Soil Fertility and Fertilizers
Professor Somsubhra Chakraborty
Agricultural and Food Engineering Department
Indian Institute of Technology, Kharagpur
Week 5
Lecture 25
Soil Micronutrients and Their Role in Plant Nutrition (Contd.)

Welcome friends to this last lecture of week 5, lecture number 25 of this NPTEL online certification course of soil fertility and fertilizers. And in this week 5 we are talking about soil macronutrients and their role in plant nutrition. In our first four lectures, we have discussed about basics of micronutrients, micronutrients cycle, their sufficiency and deficiency, their critical ranges, their toxicity symptoms, their deficiency symptoms in details. And in this last lecture, that is lecture number 25. We are going to discuss these following concepts.

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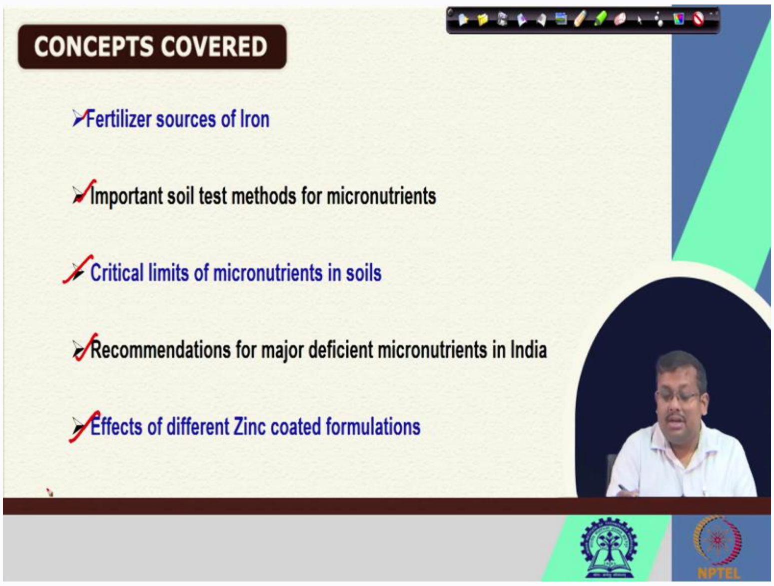

These are first of all we are going to discuss the fertilizer sources of iron and then important soil test methods for micronutrients and then critical limits of micronutrients in soils and then recommendation for major deficient micronutrients in India and also effects of different zinc coated formulations. So, these are some of the concepts which we are going to discuss.

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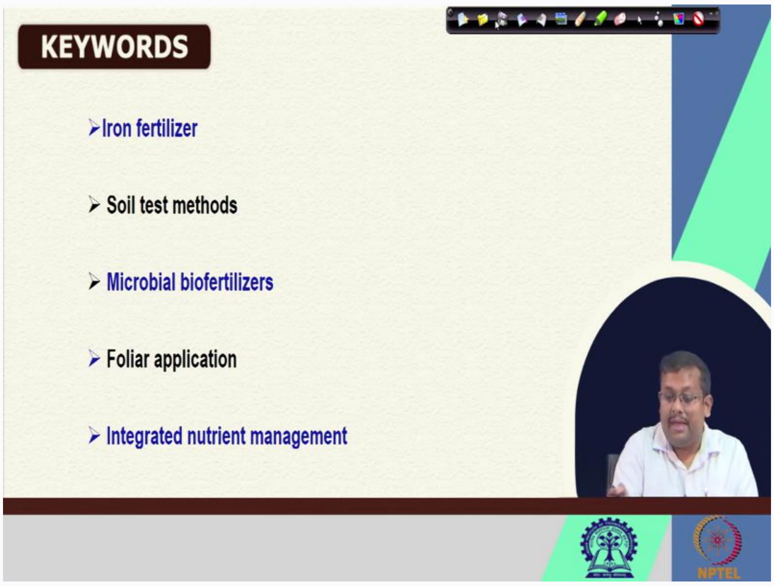

These are the keywords for this lecture, iron fertilizer, soil test methods, microbial biofertilizers, foliar application and integrated nutrient management.

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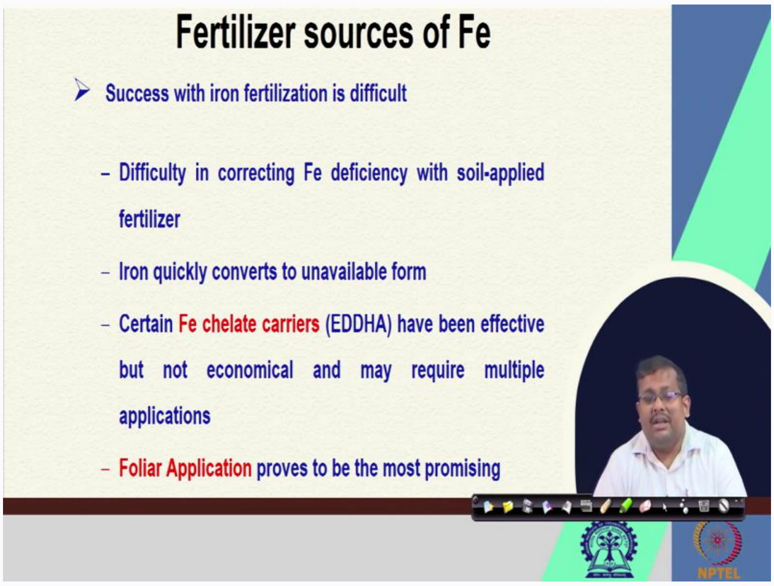

So, let us see what are the fertilizer sources of iron. Now, we must remember that success with iron fertilization is difficult because there is a difficulty in correcting iron deficiency with soil applied fertilizer because when we apply this iron, iron quickly converts to unavailable form certain iron chelate carriers like EDDHA have been effective but not economical and may require multiple applications.

And foliar application of iron proves to be the most promising approach for correcting the iron deficiency in the crop. So, when we apply this, why iron converts to unavailable form because the available form is Fe2 plus when you apply this Fe2 plus in the soil it gets oxidised to Fe3 plus form and that becomes unavailable to the plant. So, this is how the iron's fertilization through soil applied fertilizer is difficult. So foliar application is an approach which can takes care of the iron deficiency in the crop.

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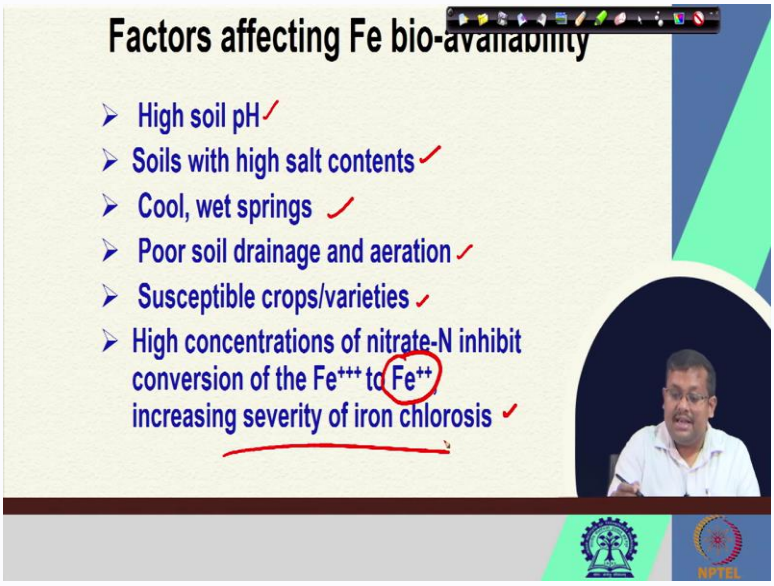

Now, what are the factors affecting the iron bio-availability? First of all, soil pH, is in high soil pH, you know that iron and manganese are mostly available in low soil pH. However, when there is a high soil piece that impact the iron availability and creates the iron deficiency.

Soils with high salt contents also can create the bioavailability of iron and then cool, wet springs are also responsible for reducing the bio-availability of iron, poor soil drainage and aeration is another reason for iron deficiency and susceptible crops and varieties are also very much prone to iron deficiency and then high concentration of nitrate nitrogen inhibit conversion of Fe3 plus to Fe2 plus increasing severity of iron chlorosis.

So, what happens generally we know that iron is available to the plant as Fe2 plus, now when there is a high concentration of nitrate nitrogen that inhibit the current version of this Fe3 plus to Fe2 plus thereby increasing the iron deficiency and the symptoms can be seen as iron chlorosis.

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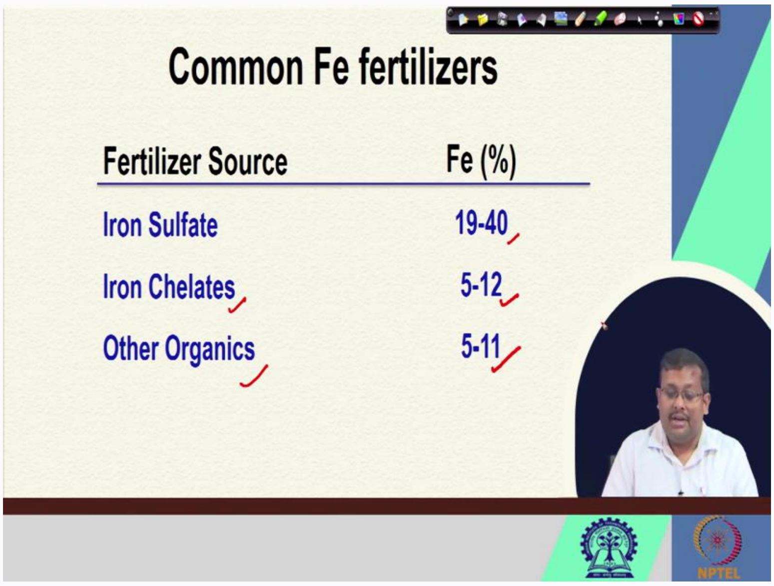

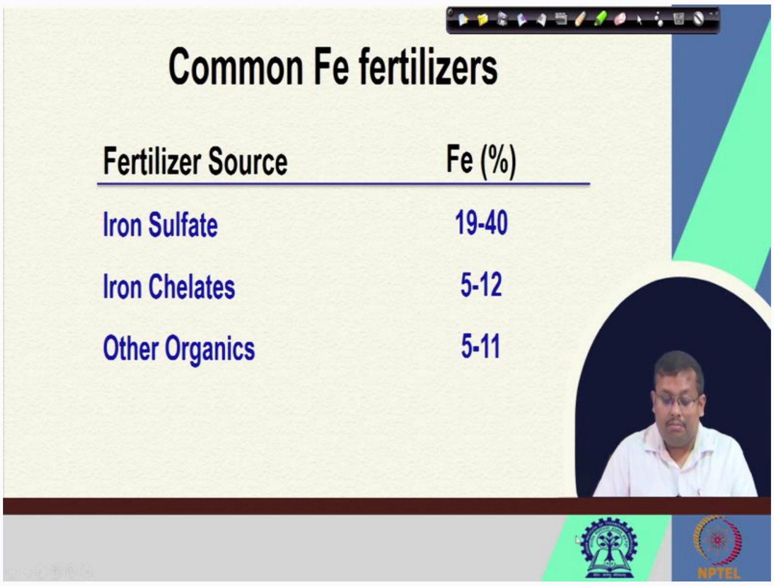

Now, common iron fertilizer we can see that fertilizers source like iron sulphate when there is an iron sulphate the iron content is 19 to 40 percent. When there is an iron chelates, the iron content is 5 to 12 percent. And when we use other organics that contain 5 to 11 percent of iron. So, these are the some common iron sources of fertilizers.

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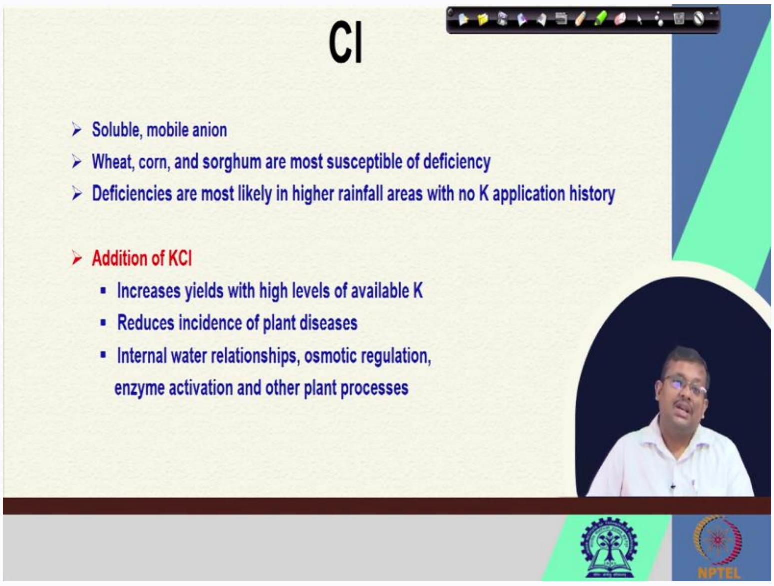

Now, once we completed iron, let us move to, let us move to chlorine. Now, chlorine is available to the plant as chloride anion, which is a soluble, mobile anion and wheat, corn and sorghum are most susceptible of chlorine deficiency. The chlorine is very much important, because that governs the different plant activities and deficiency are most likely in higher rainfall areas with no potassium application history.

So, what happens when there is a high rainfall that can leach all the chlorine because this is a high mobile highly mobile anion. So, chloride ion can be easily leached away from the soil with high amount of water and ultimately creating the chlorine deficiency. Addition of potassium chloride or Muriate of potash can increase the yield with high levels of available potassium.

It can reduce this incidence of plant diseases and it can regulate the internal water relationship osmotic regulation, enzyme activation and other plant processes since, chlorine is very much important for water internal what relationship, osmotic regulation. So, when we apply this Muriate of potash, that also takes care of these enzymatic activation, osmotic regulation and internal water relationship.

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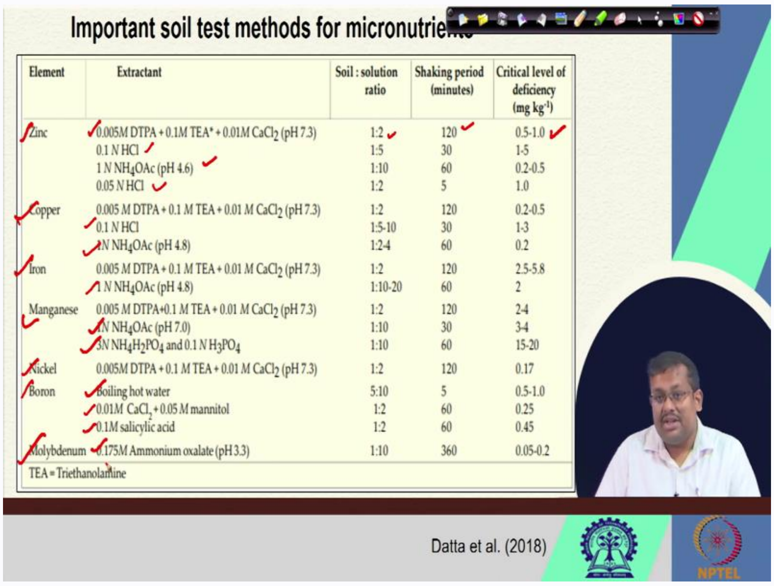

Element	Extractant	Soil : solution ratio	Shaking period (minutes)	Critical level of deficiency (mg kg^{-1})
Zinc	0.005M DTPA + 0.1M TEA* + 0.01M $CaCl_2$ (pH 7.3)	1:2	120	0.5-1.0
	0.1 N HCl	1:5	30	1-5
	1 N NH_4OAc (pH 4.6)	1:10	60	0.2-0.5
	0.05 N HCl	1:2	5	1.0
Copper	0.005 M DTPA + 0.1 M TEA + 0.01 M $CaCl_2$ (pH 7.3)	1:2	120	0.2-0.5
	0.1 N HCl	1:5-10	30	1-3
	1N NH_4OAc (pH 4.8)	1:2-4	60	0.2
Iron	0.005 M DTPA + 0.1 M TEA + 0.01 M $CaCl_2$ (pH 7.3)	1:2	120	2.5-5.8
	1 N NH_4OAc (pH 4.8)	1:10-20	60	2
Manganese	0.005 M DTPA+0.1 M TEA + 0.01 M $CaCl_2$ (pH 7.3)	1:2	120	2-4
	1N NH_4OAc (pH 7.0)	1:10	30	3-4
	3N $NH_4H_2PO_4$ and 0.1 N H_3PO_4	1:10	60	15-20
Nickel	0.005M DTPA + 0.1 M TEA + 0.01 M $CaCl_2$ (pH 7.3)	1:2	120	0.17
Boron	Boiling hot water	5:10	5	0.5-1.0
	0.01M $CaCl_2$ + 0.05 M mannitol	1:2	60	0.25
	0.1M salicylic acid	1:2	60	0.45
Molybdenum	0.175M Ammonium oxalate (pH 3.3)	1:10	360	0.05-0.2

TEA = Triethanolamine

Now, let us see some important soil test methods for micronutrient tests in the soil. So, if we see zinc as an element, so, we use different types of extractants for extracting these micronutrients from the soil. So, this zinc can be extracted by a mixture of 0.005 molar of DTPA which is a chelating agent and 0.1 molar TEA or triethanolamine and 0.01 molar calcium chloride at pH, buffered at pH 7.3.

So, in this case, the soil solution ratio will be 1.2 and the shaking period will be 120 minutes. And here in this method the critical level of deficiency could be 0.5 to 1 ppm. We can also extract this available zinc with 1 normal, 0.1 normal HCL, 1 normal ammonium acetate at pH 4.6 or 0.05 normal of HCl and for them, the soil solution ratio, shaking period and critical levels are also mentioned here.

In case of copper, we can also use the same DTPA TEA CaCl2 in fact, these DTPA TEA CaCl2 mixture can be used for both zinc copper, iron and also manganese and also nickel. So, all these 5 micronutrients can be extracted by this mixture of DTPA and then triethanolamine and calcium chloride. So, now, apart from this in case of copper we can also see these 0.1 normal HCL can be used and also 1 normal ammonium acetate can be used at pH 4.8.

Iron 1 normal ammonium acetate with pH 4.8 and we know, 1 normal ammonium acetate at pH 7 can be used for manganese and 3 normal this ammonium hydrogen phosphate and then phosphoric acid can be used for extracting the manganese. In case of boron, boron can be extracted from the soil through boiling water, boiling hot water. So, that is why it is called the hot water-soluble boron and we can also extract the boron with 0.01 molar calcium chloride plus 0.05 molar of mannitol and also boron can be extracted by 0.1 molar salicylic acid.

For extracting the molybdenum, generally we use 0.175 molar of ammonium oxalate at pH 3.3. So, these are some of the extracted which can extract these micronutrients and after extracting these micronutrients, there are several methods which we use for measurement of this micronutrient concentration in this extracted solution. For example, zinc, copper, iron and manganese we can measure with atomic absorption spectrophotometer or AAS.

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Now, let us see what are the recommendations for major deficient micronutrients in India.

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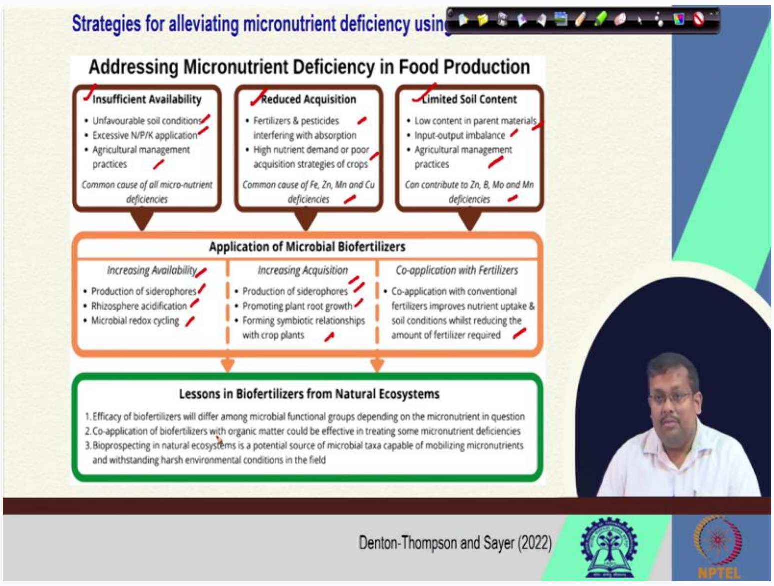

So, these are the strategies for alleviating micronutrient deficiencies. So, we can address the micro deficiency in food production by three methods. First of all, let us discuss what are the major causes of micronutrient deficiency. First of all, insufficient availability, second is reduced acquisition and third is limited soil content.

So, insufficient availability of the micronutrients can be caused by unfavourable soil conditions, then excessive NPK application and agricultural management practices, faulty agricultural management practices, these are the major reasons for insufficient availability of the micronutrients. These are the common cause of all micronutrient deficiencies. So, for these for rectifying these we can apply microbial biofertilizer which can increase the availability by production of siderophores and rhizosphere acidification and microbial redox cycling.

So, microbial redox cycling can help to convert the unavailable forms to some available forms by changing their redox number or redox potential. So, these are some of the ways. Now, did you see acquisition is another reason where fertilizers and pesticides interfering with adsorbed absorption, then high nutrient demand or poor acquisition strategies of the crops are responsible.

So, these two are the common cause of iron, zinc, manganese, and copper deficiency. And if the solution for these is increasing the acquisition, how to increase the acquisition by microbial fertilizer because they helps in production of siderophores. Siderophores acts like chelate. So, basically, they bind these metal ions and then make increase their availability then promote the plant root growth and they can form the symbiotic relationship with crop plants.

So, these are some of the ways through which micronutrient biofertilizers can be applied to increase the micronutrient acquisition. Limited soil content is another reason for micronutrient deficiency and low content in parent material and the input output imbalance and agricultural management practices can contribute to the zinc, boron, molybdenum and manganese deficiency.

And this co-application of this micronutrients microbial biofertilizers with fertilizer that can help because co-application with conventional fertilizer improves nutrient uptake and soil conditions while reducing the amount of fertilizer required. So, this is how this application of bio fertilizers can help in microbial can help in alleviating the micronutrient deficiencies. So, lessons in bio fertilizers from natural ecosystems.

So, we can see that efficacy of biofertilizer will differ among microbial functional groups, depending on the micronutrient in question and co-application of biofertilizers with organic matter could be effective in treating some micronutrient deficiencies. And bioprocessing in natural ecosystem is a potential source of microbial taxa capable of mobilising micronutrients and withstanding harsh environment condition in the field.

So, we can alleviate this micronutrient deficiency this way by applying these different types of micronutrient or microbial bio fertilizers.

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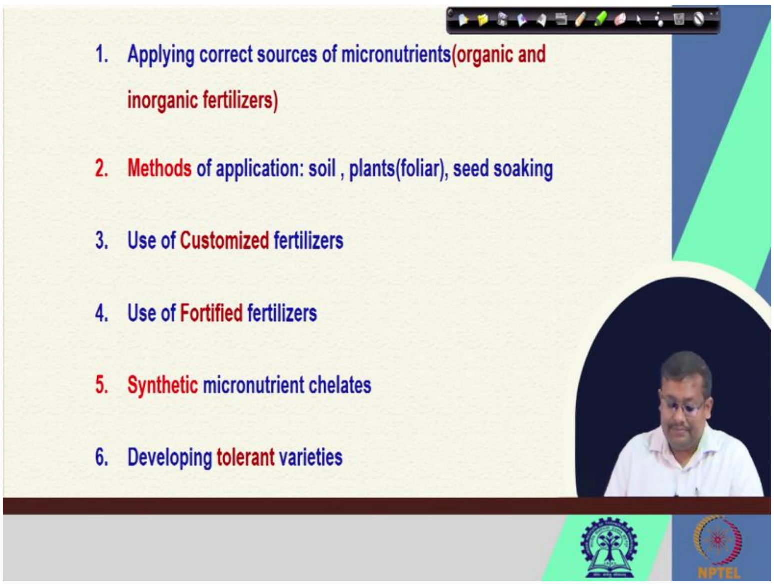

So, these are some of the ways to which we can correct this biofertilizer microbial deficiency, first of all, applying the correct source of, sources of micronutrients, both organic or inorganic fertilizers. Secondly, methods of application, it could be either soil foliar application or seed soaking. We can also use customised fertilizers, we can also use fortified fertilizer, we can also use synthetic micronutrient chelates or developing taller and varieties which can withstand these micronutrient deficiencies.

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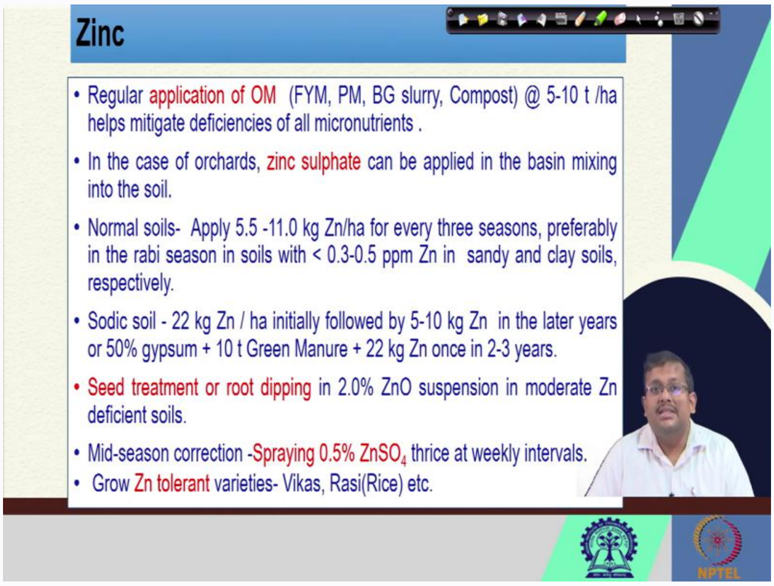

Now, let us talk about the zinc, now regular application of in case of zinc the regular application of organic matter in terms of farmland manure or poultry manure or biogas slurry and compost, at the rate of 5 to 10 tonne per hectare helps mitigate the deficiencies of all micronutrient. So, generally that contains also zinc. So, if we want to reduce the zinc deficiency, we can apply the organic matter at the rate of 5 to 10 tonnes.

So, in case of orchards we can apply zinc sulphate in the basin mixing into the soil. Normal in case of normal soil we can apply 5.5 to 11 kg of zinc per hectare for every three seasons, preferably in the rabi season in soils with less than 0.3 to 0.5 ppm of zinc, which can occur in sandy and clay soils. In case of sodic soil, we can apply 22 kg of zinc per hectare initially followed by 5 to 10 kg of zinc in the later years or 50 percent gypsum plus 10 tonnes of green manual plus 22 kg of zinc once in 2 to 3 years.

So, this is how we can will supply the zinc in the soil. Also, we can do seed treatment or root dripping in 2 percent zinc oxide suspension in moderate zinc-deficient soils and also, we can do midseason correction by spraying 0.5 percent zinc sulphate thrice at weekly intervals and also we can grow zinc tolerant varieties like Vikas, Rasi these are all rice varieties. So, we can grow these zinc tolerant varieties to cope up with the zinc deficiency.

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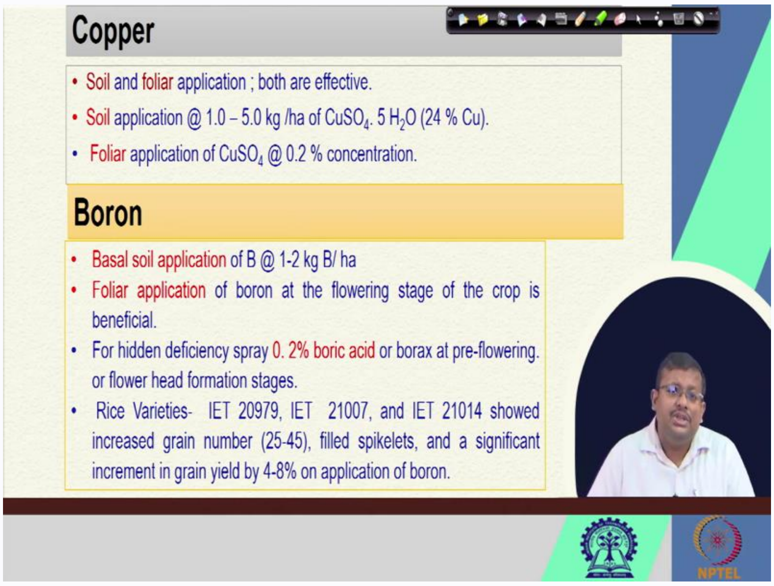

In case of copper soil and foliar applications are both effective and in case of soil application we should apply 1 to 5 kg per hectare of copper sulphate pentahydrate which contains 24 percent copper and foliar application of copper sulphate at the rate of 0.2 percent concentration can be also done. In case of boron we already know that we have to apply basal soil application of boron of 1.1 to 2 kg per hectare, foliar application of boron at the flowering stage of the crop is also beneficial.

For hidden deficiency that means, the plant has deficiency but it is not showing any deficiency symptoms we call it hidden hunger also. So, for this hidden deficiency we can spray 0.2 percent boric acid or borax at pre-flowering stage or our flower head formation stages. What are the rice varieties like IET 20979, IET 21007 and IET 21014 showed increased grain number, filled spikelet and a significant increment in grain yield by 4 to 8 percent of application of boron. So, these are some of the ways to which you can apply the boron fertilizer.

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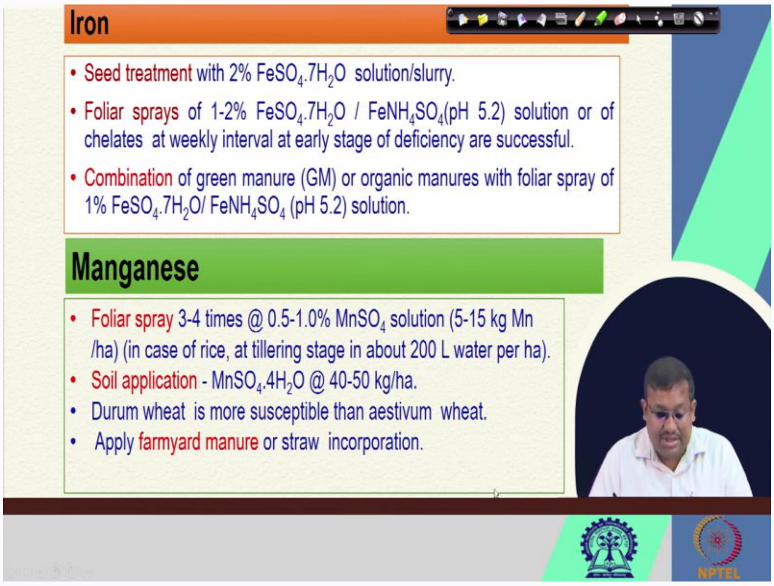

What about iron? Now seed treatment with 2 percent ferrous sulphate heptahydrate solution or slurry can be one way one of the ways also foliar sprays of 1 to 2 percent of ferrous sulphate heptahydrate ferrous ammonium sulphate at pH 5.2 solution or of chelates at weekly interval at early stage of deficiency can be successful and combination of green manure or organic manual with foliar spray of one percent ferrous sulphate heptahydrate or ferrous ammonium sulphate solution can be also done.

In case of manganese foliar spray 3 to 4 times at the rate of 0.5 to 1 percent of MnSO4 solution which is around 5 to 15 kg of manganese per hectare. Now, in case of rice at tillering stage about 200 litre water per hectare, so, this is a foliar spray. In case of soil application, we should apply this MnSO4.H2O at 40 to 50 kg per hectare. Durum wheat is more susceptible than aestivum wheat for manganese deficiency and we should apply farmyard manure or straw. We can also incorporate the straw in the soil to improve the manganese deficiency.

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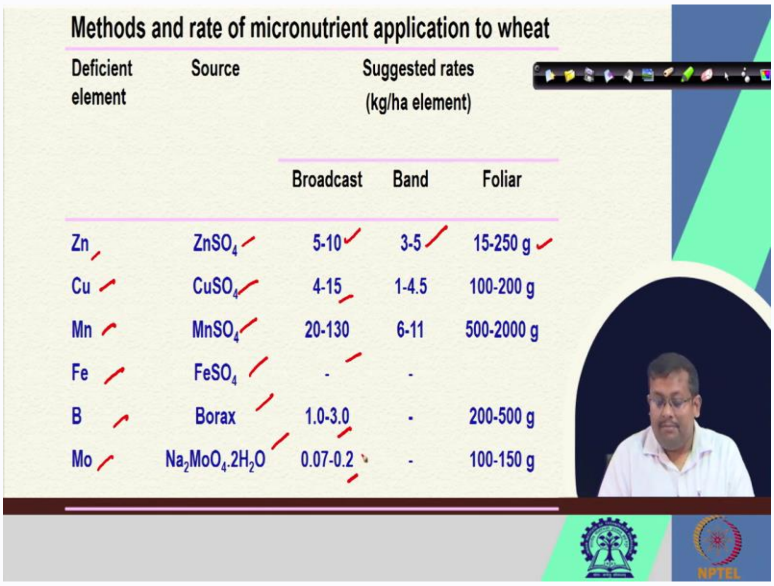

So, if we see the methods and rate of micronutrient application to wheat, we can see here, these are some deficient elements like zinc and these are the sources so, zinc we should apply as zinc sulphate, copper we should apply copper sulphate manganese MnSO4, Fe, FeSO4, boron, borax, molybdenum, sodium molybdate and this is, these are the suggested rates in kg per area hectare elements so, we can apply 5 to 10 for zinc as broadcast, band application should be 3 to 5 kg per hectare. And foliar applications should be 15 to 250 gramme. So, similarly for copper and for manganese and for boron and molybdenum are given here and this is for the wheat crop.

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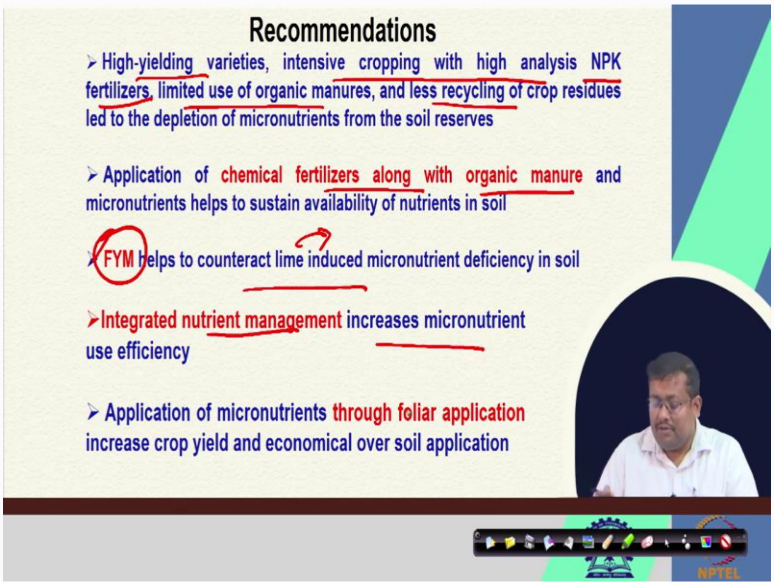

Now, what are the recommendations? So high yielding varieties and also intensive cropping with high analysis NPK fertilizer and limited use of organic manures and less recycling of crop residues led to the depletion of micronutrients from the soil reserves. So, what happens? These are some of the important factors which results in depletion of micronutrients from the soil like high yielding varieties, intensive cropping with high analysis, NPK fertilizer, limited use of organic manure, and less recycling of crop residues.

They are the major reason for micronutrient deficiency in the soil and application of chemical fertilizer along with organic manure and micronutrients helps to maintain sustain this availability of nutrients in the soil. FYM, this is the most common organic matter source, organic fertilizer in Indian condition helps to counteract the lime induced micronutrient deficiency in the soil.

So, generally when we apply the lime that can increase the soil pH and when it increases the soil pH several nutrients become unavailable. So, when we apply the farmyard manure there are several organic acids that can help to reduce or stabilise the pH in the normal range so that most of the micronutrients can be available. So, also another ways integrated nutrient management which can increase the micro nutrient use efficiency, application of micronutrients to foliar application also increase crop yield and can be economical over soil application.

So, these are some of the when we apply these micronutrients to foliar application can also increase the crop yield and of course, this is more economical than application of these fertilizers that were in soil.

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So, let us see some case studies, so, of this micronutrient fertilization.

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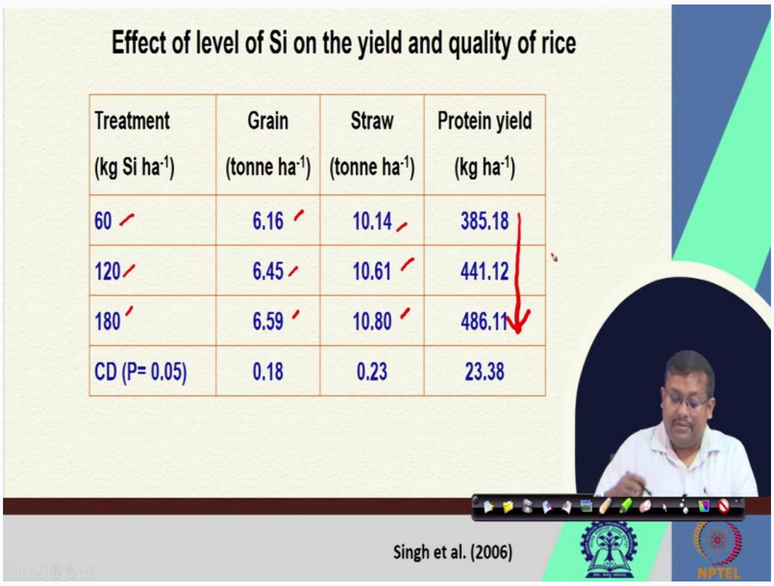

So, seeing it all in 2006 have found that this is an effect of silicon on the yield and quality of the rice. So, we can see when the treatment of silicon in kg per hectare increases from 60 to 120 to 180 kg per hectare, then grain yield, we can see has continuously increased from 6.16 tonne per hectare to 6.45 to 6.59. In case of straw yield also it was increased 10.14 tonnes per hectare to 10.61 tonnes per hectare to 10.80 tonnes per hectare. And protein yield can also be seen increasing when we increase the silicon application or when we increase the silicon application in that crop.

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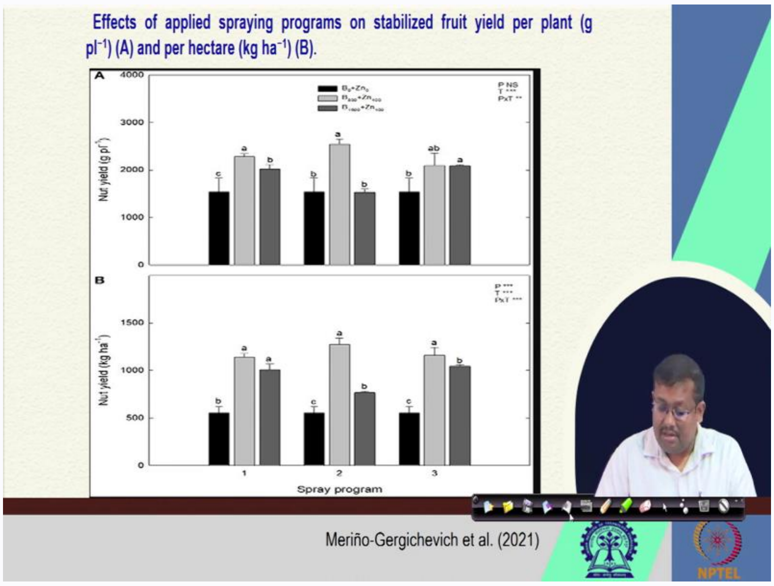

We have you know this Merino Gregichevich, et al in 2021 they have seen the effect of applying spring spraying programmes on stabilised fruit yield per plant. So, we can see that when they apply different types of micronutrient fertilizers like boron and zinc in combination, we can see the increase they are in that fruit yield. So, this is another important aspect of what one of the important case studies showing the importance of fertilizer application or micronutrient fertilizer application.

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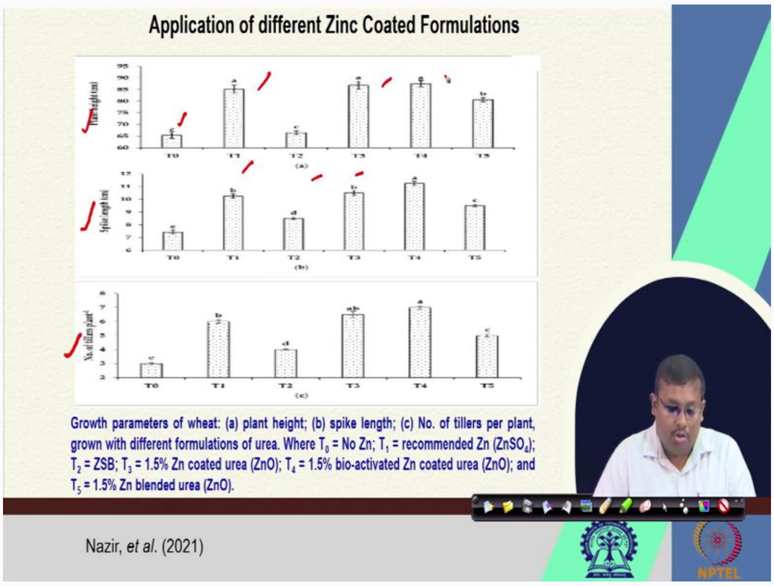

And this is also application of different zinc coated formulations. So, we can see here Nazir, et al in 2021, they have calculated 3 parameters, one is plant height and other is spike length and other is spike length and number of tillers per plant in case of wheat and they have given different types of formulation of urea. Where T0 stands for no zinc and T1 stands for recommended zinc, T2 stands for different types of zinc coated urea.

So, we can see that when we apply different types of zinc coated urea that can improve the yield and other parameters. Sorry, the plant height and spike length and number of tillers alerts as compared to the no fertilizer condition fertilization condition where no zinc was applied. So, that shows the importance of application of zinc for growth of the plant.

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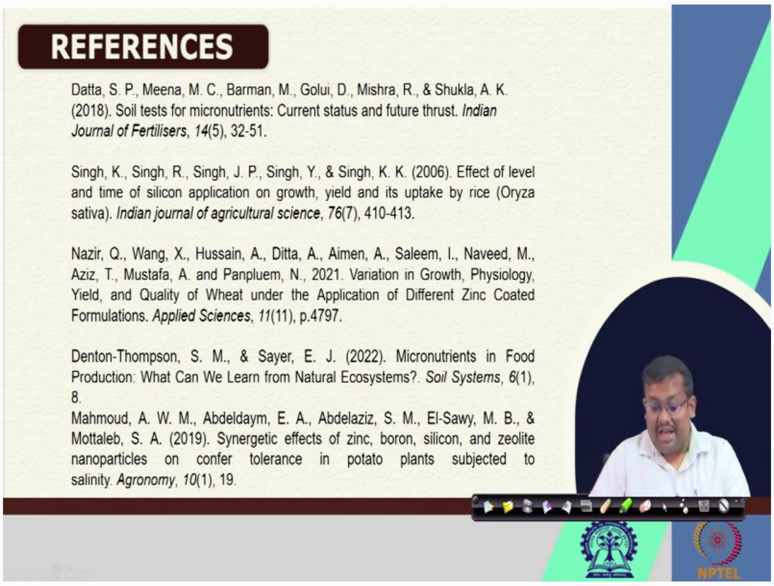

So, this makes the end of this whole week 5. So, in a nutshell, in this week we have seen the, the micronutrients and we have seen the basic, their basic overview, their sources, the micronutrients cycle, what are the critical stages? What are the deficiency symptoms? How? What are the remedial measures to correct those deficiency symptoms?

What are the strategies, management strategies to correct these micronutrient deficiency symptoms? We have seen we have also seen the some quasi essential elements like silicon and why it is important for rice cultivation. So, these are some of the references which I have used for this lecture.

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And please feel free to go and see them in details and if you find any difficulty, just let us know, and we will be happy to answer your queries. So, guys that the by this we are wrapping, wrapping up this week 5 of this NPTEL online certification course of soil fertility and fertilizers. And let us meet in week 6 to discuss more about soil fertility and fertilizers. Thank you very much.