not been determined essential for on plants, but maybe beneficial for many. So, that is why it is known as a quasi-essential element.

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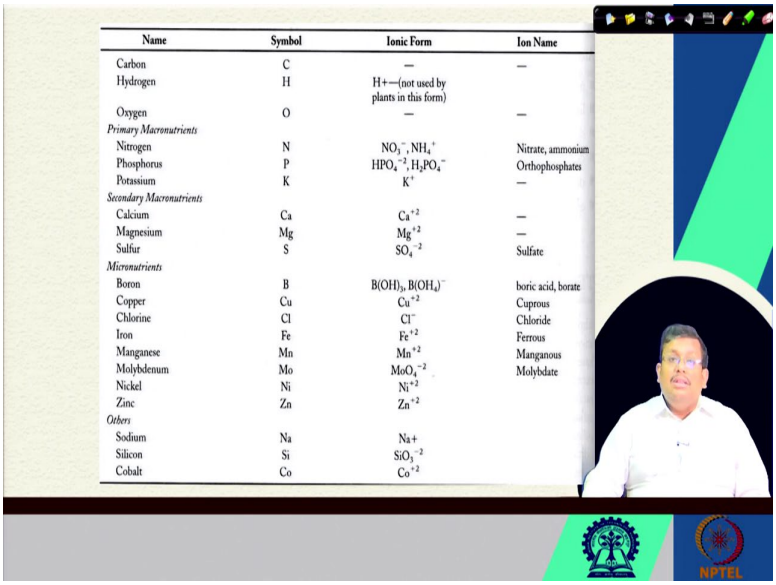

So, this table shows the different nutrients as their symbol they are ionic forms, which are available to the forms available to the plant. So, you can see that carbon hydrogen their symbol and generally… and carbon, hydrogen, oxygen they are generally received by the plants from air and water and among the primary nutrients nitrogen is there.

So, nitrogen is available to the plant in the form of nitrate and ammonium, phosphorus is available form primary orthophosphate and secondary orthophosphate, potassium is in K plus form available to the plants, secondary micronutrient calcium Ca2 plus magnesium, magnesium 2 plus ion, sulphur sulphate ion and among the micro-nutrients boron is present… boron will be available to the plants in the form of boric acid and borate.

And copper will be available as Cupreous Cu2 plus, chlorine will be available as chloride ion, iron will be available as Fe2 plus or ferrous, manganese will be available as manganous Mn2 plus, molybdenum will be available as molybdate, nickel will be available as Ni2 plus and zinc will be available as Zn2 plus ion.

Others sodium will be available as sodium ion sodium plus, silicon will be available as silicate ion and cobalt will be available as cobalt ion. So, this is the ionic forms which are available to the plants, remember plants cannot take all the forms of a nutrient, there are certain forms which are only can… only will be available to the plants for their growth.

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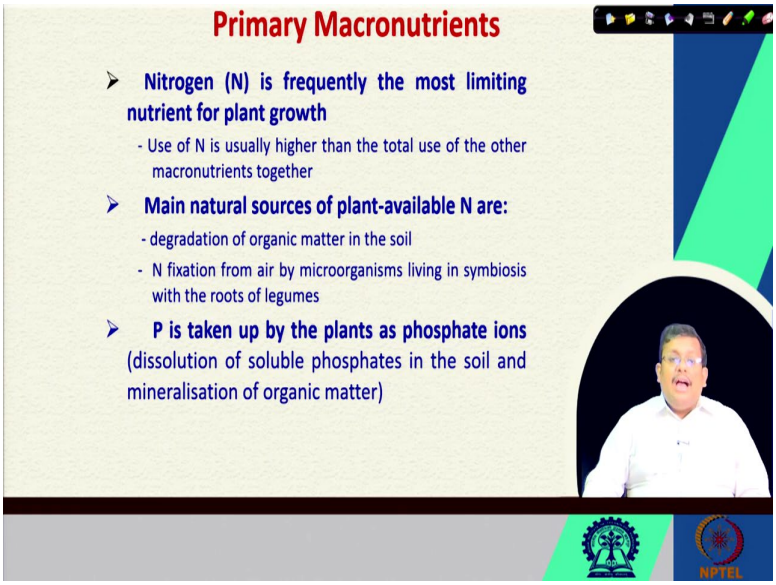

Now, remember that nitrogen is frequently the most limiting nutrient for plant growth. So, use of nitrogen is usually higher than that of total use of other macro-nutrients together. So, you will see that most often people are saying about nitrogenous fertilizer like urea and other nitrogenous fertilizer, because they have to, and because these nitrogenous fertilizer have to apply in higher quantities than any other fertilizers.

Now, it is a main natural sources of plant available nitrogen, organic matter, because when organic matter degrades, that gives the… that supplies the nitrogen for the plants and also nitrogen fixation from air by microorganisms living in symbiotic relationship with legume roots are also an important source of plant available nitrogen we are going to discuss this in our in our upcoming weeks in details.

Phosphorus is taken up by the plants as phosphate ions and this dissolution of soluble phosphates in the soil and mineralization of organic matter are the factors which influence with the phosphate ion availability in the soil.

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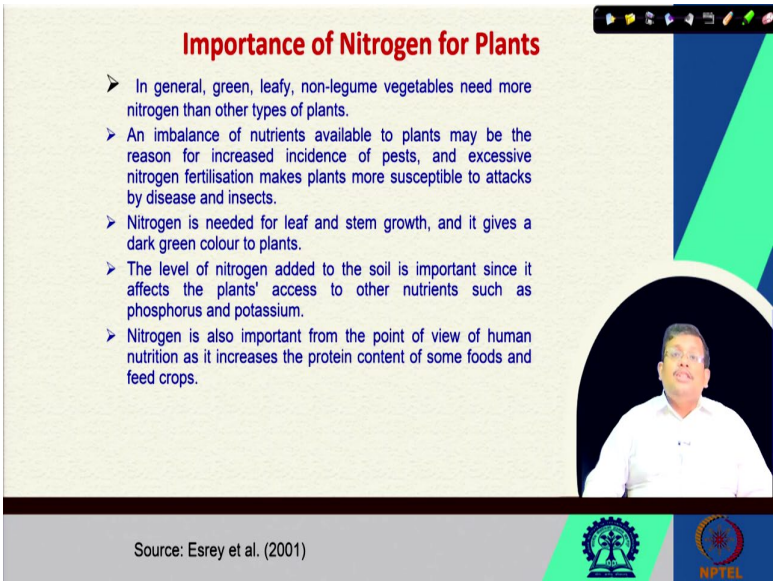

Now, if you see the importance of nitrogen for the plants, remember that in general green leafy non-legume vegetables need more nitrogen than other types of the plants and imbalance of nutrients available to the plants may be the reason for increase incidence of pests and excessive nitrogen fertilizer makes plants more susceptible to attacks by disease and insects.

Just like I have mentioned that we should not apply to any nutrient in less quantity or in toxic quantity also, so that they can be other real effects like disease and insects. So, same time, you know, if there is a nitrogen toxicity, we can see, there are some disease and pests, nitrogen is needed for leaf and stem growth and it gives a dark green colour to the plants.

The level of nitrogen added to the soil is important since it affects the plants access to the other nutrients such as phosphorus and potassium. So, that is why nitrogen is considered as one of the most important nutrient for the plant growth. Nitrogen is also important from the point of view of human nutrition as it increases the protein content of some foods and feed crops. So, the major source of protein you know plant protein, you know is nitrogen, and without nitrogen, the plant growth will be stunted severely.

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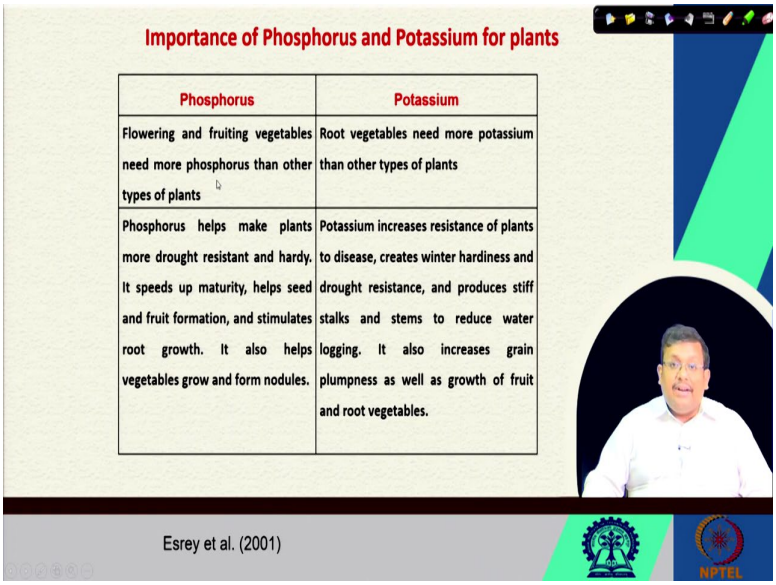

So, if you see the importance of phosphorus and potassium for the plants, you can see that flowering and fruiting vegetables need more phosphorus than other types of the plants and root vegetables need more potassium than other types of the plants. Now, phosphorus helps makes plants more drought resistant and hardy, it speeds up maturity, helps seeds and fruit formation and stimulates root growth. It also helps vegetable grow and form nodules.

Whereas potassium increases resistance to plant to disease, creates winter hardiness and drought resistance and produces stiff stalks and stems to reduce water logging. It also increases grain plumpness as well as growth of fruit and root vegetables.

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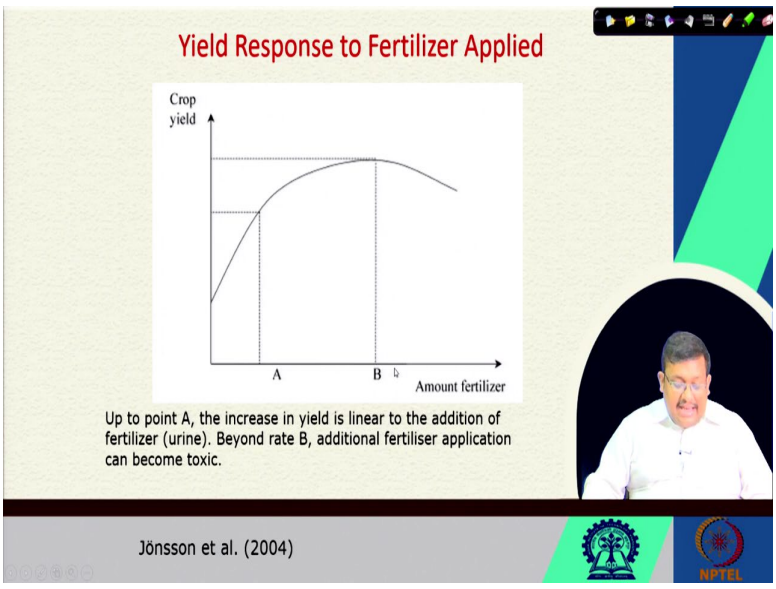

So, if we see these curve that is in response to fertilizer applied, so in the x axis, we are applying the fertilizer in the y axis we are getting the crop yield. So, you can see up to this point A the increase in yield is linear to the addition of the fertilizer in this case this is urine, which is a source rich source of nitrogen. However, beyond these rate B we can see additional fertilizer application can become toxic to the plant.

So, we have to be very very careful while adding the fertilizer we cannot indiscriminately add fertilizers without considering the effect, their effect on the crop yield of course, if we go beyond a certain rate that will create the fertilizer toxicity.

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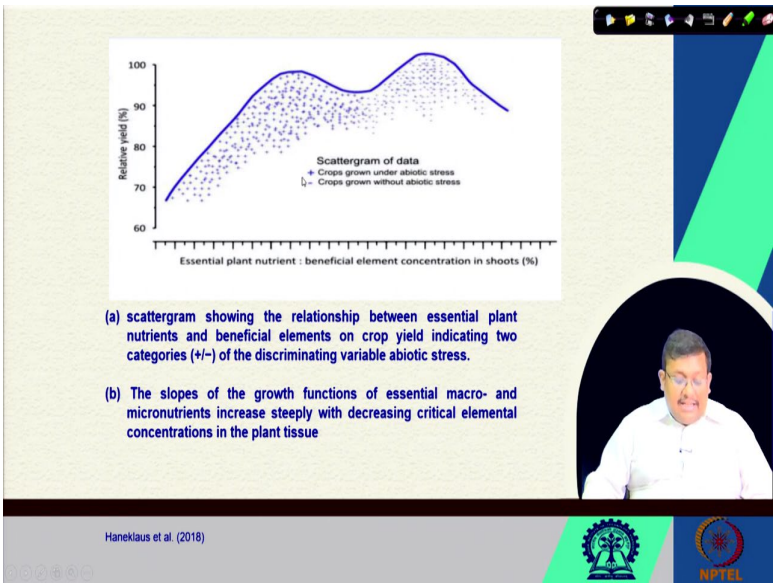

So, here in this scattergram says here you can see that plus signs are showing the crops grown under abiotic stress and negative signs are showing crop grown without abiotic stress. And in the x axis, we are seeing beneficial elements concentration in the shoots and the y axis we are getting the relative yield.

So, here this scatter diagram showing the relationship between the essential plant nutrients and beneficial elements on crop yield indicating two categories on the positive category and negative categories of the you know, showing the discriminating variable abiotic stress.

So, the slopes of the growth functions of essential macro and micro-nutrients increases steeply with the decreasing critical elemental concentration in the plant tissue. So, of course, as we go from this higher concentration to lower concentration, the steepness of the growth

function will increase as you can see here, as we are growing from this sufficiency to deficiency I would say then you can see the steepness of the growth will increase.

So, that means, the growth of the plant is vigorous in the initial stages when we apply the fertilizer and after a certain amount… it reaches a plateau, the growth reaches a plateau and after a critical limit, you know a toxicity limit there will be toxicity limit after that, there will be the further yield reduction.

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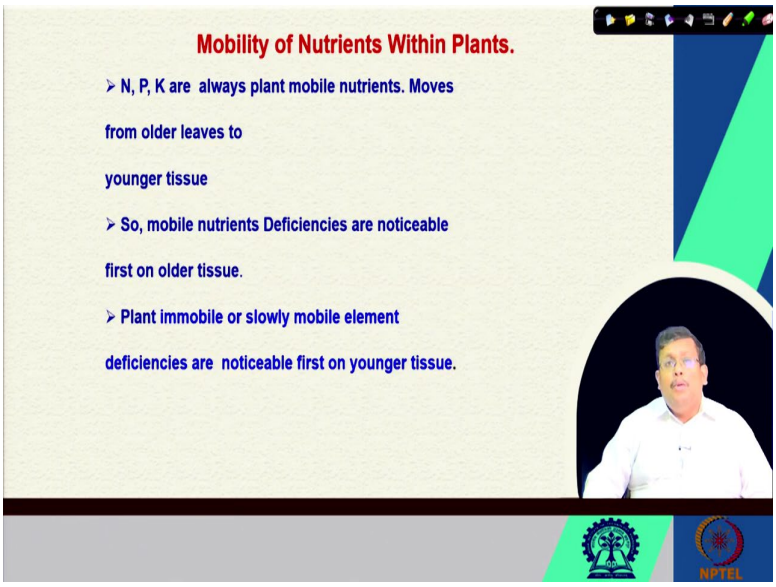

So, what are the mobilities of nutrients within the plants? So, nitrogen, phosphorus potassium are always plant mobile nutrients moves from older leaves to the younger tissues. So, mobile nutrient deficiencies are noticeable on older tissues. So, plant immobile or slowly mobile element deficiencies are noticeable first on younger tissues. So, based on whether your element is mobile or immobile, their appearance of their deficiencies would appear at different places.

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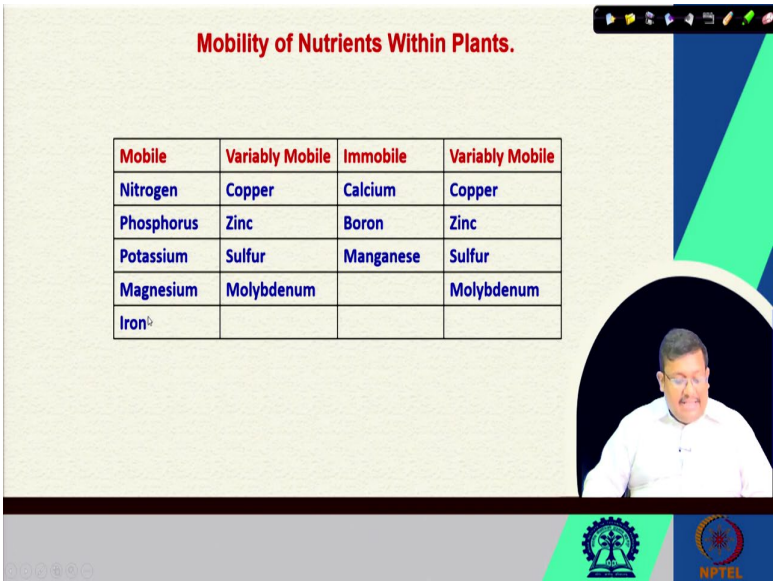

So, here this table shows, what are the mobile, variably mobile, immobile and variably mobile nutrients. So, here you can see the mobile nitrogen phosphorus, potassium, manganese, iron. Variably mobile copper, zinc, sulfur, molybdenum. Whereas immeubles are calcium, boron and manganese.

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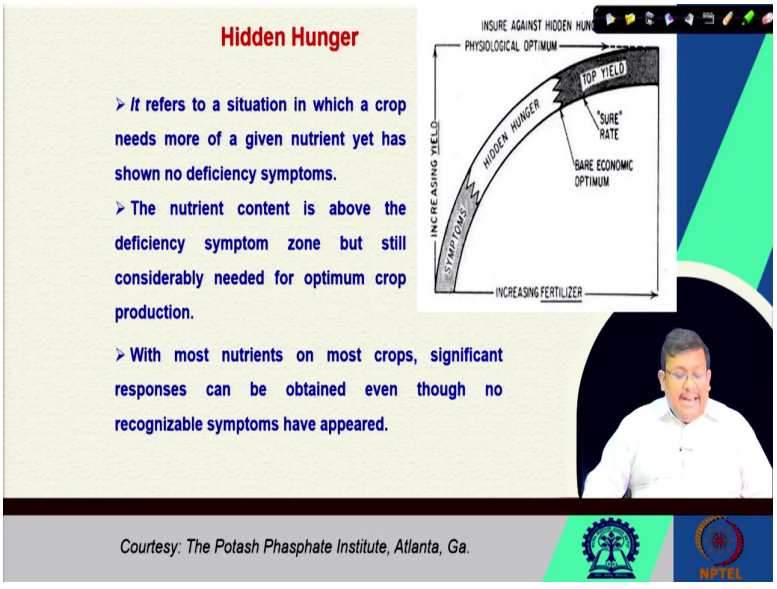

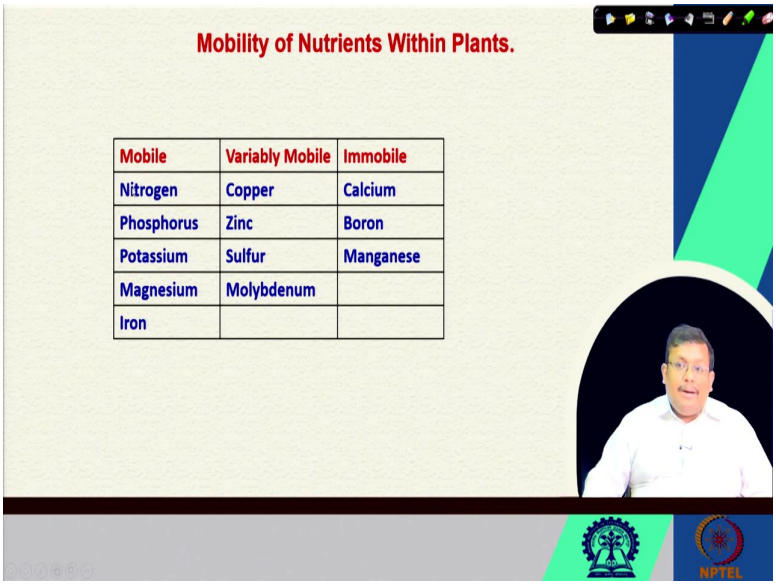

Now, what is hidden hunger? Hidden hunger refers to a situation in which a crop needs more of a given nutrient. So, now we can see based on the mobility of the nutrients within the plants we can classify them into mobile, variably mobile and immobile nutrients. Among the mobile nutrients you can see nitrogen, phosphorus, potassium, magnesium and iron are mobile elements, variably mobile elements are copper, zinc, sulfur, molybdenum, and immobile elements are calcium, boron and manganese.

Now, let us see what is hidden hunger? Hidden hunger is a situation in which crop needs more of a given nutrient, yet has shown no deficiency symptoms. So, here you can see as we are increasing the fertilizer and the crop is showing the increasing the yield this is the top yield. But here there are some symptoms up to this point.

But after these there is no symptoms, but it still requires fertilizer elements or it is requires the elements for their growth to reach the top yield. So, this is known as the hidden hunger. So, that means, when the yield, you know when the crop needs more and more nutrient, but it does not show any deficiency symptoms that is known as the hidden hunger. So, the nutrient content is above the deficiency symptoms.

So, here you can see the nutrient content in this hidden hunger is above the deficiency symptoms but still considerably needed for optimum crop production. So, for optimum crop production, we still need to apply more fertilizers. So, with most nutrients on most crops, significant responses can be obtained even though no recognizable symptoms have appeared. So, this is known as hidden hunger.

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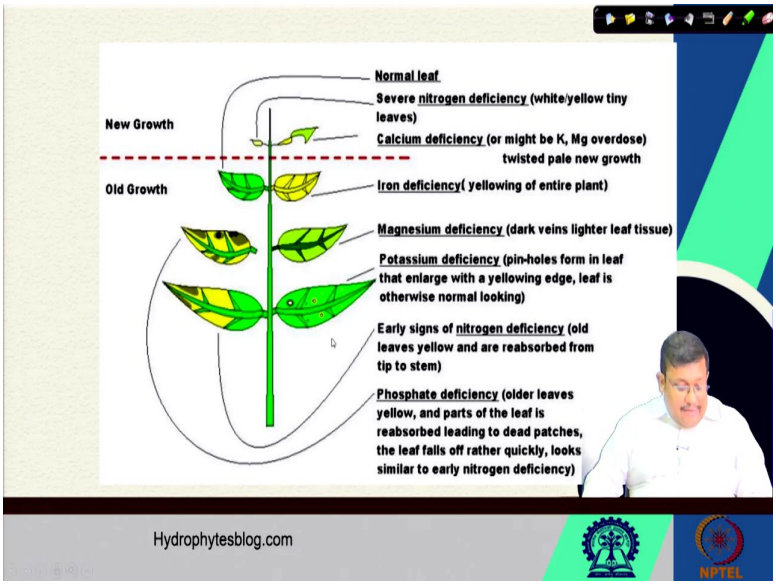

So, here you can see that what are the different symptoms of the nutrient deficiency, so this is the normal leaf. In case of severe nitrogen deficiency, you will see that white and yellowing of the tiny leaves in case of you know, in case of calcium deficiency or might be potassium, magnesium overdose, you will see twisted pale new growth and this is the iron deficiency.

Here you can see there is a yellowing of the interplant, and here this is the magnesium deficiency shows the dark green veins you know, and light a leaf tissues. In case of potassium deficiency we will see the pinholes from form in leave that enlarge with the yellowing age and leaf is otherwise normal looking.

And here you can see early signs of nitrogen deficiency that is older leaves, become yellow and are reabsorbed from tip to stain and here is a phosphate deficiency where you add the older leaves are yellow and parts of the leaves is reabsorbed leading to date patches, the leaf falls off rather quickly and looks similar to the early nitrogen deficiency. So, here you can see that due to the deficiency of different types of nutrients, what type of nutrients or deficiency expression in the plant you can expect. So, these are the new leaves and these are the older leaves.

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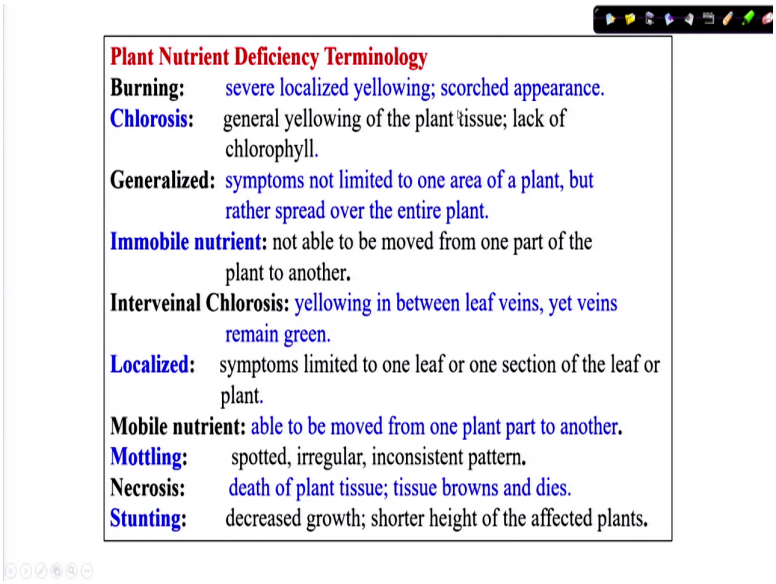

Now, there are some important Nutrient Deficiency Terminologies you should know, first of all Burning which is the severe localized yellowing or scorched appearance. Chlorosis means the general yellowing of the plant tissue lack of chlorophyll. Generalized means symptoms not limited to one area of the plant but rather spread over the entire plant. Immobile nutrient those nutrients which are not able to move from one part of the plan to another. Interveinal Chlorosis is basically yellowing in between leaf veins, yet veins remain green.

Localized if you know symptoms are symptoms limited to one leaf or one section of the leaf or plant, mobile nutrient able to be moved from one plant part to another, Mottling is spotted irregular, inconsistent pattern. Necrosis is data of plant tissue, tissue browns and dies. And finally, stunting is the stunting is the decrease growth at shorter height of the affected plants.

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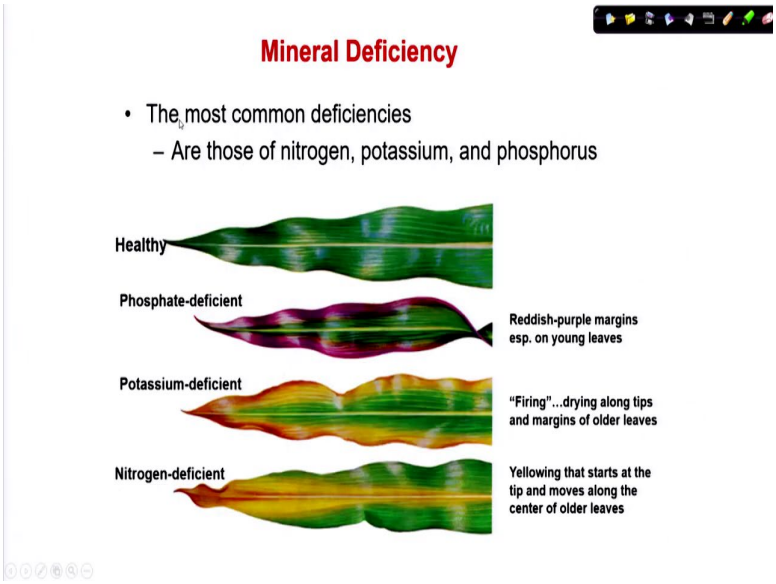

So, these are the some of the deficiency terminologies and you can see the most common deficiencies are of those nitrogen, potassium and phosphorus, you can see these is an healthy leaf and this is the phosphate deficiencies leaf you can see clearly reddish purple margins, especially on younger leaves and then potassium deficient you can see firing that is drying off along tips and margins of older leaves.

And nitrogen deficiencies, deficiency you can see yellowing that stands at the tip and moves along the centre of the older leaves. So, these are nitrogen deficient. So, you can see this is how these leaves will look like when different nutrients are deficient.

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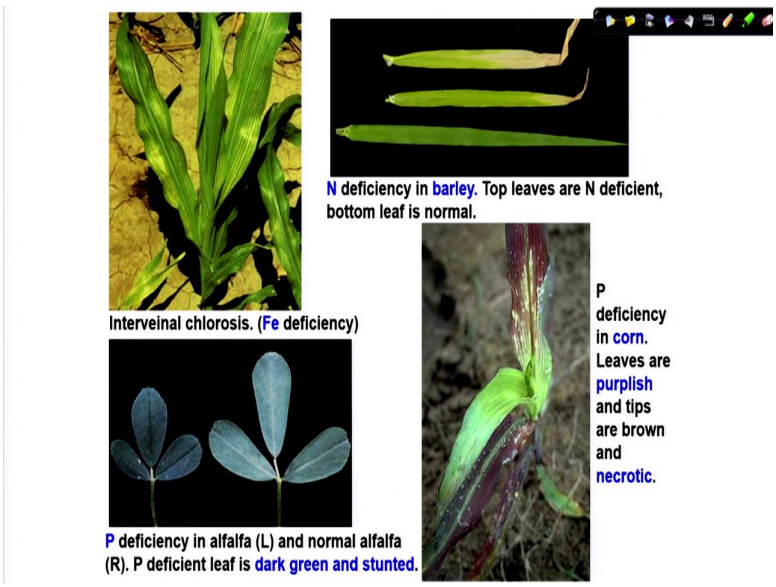

And now we can see some example of Interveinal Chlorosis due to iron deficiency. And here you can see nitrogen deficiency in barley where top leaves are nitrogen deficient bottom leaves is normal. So, this is nitrogen deficiency, however this bottom leaf is normal. And here you can see phosphorus deficiency and alfalfa left and this is the normal alfalfa.

So, phosphorus deficient leave is dark green and stunted. And you can see here this is the phosphorus deficiency in corn leaves. So, leaves that purplish and tips are brown and necrotic. So, these are some of the symptoms of different nutrient deficiency in the plant.

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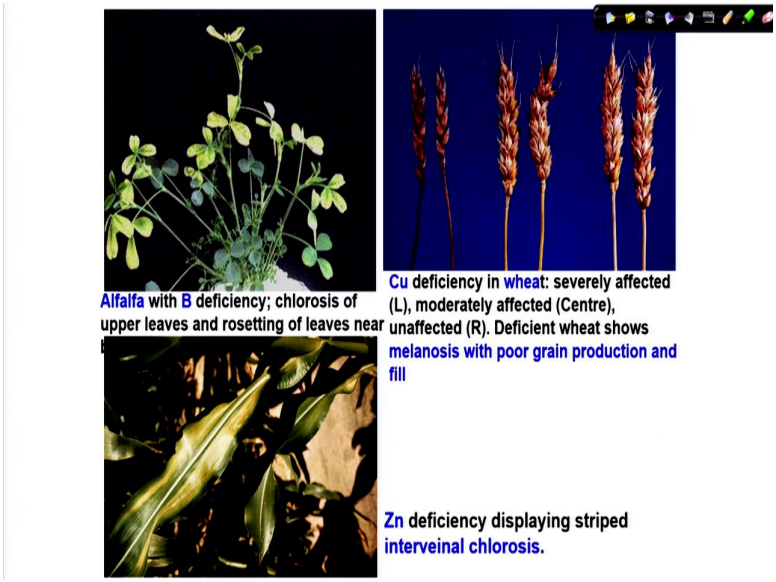

And also, we can see here, this is the alfalfa with a boron deficiency and chlorosis of upper leaves and rosetting of leaves near the base. So, you can see here rosetting of leaves near the base and chlorosis of the upper leaves. Here you can see the copper deficiency in wheat. So, this is severely affected in you know, these are the severely affected, these are moderately affected and these are unaffected.

So, deficiency which was melanosis with poor grain formation, production and feel you can clearly see here and so, this is also zinc deficiency displaying striped Interveinal Chlorosis. So, guys, I hope that now, we have understood, understood that the plan can show different types of deficiency symptoms, when certain elements are absent.

And these elements based on their sufficiency or deficiency, they can show some symptoms and of course, we have to be very, very careful about the toxicity of these nutrients, so that we can ensure a balanced nutrient supply to the plants to get the optimum yield.

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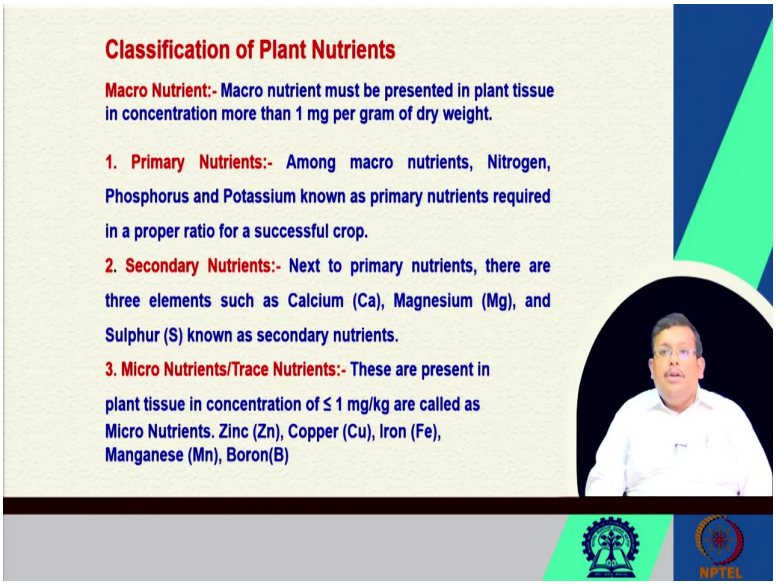

Now, let us see what is the classification of plant nutrients based on the quantity of the nutrient required. Now, there are two major categories one is macro-nutrient and other is micro-nutrient. Among macro-nutrients, macro-nutrients are of two types one is primary nutrient and other is secondary nutrients. Now, macro-nutrients are those nutrients which must be present in plant tissue in concentration more than more than 1 milligram per gram of dry weight.

Now, micro-nutrient are classified into two major categories one is primary nutrient and other is secondary nutrient. What are the primary nutrients? Primary nutrients are nitrogen, phosphorus and potassium. These are required as the primary, these are known as primary nutrients because they are required in higher quantity then other nutrients.

Now, there another category is secondary nutrients. So, secondary nutrients are those primary nutrients which are required in comparatively lesser quantity then the primary nutrients, what are the secondary nutrients the secondary nutrients are calcium, magnesium and sulfur. Now, so, these are primary these are macronutrients, another group of broad categories there that is called micro-nutrients or trace nutrients.

Now, these are generally present in plant issuing concentration of less than 1 ppm or milligram per kg and they are also known as micronutrients. So, examples are zinc, copper, iron, manganese boron.

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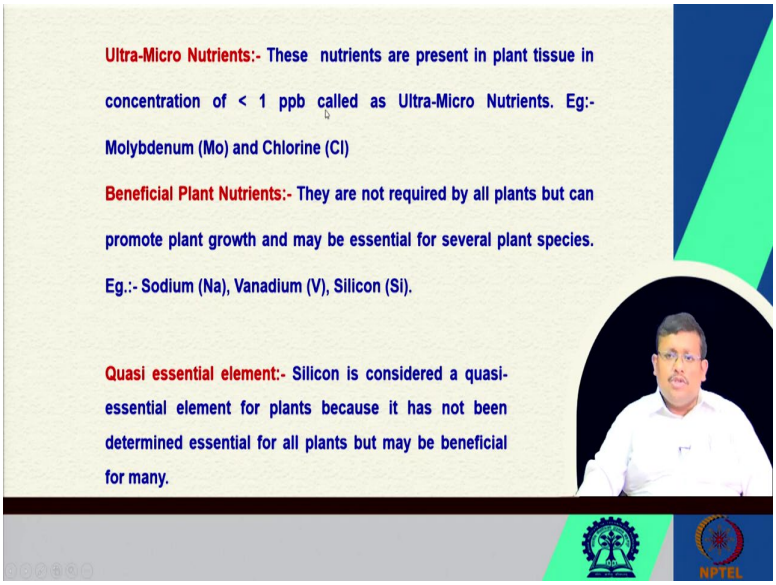

Now, remember that there are two more micro-nutrients like molybdenum and chlorine, but they are also required in very less quantity that less than one parts per billion. So, they are also known as Ultra-micro-nutrients. Remember this molybdenum and chlorine comes under the broad category of micro-nutrients, but they are also sometimes termed as Ultra-micro-nutrients because they are required in less than 1 ppb in quantity.

So, these are the essential plant nutrients, macronutrients and micronutrients are essential primary nutrients. Now, next another term is there that is called beneficial plant nutrients. Now, they are not required by all plants, but can promote plant growth and may be essential for several plant species. For example, sodium vanadium and silicon they are known as beneficial plant nutrients another terminology is there is called the quasi essential element.

So, silicon is an example of quasi essential element, because it is considered as a because it is not an essential for all the plants, but it is beneficial for many plants. So, that is why it is called the quasi essential element. Now, you have understood what is the broad classification of nutrients plant nutrients based on their essentiality and based on their quantity requirement. So, I hope that you have learned something new in this lecture. Let us meet in our next lecture to discuss some other important terms of soil and plant nutrient management. Thank you.