**Soil Fertility and Fertilizers**
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**Lecture: 21**
**Soil micronutrients and their role in plant nutrition**

Welcome friends to this twenty first lecture of NPTEL online certification course of soil fertility and fertilizers.

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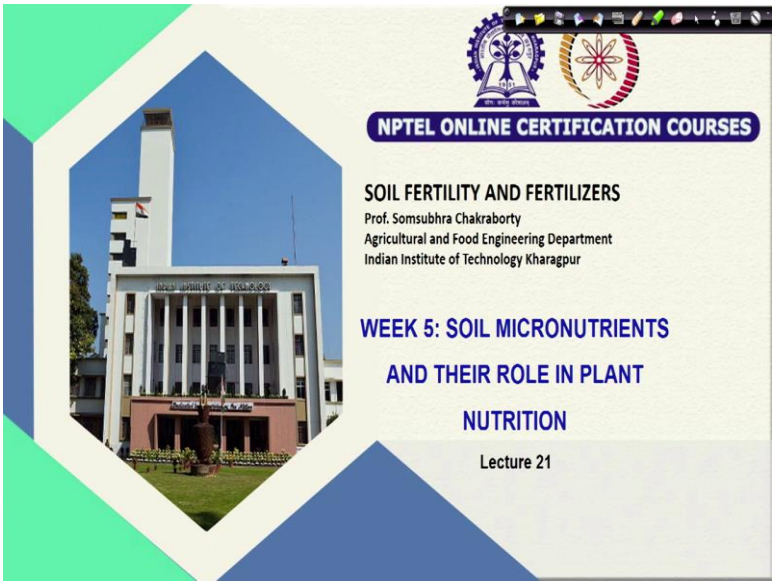


And in this new week, week 5, we are going to discuss soil micronutrients and their role in plant nutrition. So, in our previous weeks, we have already discussed all 6 macronutrients. In week 2 we have discussed nitrogen. In week 3 we have discussed phosphorus and potassium. And in week 4, we have discussed all the 3 secondary nutrients calcium, magnesium and sulfur. Now, in this week 5, we are going to discuss the micronutrients which are also very, very important for plant growth and their nutrition.

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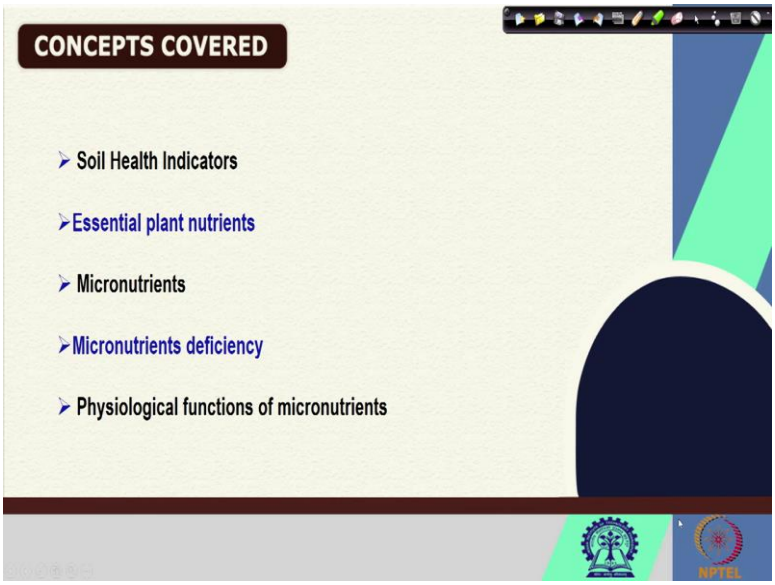


So, these are the concepts which we are going to cover in this lecture. First of all, soil health indicators we are going to discuss briefly then essential plant nutrients we are going to discuss micronutrients, micronutrient deficiency and also physiological functions of micronutrients we are going to discuss.

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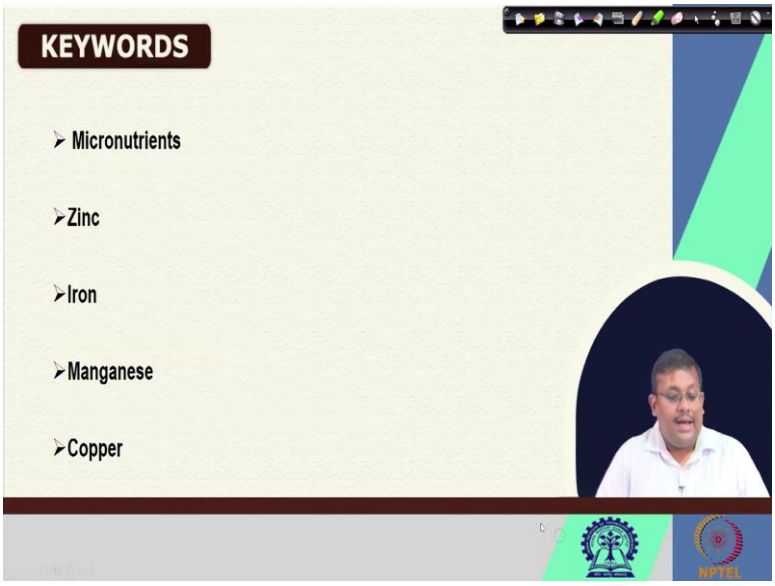

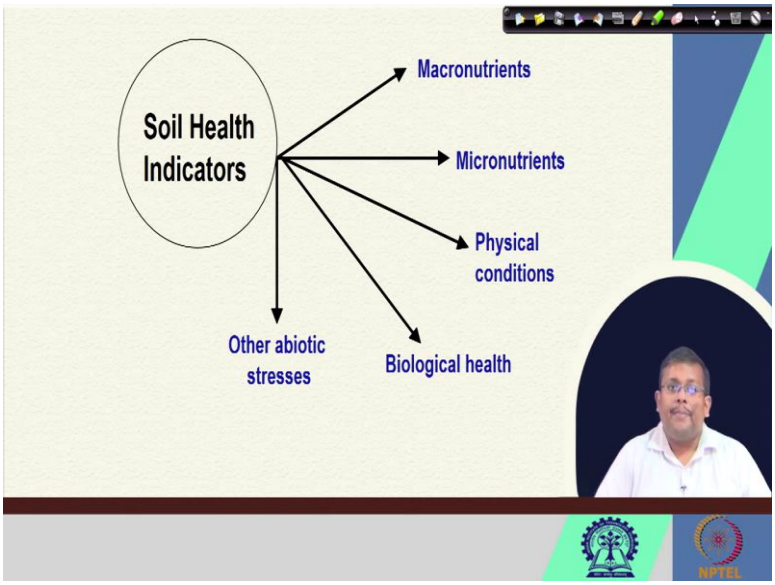


And these are some of the keywords like micronutrients then zinc, iron, manganese, copper. So, these are some of the keywords for this first lecture of week 5 or lecture number 21. So, we already know that there are different types of soil health indicators and when you define a soil health that has a connection with both macronutrients and micronutrients, different types of physical conditions of the soil, and also the biological health of the soil and other abiotic stresses. So, these all play an important role for maintaining the soil health. So, that is why along with the macronutrients micronutrients are also very much important for plant growth and nutrition.

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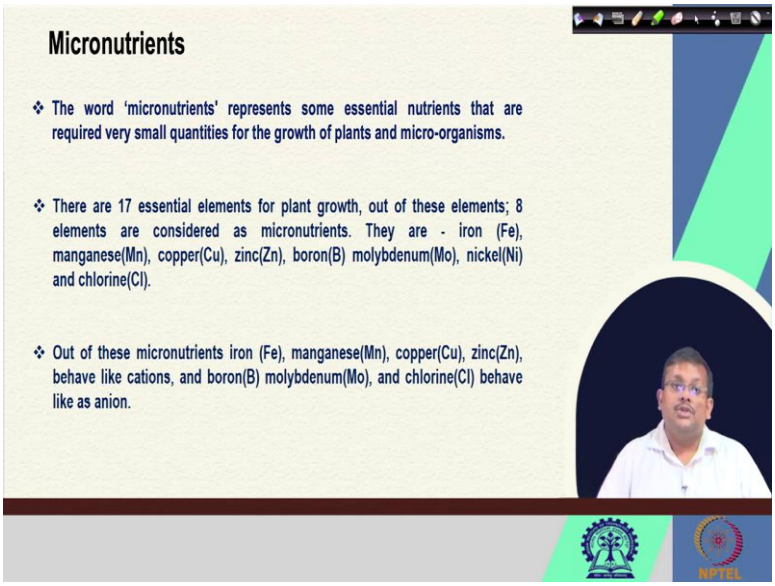


So, the word micronutrients represent some essential nutrients that are required in very small quantities for the growth of plants and microorganisms. The definition of micro is given

because of the relative quantity needed by the plant, however, irrespective of their quantity they are all important for maintaining or completing the lifecycle of the plant.

Now, there are 17 essential elements for plant growth we already know, out of these 8 elements are considered as micronutrients. What are those? They are iron, manganese, copper, zinc, boron, molybdenum, nickel and chlorine, we know that.

Also, out of these micronutrients, iron, manganese, copper, zinc behave like cataions, because Iron is available to the plant as Fe2 plus, manganese Mn2 plus, copper Cu2 plus, zinc Zn2 plus. However, boron, molybdenum and chlorine behave like as anions. So, we will see that available forms in our coming slides.

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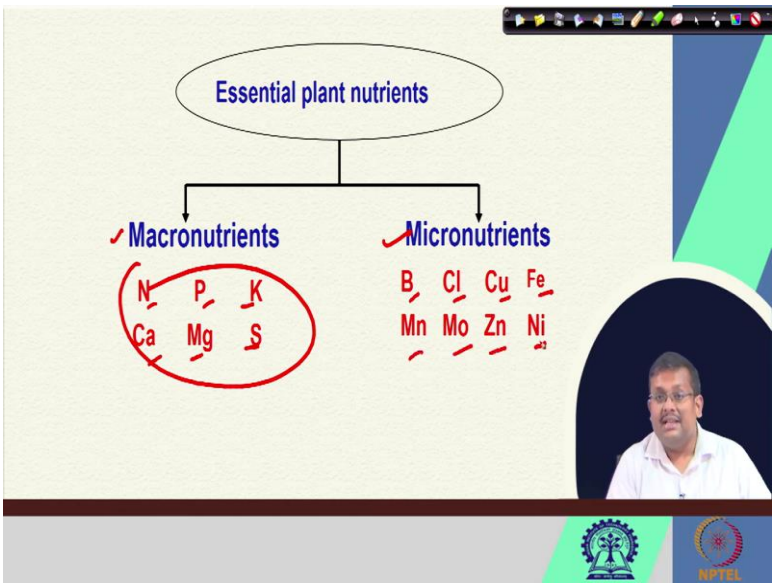


So, this is a broad classification between essential plant nutrients. We know apart from the C, H and O these are 3 structural elements. These are 6 macronutrients and micronutrients N, P, K, Ca, Mg, S, and micro macronutrients. However, in case of micronutrients we can see boron, chlorine, copper, iron, manganese, molybdenum, zinc and nickel. These 8 comes under the micronutrient category of essential plant nutrient.

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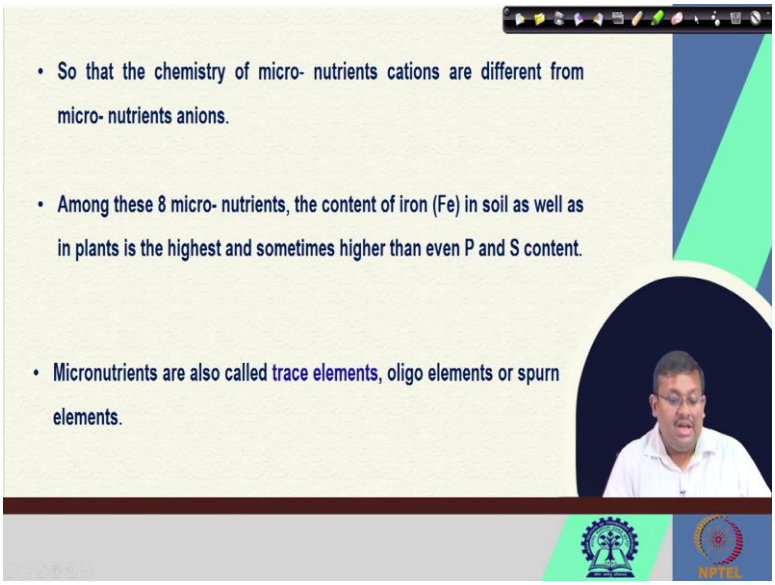


Now, the chemistry of these micronutrients are different from, so, the chemical chemistry of this micronutrient cations, like Fe2 plus Mn2 plus Cu2 plus Zn2 plus are different from the micronutrient anions. So, among these 8 micronutrients, the content of iron in soil, as well as in plants is the highest and sometime higher than even phosphorus and sulfur content.

So, iron is the most abundant micronutrient and the and also sometimes they are more richer than even for phosporous and sulphur, micronutrients are also called trace elements or oligo elements or spurn elements. So, these are some synonyms of micronutrients.

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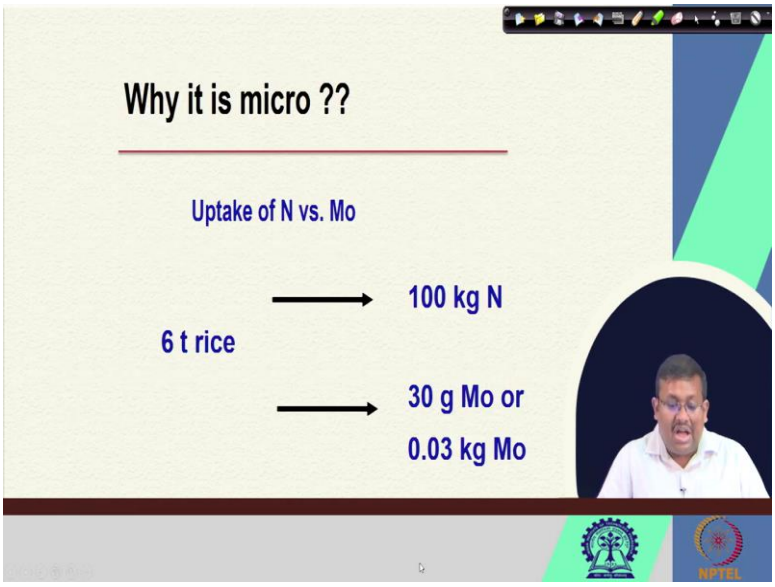

Now, what is micro? So, this slide will clarify why we will call them as micronutrients. So, if we compare the the the uptake of nitrogen versus molybdenum for producing 6 tonnes of rice. So, to produce the 6 tons of rice we require 100 kg of nitrogen however, for producing the same 6 tonnes of rice we require only 30 grams of molybdenum or 0.03 kg of molybdenum. So, you can see that there is a clear difference between the amount of needed by the plant as far as the nitrogen and molybdenum are concerned.

So, we can see clearly why we call molybdenum as a micronutrient because of the relative lace quantity of the requirement for plant growth.

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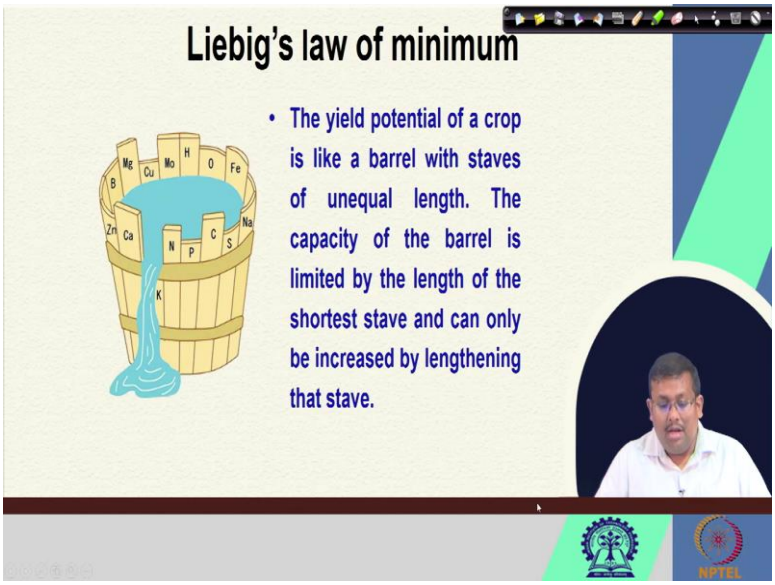


However, as I already mentioned, it does not matter whether a micronutrient is required in less quantity or not, they are always important, and that can be substantiated by Liebig's law of minimum, we have already discussed these Liebig's law of minimum in our first week of lectures.

So, we know that the yield potential of a crop is like a barrel with staves of unequal length, the capacity of the barrel is limited by the length of the shortest stave and can only be increased by lengthening that stave. So, it does not matter whether that the micro editing is require in less quantity or not the micronutrient deficiency can affect the the growth of the plant more than other available nutrients when it is deficient, because of Liebig's law of minimum.

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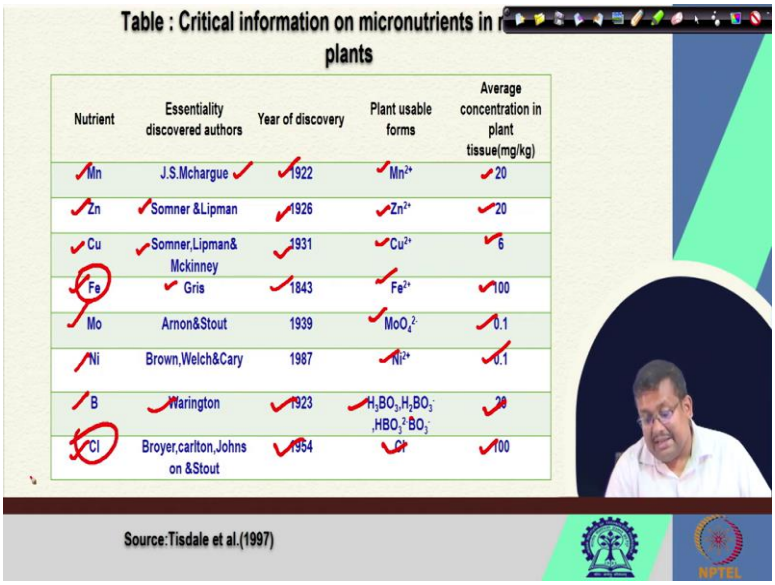


Now, let us see some critical information on micronutrients in relation to the plant. So, these are some of the micronutrients and they are the the authors who have discovered their essential duties and the year of discovery and plant usable form and and and we have seen we can see that average concentration plant tissue. So, manganese was discovered by Mchargue in 1922 and the plant usable form is Mn2 plus, whereas, average concentration in plant tissues 20 milligram per kg or 20 ppm.

Zinc was discovered by essentially 80 of zinc was discovered by Somner and Lipman in 1926. And plant usable form is Zn2 plus and average concentration is 20 ppm. In case of copper it was discovered in 1931 by Somner and Lipman and Mckinney and plant usable form is Cu2 plus average concentration is 6 ppm. Iron was discovered by Greece in 1843 plant usable form is actually the availability of the, or the essentiality of Iron was discovered by Greece in 1843.

And the plant usable form is Fe2 plus an average concentration in plant tissue is 100 PPM. Arnon and Stout in 1939 discovered the essentiality of molybdenum and plant usable form is molybdate or MoO 4 2 minus and average concentration in the plant is 0.1 ppm, Brown Welch and Cary in 1987 discovered the essentiality of nickel and the plant usable form is in a 2 plus an average concentration plant tissues 0.1 PPM.

Boron, the average the essentiality of boron was discovered by Warington in 1923. And it is available in this form H 3 BO 3, H 2 BO 3 minus, HBO 3, 2 minus and BO 3 minus, and

average tissue concentration is 20 ppm. And in case of the they essentiality of chlorine was discovered by Broyer, Carlton, Johnson and Stout. In 1954 the plant usable form is chloride and average concentration is in plant tissue is 100 ppm.

So, we can see that average concentration of both iron and chlorine are almost similar and this is 100 ppm in that plant tissue.

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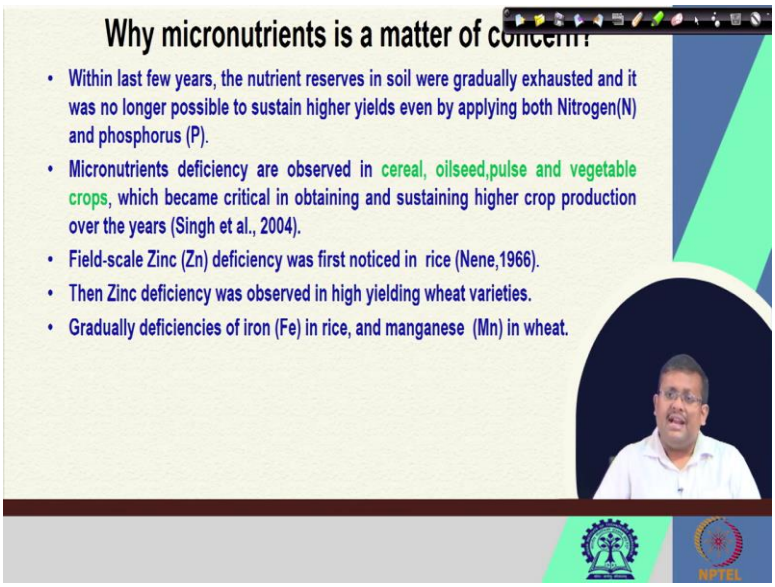


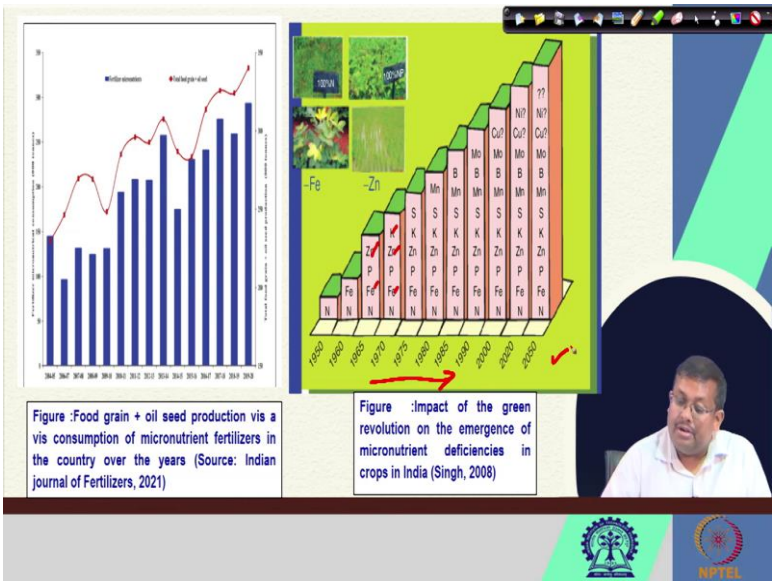


Now, why micronutrient is a matter of concern? Although it is declared in very less quantity, so, why we even care about whether they are available in the soil or not. Now, within the last few years the nutrient reserve in soil, we have seen that this is the nutrient reserve in the soil

is gradually exhausted and it was no longer possible to sustain higher yields even by applying botqh nitrogen and phosphorus.

So, supply nitrogen and phosphorus cannot cope up with the decrease in yield as a result of exertion of nutrient reserves. So, micronutrient deficiency are also observed in cereal oil seed pulse and vegetable crops, which became critical in obtaining and sustaining higher crop production over the years.

Field-scales zinc deficiency was first noticed in rice in 1966. And then zinc deficiency was observed in highly wheat varieties to and gradually deficiencies of iron in rice and manganese in wheat were also observed. So, for the last couple of decades, we have seen a gradual increase in micronutrient deficiency in the soil and there are several reasons behind that.

So, before going to those reason, let us see that the foodgrain plus oil seed production versus a the consumption of micronutrient fertilizer in the country over the years. So, starting from 2004 to 5, the data is given up to 2020 and we can see that, with the fertilizer, fertilizer micronutrient consumption is continuously increase and also the total food grain per oilseed production is also continuously increased.

So, this red line is showing the increase continuous increase in total food grain products plus oilseed production, whereas fertilizer consumption, so, 1 thing is clear, with the increase of total production of grain and oil seeds, we have seen a continuous increase in fertilizer consumption, micronutrient fertilizer consumption also in this right figure, it can be seen that it has an impact of green revolution on the emergence of micronutrient deficiencies in crops of India. So, you can see from 1950s, 60s, 70s, 65, 70, 75 in 1980s, up to 2050. So, it is projected. So, we can see how gradually different micronutrients are becoming unavailable.

So, 1965 we have seen the deficiency of iron and zinc in 1970 the deficiency of iron, zinc and potassium apart from this iron and zinc, we have seen the deficiency of nitrogen phosphorus potassium, then, in 1975 Apart from these iron and zinc, the nitrogen phosphorus potassium sulfur, where so, as the time progresses the number of elements showing the deficienc continuously increases due to different types of reasons.

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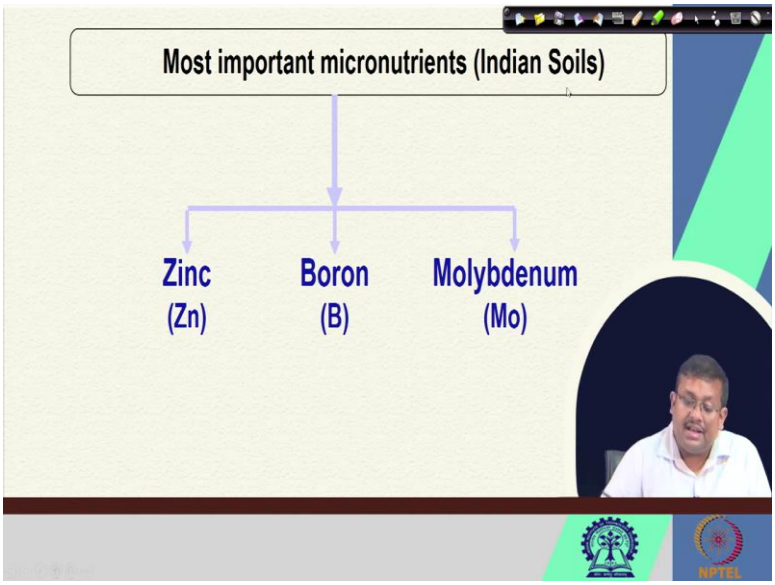


So, if we consider the Indian soil the 3 most important micronutrients are zinc, boron molybdenum, because in many parts of India, the deficiencies of these 3 micronutrients are very much good, we, you can observe the deficiency of these 3 nutrients in different parts of India. So, that is why these are important micronutrients as far as the Indian soils are concerned.

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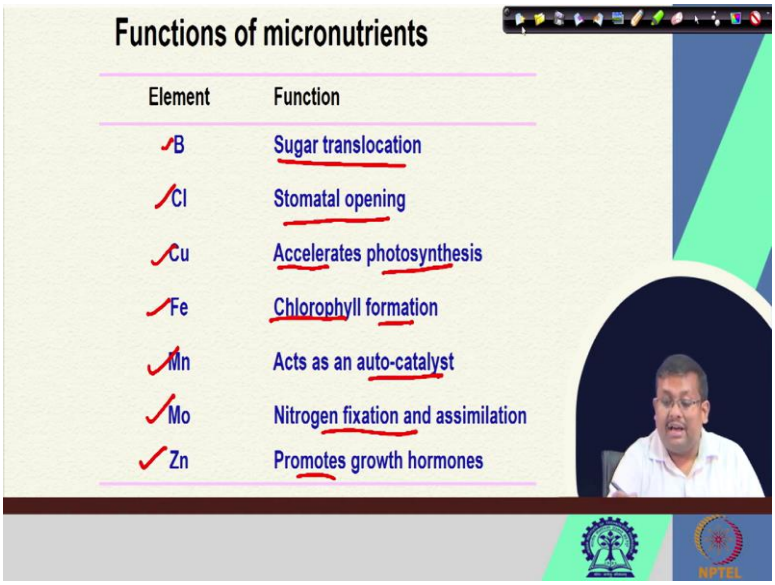


Now, let us see what are the functions of micronutrients. So, if we consider the boron, boron is useful for sugars translocation in plant and also chlorine which is important for stomatal opening and copper is important for accelerating the photosynthesis Iron is important for

chlorophyll formation. Manganese is important for as an auto catalyst molybdenum is a macronutrient which helps in nitrogen fixation and assimilation and zinc helps in promoting the growth hormone.

So, these are the functions, major functions of these micronutrients. So, you can see that for the growth and metabolism of the plant, these elements are very essential.

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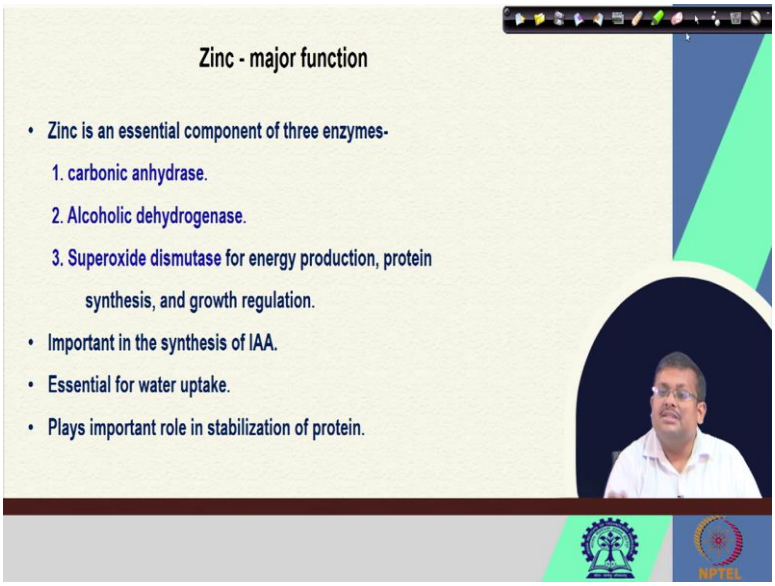


Now, let us see the functions major functions of different elements one by one. So, we can see in case of zinc, zinc is an essential component of three enzymes, one is carbonic anhydrase, another is alcoholic dehydrogenase and superoxide dismutase for energy production, protein synthesis and growth regulation, it is also an important in the synthesis of indole acetic acid and also this is essential for water uptake. Zinc plays an important role in stabilization of the protein.

So, you can understand that how zinc is very much important it is with pretty much essential for different enzymes, enzymatic activities, which regulates the energy production and protein synthesis and growth regulation.

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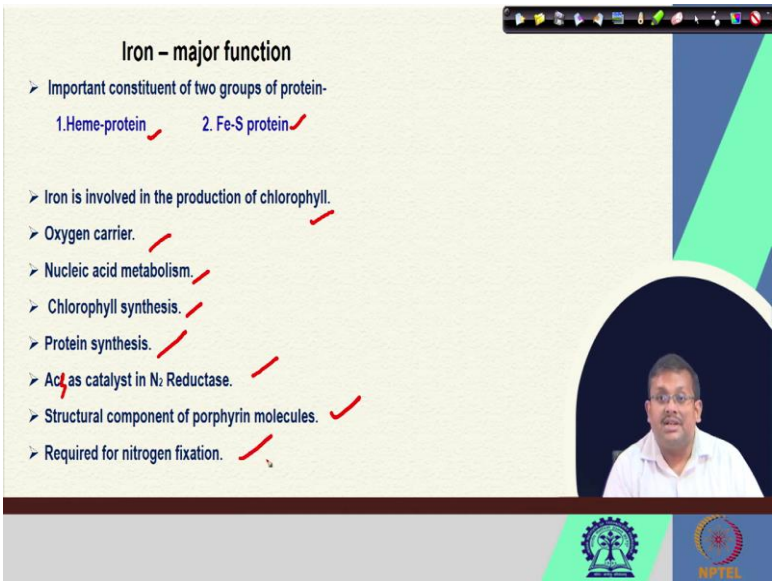


Iron in case of Iron, it is an important constituent of two main groups of protein. So, one is Heme-protein another is iron sulfur protein.

So, iron is involved in the production of chlorophyll it is in, it also acts as oxygen carrier it helps in the nucleic acid metabolism, it helps in chlorophyll synthesis protein synthesis, it the iron acts as in, as catalyst inactivated nitrous indeed that is also it is a structural component of porphyrin molecules and it required for nitrogen fixation. So, these are some of the major functions of iron.

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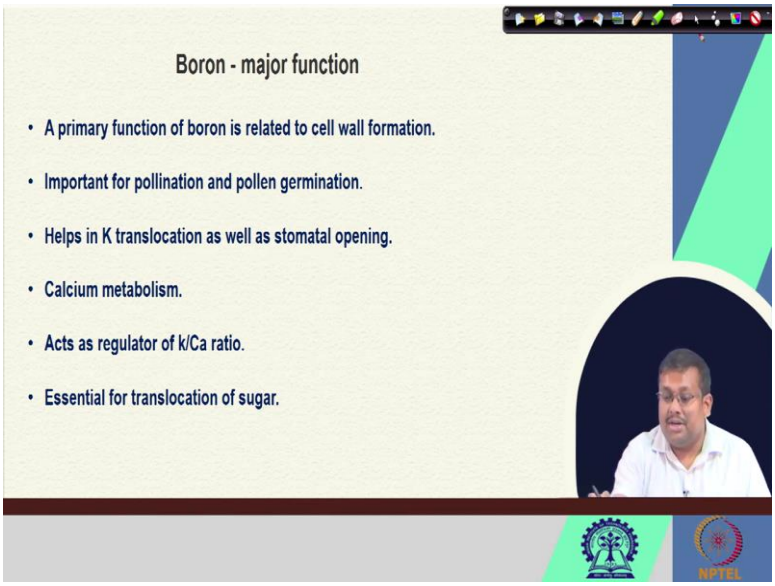

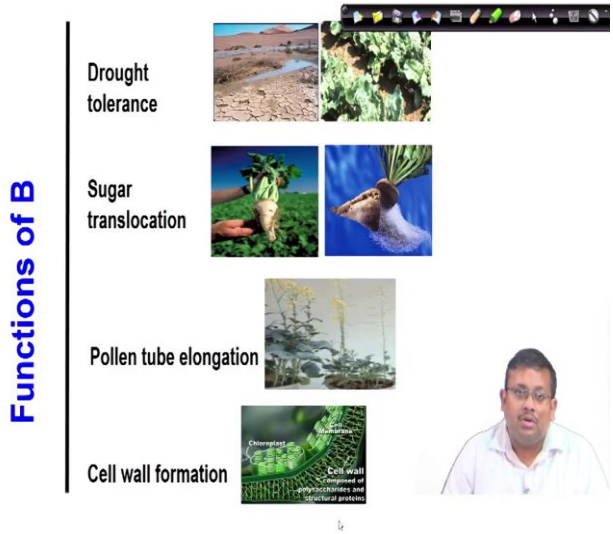


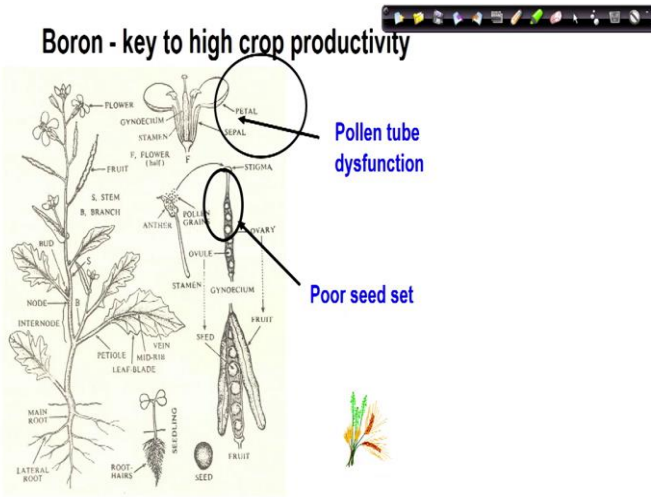


Now, let us talk about the major function of boron. So, we can see that the primary function of boron is related to cell wall formation, it is important for pollination and pollen germination, it helps in potassium translocation as well as stomatal opening, helps in calcium metabolism, it acts as a regulator of potassium calcium ratio and it is also essential for translocation of sugar.

So, these are the major functions of boron. So, if we can classify the four major functions of boron are drought tolerance, sugar translocation, pollen tube elongation and cell wall formation, deficiency of boron can impact the pollen tube and ultimately create the pollen tube dysfunction and also ultimately results in poor seed set.

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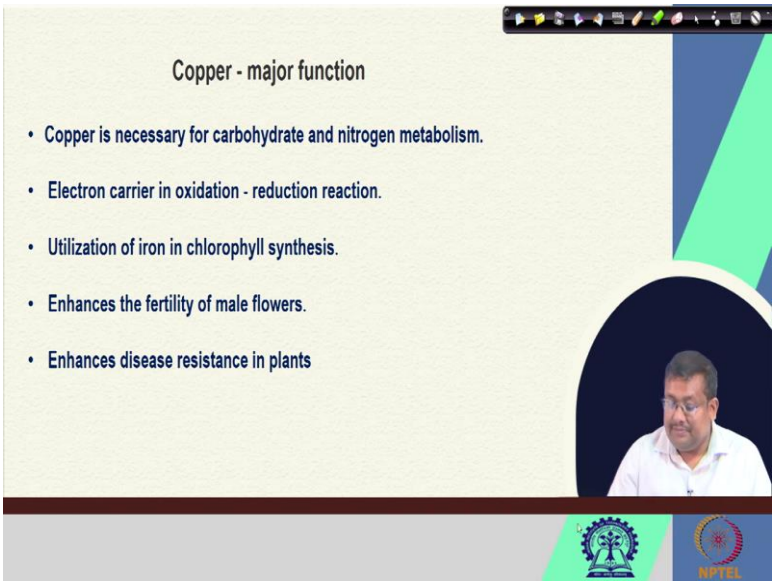


And in case of copper, the major functions are carbohydrate and nitrogen metabolism, it is it is a copper is a carrier in oxidation reduction reaction, it it helps in utilization of iron in chlorophyll synthesis, and it also enhances the fertility of the male flowers and it also enhances the disease resistance in the plants.

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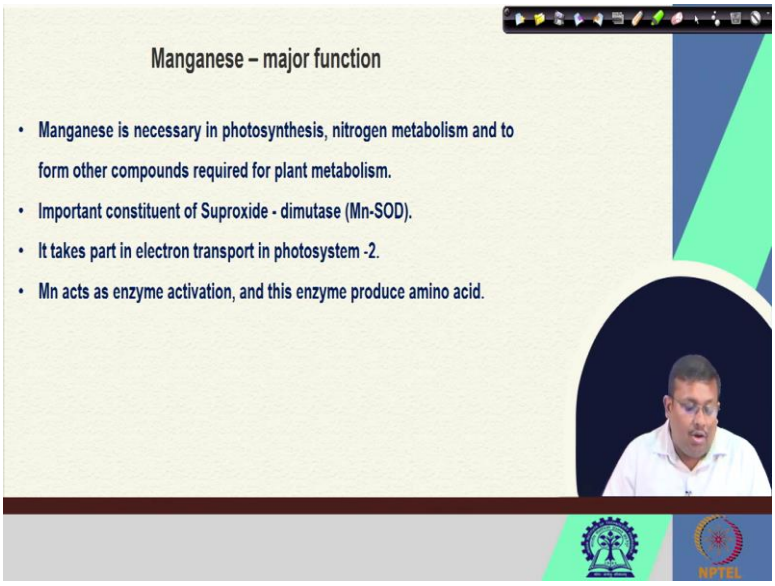


In case of manganese, manganese is necessary in photosynthesis nitrogen metabolism and to form other compounds required for plant metabolism, it is important constituents of suproxide dismutase or Mn-SOD. It takes part in electron transport photosystem 2 and

electron transport in photosystem 2 and it also acts as enzyme activation and these enzyme produce amino acids.

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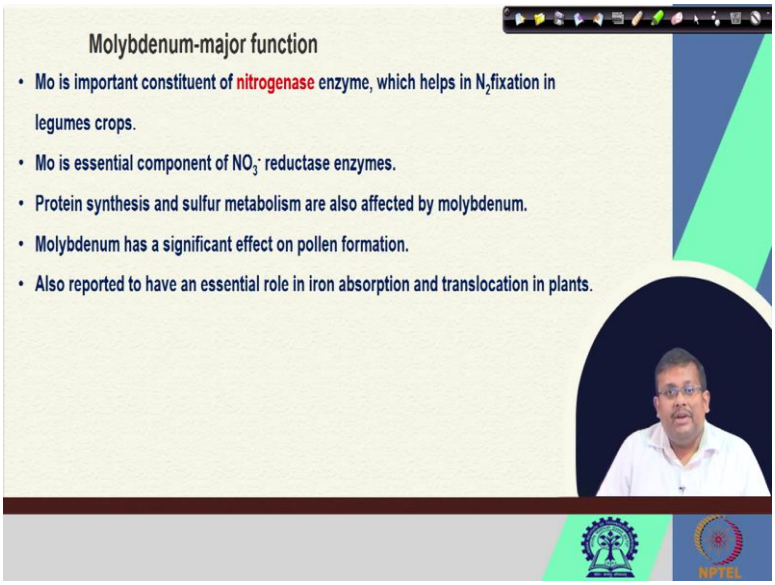


So, in case of molybdenum, molybdenum is an important constituent of nitrogenase enzyme, which helps in Nitrogen fixation in legume crops and it is an essential component of nitrateic acid and reductase enzyme.

Also helps in protein synthesis and sulfur metabolism and also has a significant effect on pollen formation. And it has also an essential role in iron absorption and translocation in plants.

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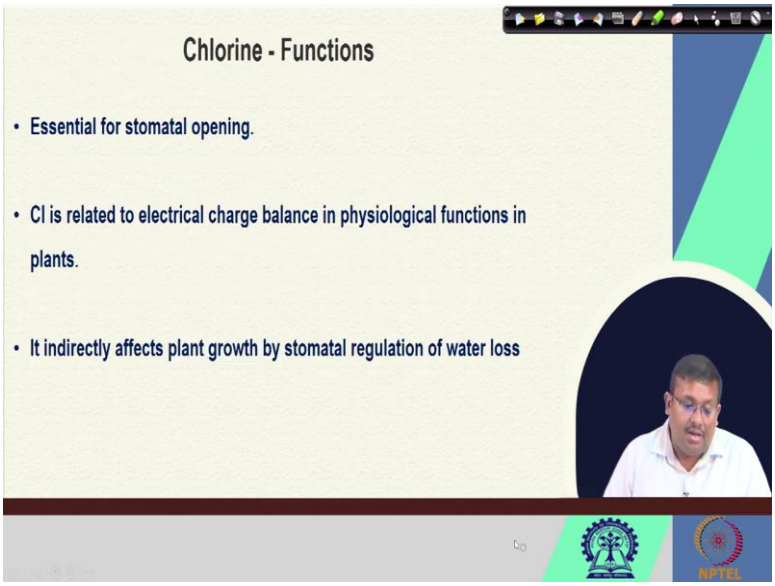

In case of chlorine it is essential for stomatal opinion and chlorine is related to electrical charge balance in physiological functions in plants and it indirectly affects plant growth by stomatal regulation of water loss.

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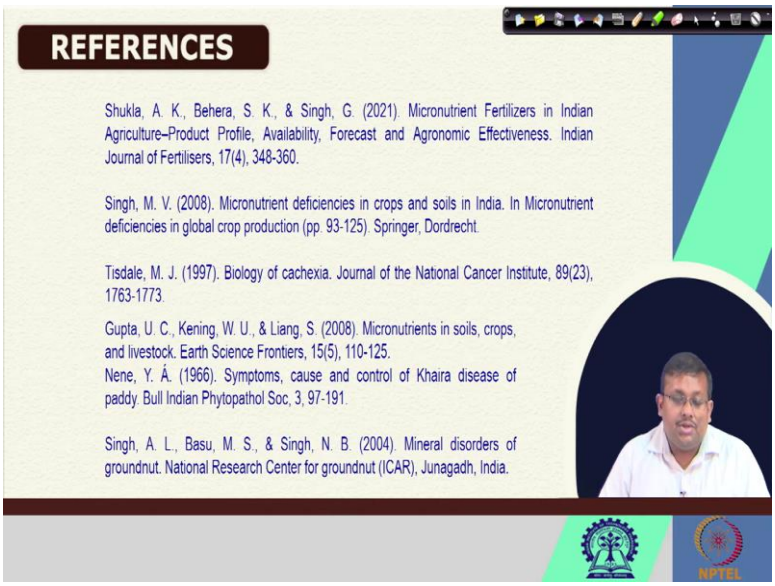


So, guys, by this, let us wrap up this lecture in this lecture we have seen the basics of micronutrients and why they are important, they are ruled in the plant metabolism we have discussed and also we have discussed they are available forms and when they were they are essentiality criteria was discovered we have discussed.

So, these important basic overview of these micronutrients will be required for identifying, they are for identifying or for explaining their role in the growth of the plants and their metabolism so let us wrap up this lecture here and we will start from here in the next lecture and we will discuss more about these micronutrients, thank you.