Soil Fertility and Fertilizers

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Lecture 24

Soil Micronutrients and Their Role in Plant Nutrition

Welcome friends to these 24th lecture of NPTEL online certification course of soil fertility and fertilizers and we are at week 5 and in this week, we are talking about soil micronutrients and their role in plant nutrition. And in the previous three lectures of this week, we have discussed about basics of micronutrients, their deficiency symptoms and micronutrient cycle.

What is the sufficiency and deficiency criteria of any nutrient? What are the critical ranges we have discussed? Now, also we have discussed what are the soil conditions, which affect the availability of various micronutrients. Now, in this lecture, we are going to cover these following concepts.

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First of all, we are going to talk about the role of silicon in crops and also, we want to discuss the silicon compounds and their properties in the soil and then silicon nutrition in rice and then we are going to discuss the remedy for micronutrient deficiencies. And finally, we want to discuss the management practices of soil boron. So, these are the five major concepts which we are going to discuss in this 24th lecture of week 5.

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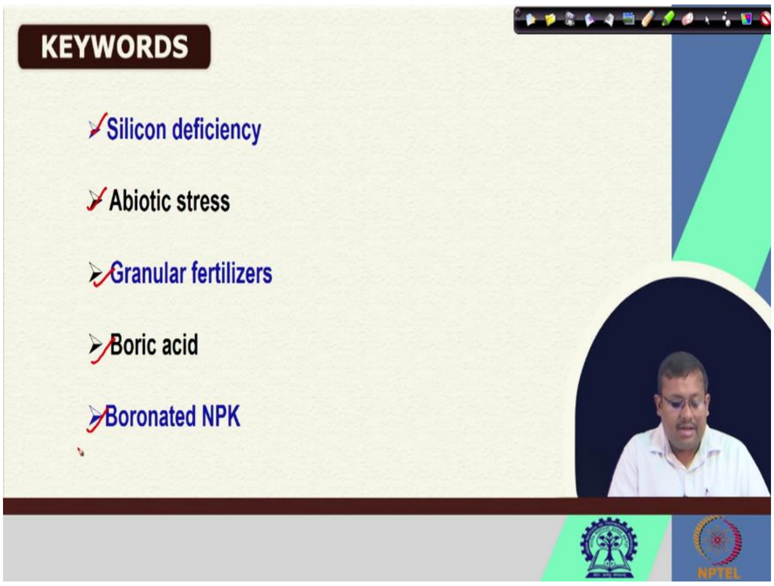

Now, talking about the keywords, these are the keywords which we are going to discuss, first of all we are going to discuss the silicon deficiency, then abiotic stress, then granular fertilizer, boric acid, boronated NPK. So, these are some of the keywords of this lecture 24.

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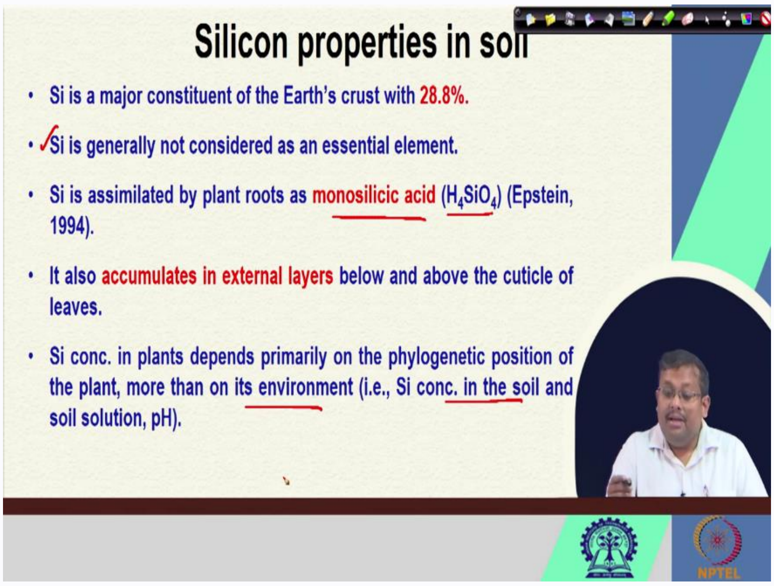

Now, if we go ahead and see what are the major properties of silicon in soil. Now, silicon is a major constituent of earth crust with 28.8 percent of total content. So, and also silicon is generally not considered as an essential element. Now, silicon is assimilated by plant root as monosilicic acid, the formula of monosilicic acid is H4SiO4. It accumulates in external layers below and above the cuticle of the leaves.

So, the silicon basically shows you know some accumulation below and above the cuticle of the leaf and silicon concentration in plants depends primarily on the phylogenetic position of the plant more than on its environment like silicon concentration in the soil and soil solution, pH, so more than these factors, the phylogenetic position of the plant governments the silicon concentration in the plan.

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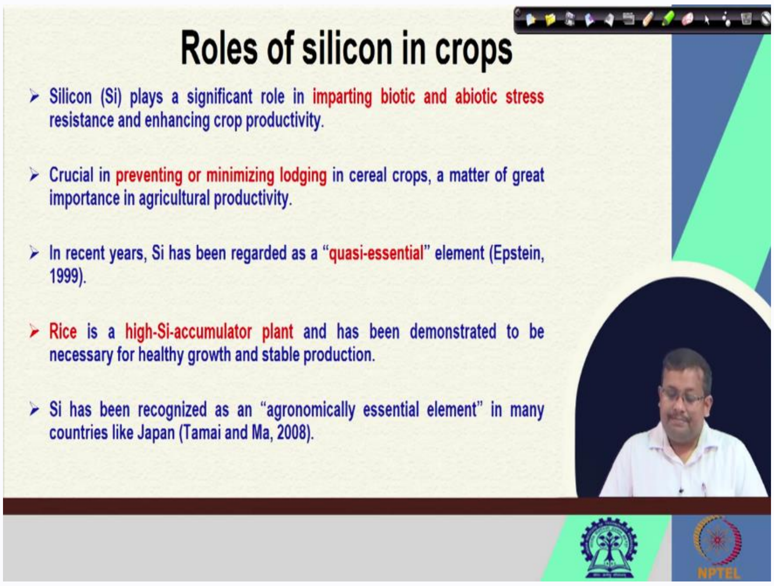

So, what are the rules of silicon in crop? So, silicon plays a significant role in imparting biotic and abiotic stress resistance and enhancing their crop productivity. So, biotic and abiotic stress means, what are the abiotic stress? Abiotic stress means high temperature is an abiotic stress, drought condition is an abiotic stress.

And biotic stress could be due to different types of biological process like peas disease and different types of other problems, biological related problem these are biotic stresses. So, silicon plays an important role in imparting the resistance against these biotic and abiotic stresses and ultimately, which helps in enhancing the crop productivity. It is also crucial in preventing or minimising the lodging in cereal crops, which is a matter of great importance in agricultural productivity.

Most of you know a huge number of crop failures can be seen as a result of lodging of these cereal crops. Now, when plants lodge, they are their products cannot be used. So, for example rice. So, as a result of that, that silicon plays an important role for preventing this lodging of the cereal crops. In recent years silicon has been regarded as the quasi-essential element.

Although it is not an essential element but some, it is a recent time it has been regarded as a quasi-almost essential element. So, rice is a, talking about different plants, which required the silicon, rice is a high silicon accumulator plant and has been demonstrated to be necessary for healthy growth and stable production and silicon has been recognised as an agronomically essential element in many countries like Japan.

So, regardless whether silicon is essential or not, it has played an important role or it can play an important role for the ultimate growth of the plant by imparting the resistance again the biotic, abiotic stress, and lodging.

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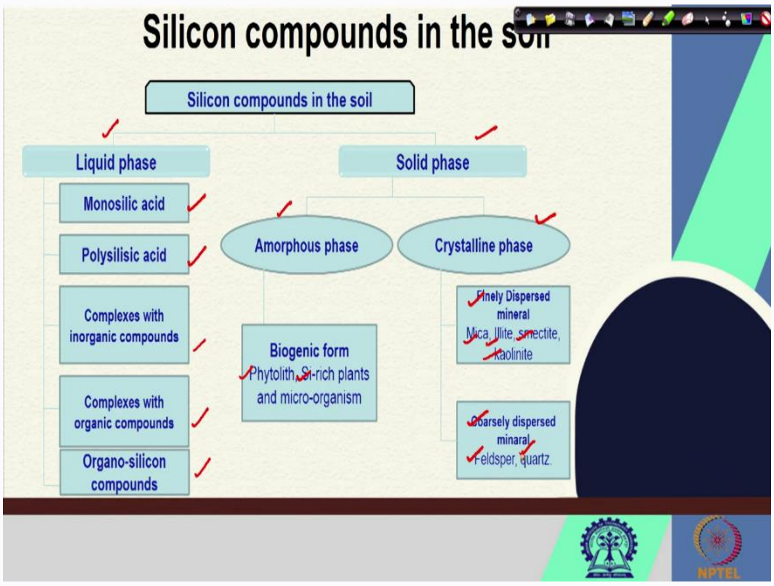

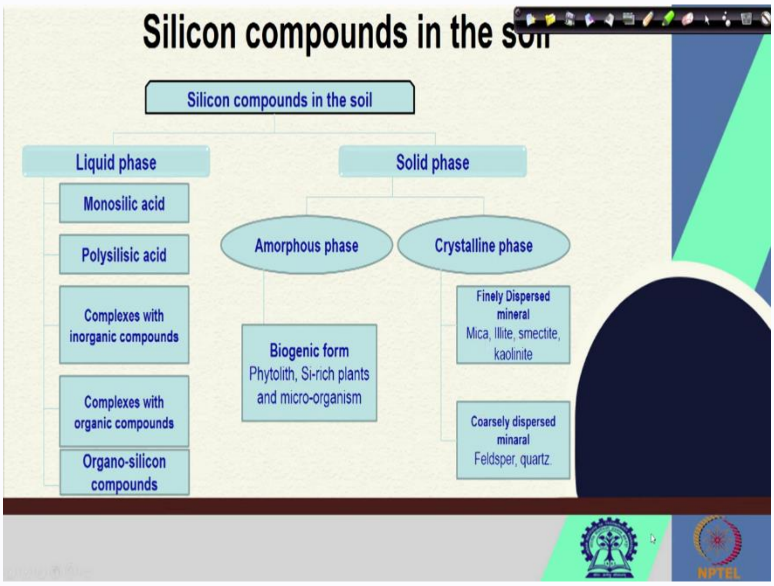

Now, if we see the silicon compound distribution in the soil, now, silicon compound can be divided into two phases, one is a liquid phase and other is solid phase. In the liquid phase we can see monosilicic acid, polysilicic acid, then complexes with inorganic compounds, silicon complex with inorganic compound and silicon complex with organic compounds and organo-silicon compounds.

So, these are the liquid phase of silicon. However, the solid phase of silicon can be again subdivided into amorphous phase and crystalline phase. Among them on first phase we can see biogenic forms of silicon like phytolith, silicon rich plants and microorganism. Whereas, in case of crystalline phase we can see finely dispersed mineral like mica, illite, smectite, kaolinite.

All these are made of the silica tetrahedral sheet and in this silica tetrahedral sheet, silicon is the major component because one silica atom is surrounded by 4 oxygen atom to develop 1 silica tetrahedron and this silica tetrahedron linked together to form the silicon tetrahedral sheet, which is an basic unit of clay mineral structure. Also, they can be seen as closely dispersed mineral essentially in the primary minerals like feldspers and quartz. So, these are the distribution of silicon in soil both in solid phase as well as in liquid phase.

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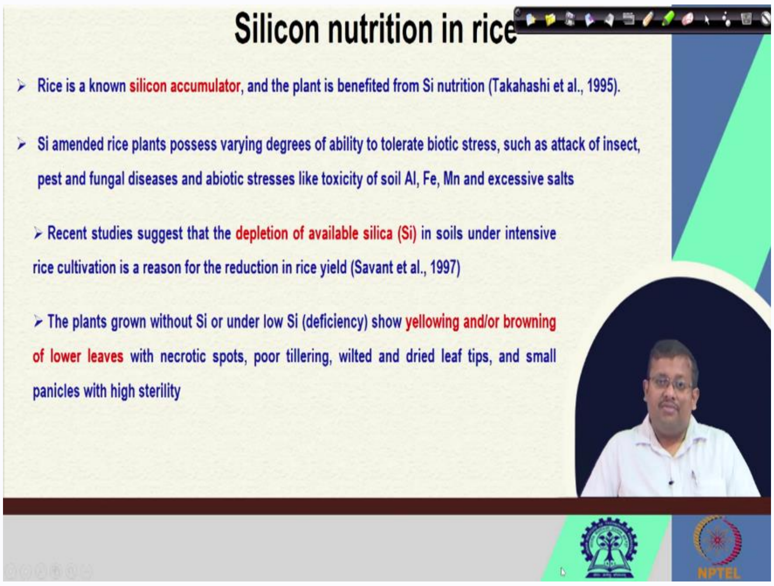

Now, since a rice is an important plant that shows the silicon nutrition, let us discuss, what are the important aspects of silicon nutrition in rice. Now, rice is known as a silicon accumulator and the plant is benefited from this silicon nutrition. So, silicon amended rice plants possess a varying degree of varying degrees of ability to tolerate a biotic stress such as attack of insects, pest and fungal diseases and abiotic stress like toxicity of soil, aluminium, iron, manganese and excessive salts.

Now, you know that when there is an excessive amount of aluminium that impact the root growth. So, also excessive amount of salt also create a huge amount of abiotic stress for any crop. So, the silicon amended rice plant can show their tolerance against these biotic and abiotic stresses. Now, recent studies suggest that that depletion of available silicon in soils under intensive rice cultivation is a reason for the reduction in rice yield.

So, when there is an intensive rice cultivation since rice can hype accumulate this silicon in their body that those areas can show a reduction in the rice field. So, the mean depletion of available silicon when there is a depletion of available silicon in the in the rice field. Then we can see the depletion or reduction in their yield also. So, that shows the importance of silicon for rice yield, so, the plants grow without silicon or under low silicon or deficiency conditions show yellowing or browning of lower leaves with necrotic spots.

Also, they show poor tillering wilted and rightly tapes and small panicles with high stability. So, these are some of the disadvantages of silicon deficiency. So, when we can see silicon deficiency in rice, these are some of the symptoms like yellowing and browning of the lower leaves with necrotic spots, poor tillering, wilting, drying of the leaf tips and small panicles with high stability. So, ultimately the yield goes down drastically.

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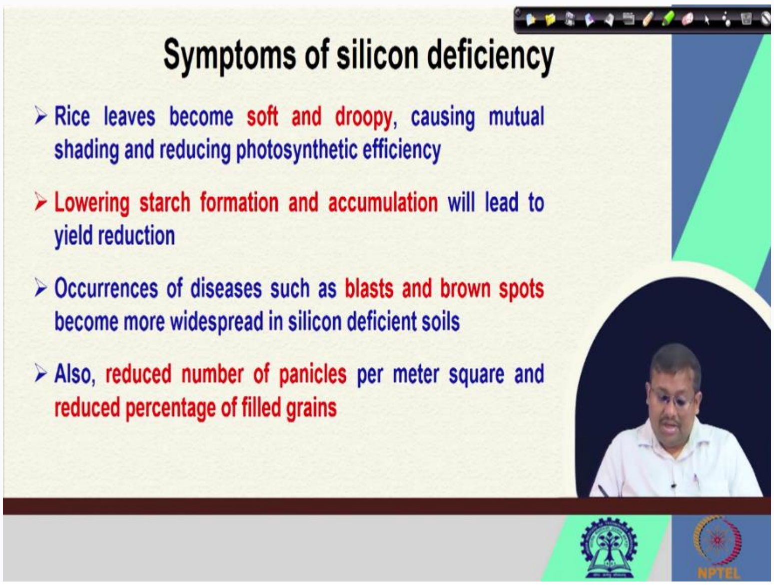

So, as I have mentioned so, silicon deficiency in the rice leaves can show in terms of soft and droopy appearance causing mutual shading and reducing photosynthetic efficiency also, that silicon deficiency can lower the starch formation and accumulation of the starch which will lead to a yield reduction of course, when there is a starch production that will lead to yield reduction and also we can see occurrences of diseases such as blast and brown spots when there is a widespread silicon deficiency.

Reduced number of panicles per metre, per square metre per area and reduce percentage of filled grains are also important symptoms of silicon deficiency. As a result, the ultimately the yield of the crop goes down.

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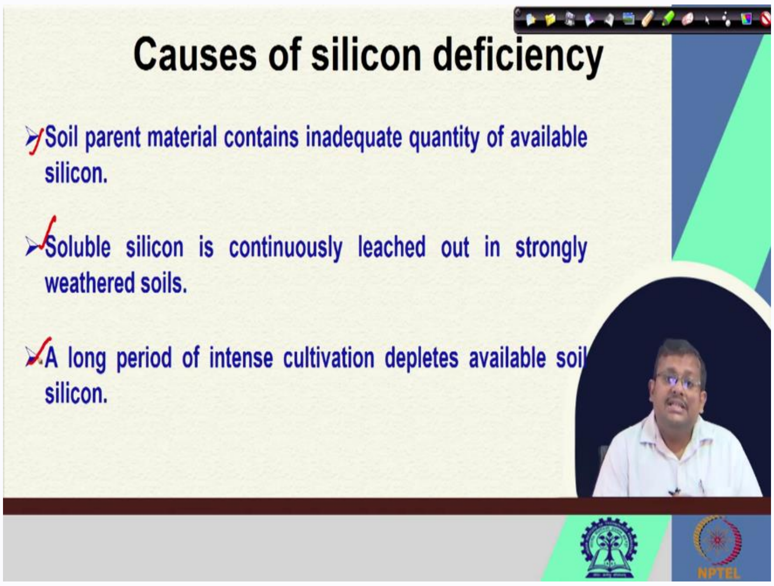

Now, what are the causes of silicon deficiency? There are several causes of silicon deficiency. First of all, soil parent material contain inadequate quantity of available silicone. So, if the silicone, if the parent material of the soil containing adequate quantity of available silicon that can create silicon deficiency. When soluble silicon is continuously leached out in strongly awaited soil that can also create silicon deficiency in the soil. Also, a long period of intense cultivation depletes available soil silicone. So, these are some of the reasons for silicon deficiency in soil.

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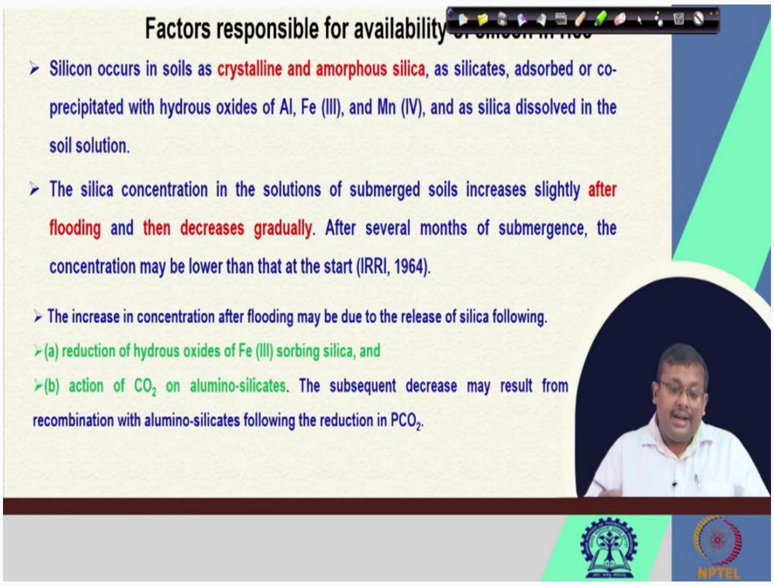

Now, what are the factors which are responsible for availability of silica in rice? So, if we can see that so, silicon occurs in soils as crystalline and amorphous silica, we have already seen that as silicates adsorbed or coprecipitated with hydrous oxides of aluminium, iron and manganese and as silica dissolved in the soil solution. So, these are some of the forms through which we can see the occurrence of silica.

Now, the silica concentration in the solutions of submerge soil increases slightly after flooding and then decreases gradually. Now, after several months of submergence, the concentration may be lower than that at the start. So, we can see that the silicon concentration in the submerge condition of rice first initially increases after the flooding and then decreases gradually and after several months.

We can see the concentration of the silicon in the soil goes down then that at the start of the of the growth of the plant. Now, the increase in concentration after flooding may be due to the release of silica following couple of condition first of all, the reduction of hydrous oxides of ferric sorbing silica. So, when the ferric ion, the hydrous oxides of ferric ion get reduced to ferrous as a result of submergence.

So, in that case whatever silica was sorbed previously, they can come into the soil solution and enriching the soil solution that can be a reason of increasing the silicon concentration just after flooding and also action of carbon dioxide on alumino-silicate. So, the subsequent decrease when we can see the after the submergence there is a sudden increase and then subsequent decrease.

So, the subsequent decrease may result from recombination with alumina-silicates following the reduction of reduction in partial pressure of carbon dioxide. So, when there is a submergence of course, the (())(14:48) the reduction partial pressure of carbon dioxide goes down and then there is a recombination with alumina-silicates, ultimately, the silicon availability goes down. So, this is how the silicon can get available just after the flooding and then their availability goes down.

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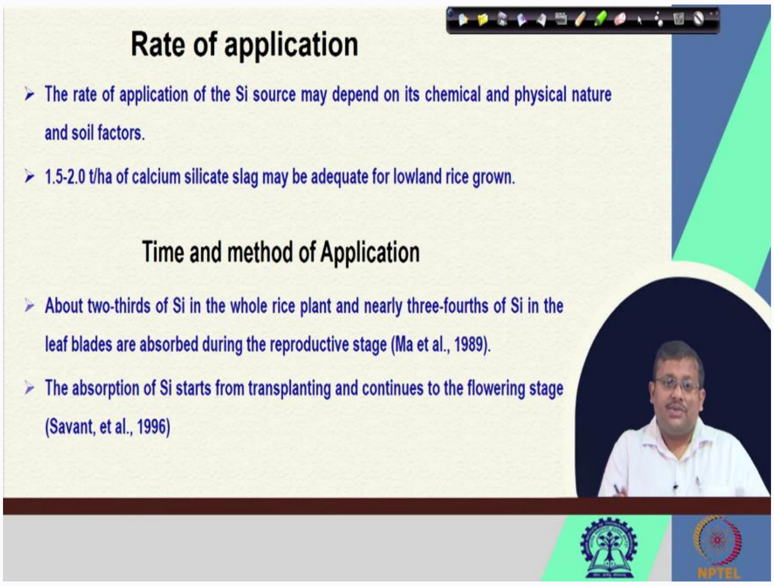

And now what is the what can be the rate of application of silicon so the rate of application of silicon source may depend on its chemical and physical nature and soil factors. Now generally 1 to 2 tonnes per hectare of calcium silicate slag may be adequate for lowland rice grown. In case of lowland rice zone generally we can apply 1 to 2 tonnes per hectare of calcium silicate slag.

What are the time and methods of application? Now about two thirds of the silicon in the whole rice plant and nearly three fourths of the silicon in the leaf blades are absorbed during the reproduction or reproductive stage and the absorption of silica starts from transplanting and continue to the flowering stage. So, you have to adjust your application based on these steps.

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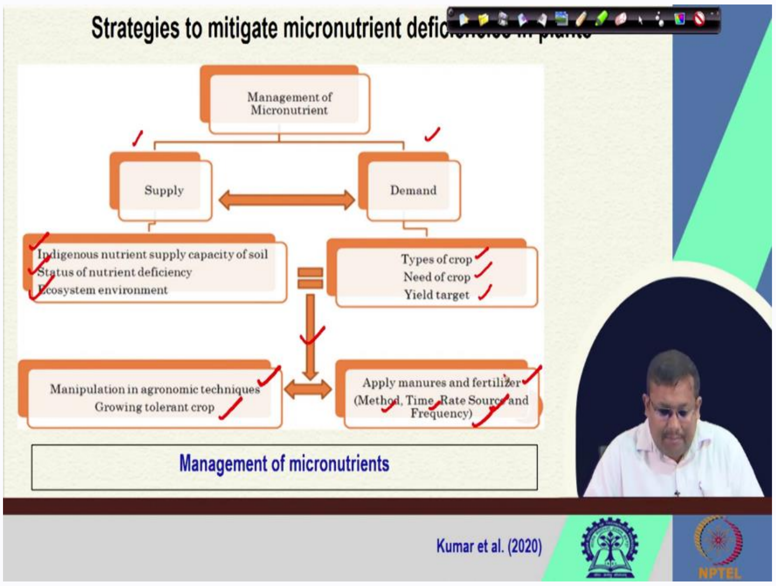

Now, what are the strategies to mitigate the micronutrient deficiencies in the plants? So, this flowchart gives an comprehensive understanding of how to deal with, mitigate or mitigate the micronutrient deficiency in the plant, we can see the management of micronutrient base should be based on supply and also demand. Now, demand of these micronutrients based on types of crop need of the crop and also the yield target. What is our target yield?

And of course, that demand the difference between supply and demand should be considered for management of the micronutrient. Now supply of the micronutrient can be achieved by indigenous nutrient supply capacity of the soil. And it is also governed by status of nutrient deficiency and ecosystem environment. We have already discussed several factors in the soil which governs the micronutrient availability.

So, these factors also influence the type of the crop need of the crop and yield target. Ultimately, we can get, ultimately for management of this micronutrient, we need to do manipulation in agronomic techniques and also growing of tolerant crops that means those crops which can tolerate this micronutrient deficiency. Also, we should apply manure and fertilizer and of course, with proper method, time of application, rate source and frequency. So, these are some of the ways to which micronutrient can be managed in the soil.

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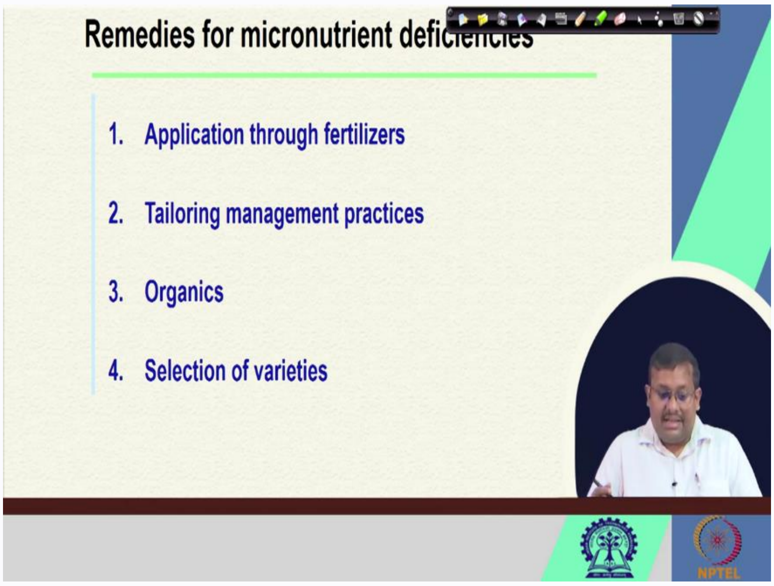

Now, what are the remedies for micronutrient deficiencies? Now, of course, there are 4 major remedies one is application to fertilizers. Secondly, tailoring management practices which are suitable for the plant and organics, application of organics, and selection of tolerant varieties. So, these are the 4 major strategies to compensate or to correct the micronutrient deficiency in the soil.

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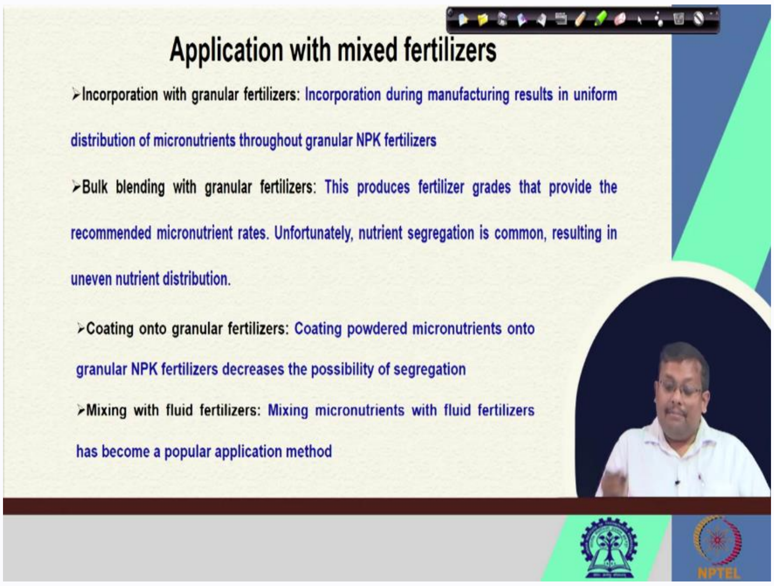

Now, applications with application with mixed fertilizer also an important aspect of micronutrient fertilisation. So, generally, these micronutrient fertilizers are mixed with micronutrients are mixed with mixed fertilizers. So, generally incorporation sometimes they are incorporated in the with the granular fertilizer. So, this incorporation during manufacturing results in uniform distribution of micronutrients throughout granular NPK fertilizer.

So, these micro tests can be mixed with the granular NPK fertilizer, so that we can get a uniform and uniform distribution of the micronutrients throughout these granular fertilizers. Also, bulk blending with granular fertilizer can be another way. Now this produces fertilizer grades that provide the recommended micronutrient rates. Unfortunately, nutrient segregation is common, resulting in uneven nutrient distribution.

So, the bulk blending with granular fertilizer can be made to get the recommended micronutrient rate. However, that distribution of nutrient is uneven. The third way is coating onto granular fertilizers. So, coating powder, powdered micronutrient onto granular fertilizer, NPK fertilizer decreases the possibility of segregation and finally mixing with fluid fertilizer. So, mixing micronutrients with fluid fertilizer has become a popular application method. So, these are some of the ways through which we can apply the micronutrients to the crop.

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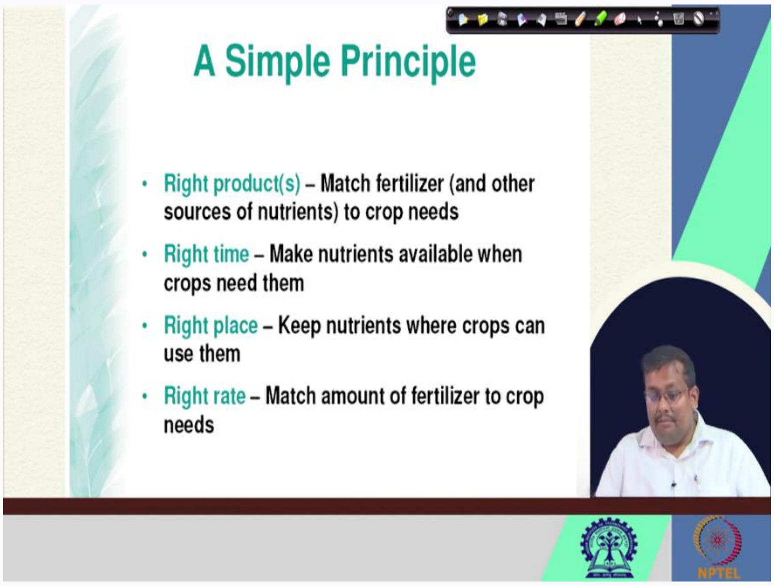

Now, remember that whenever we apply any nutrient to the crop, we generally follow the 4R concept. So, 4R basically says right product, right time, right place, and right rate. So, right product indicates we have to match the fertilizer and other sources of nutrients to crop needs right time means we have to make the nutrients available when crop needs them. We do not need to make it available all the time we can only make it available when crop needs them.

Right place, keep nutrients where crops can use them and finally, right rate match amount of fertilizer to crop needs. So, whenever we devise any plan to increase the availability of any fertilizer, irrespective of whether it is a macro fertilizer, macronutrient fertilizer or micronutrient fertilizer, we should always keep in mind this 4R concept. So, same for our concept is also applicable in case of micronutrients.

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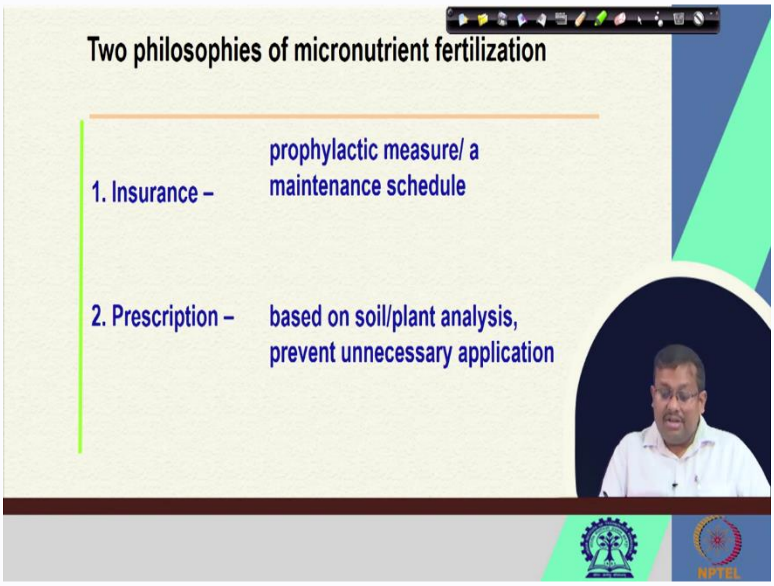

Now, there are two philosophies of micronutrient fertilisation one is insurance philosophy, another is prescription-based philosophy. Now, insurance-based philosophy basically depends on prophylactic measures or maintenance schedule. So, prophylactic measures means when we anticipate some problem and we go for the initial application to offset that anticipated problem and prescriptive approach is which is based on the soil and plant analysis, which prevents the unnecessary application. So, these are two philosophies on micronutrient fertilisation.

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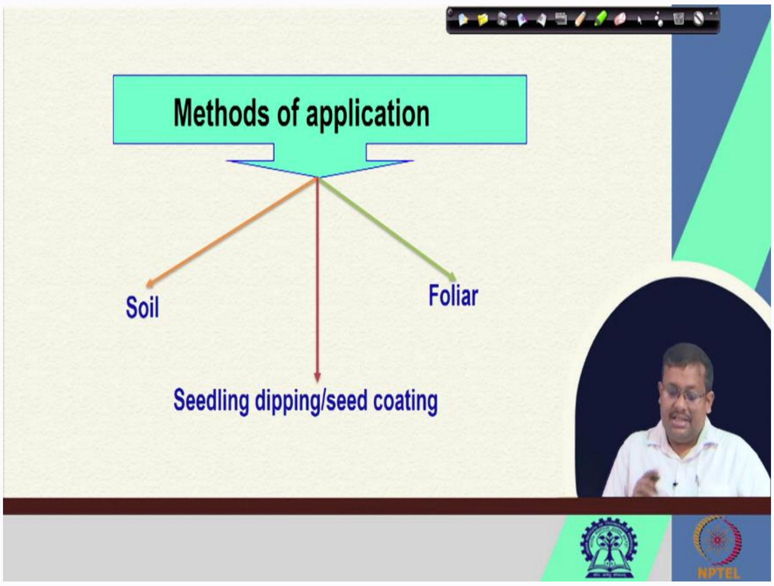

The methods of application can be of 3 types one is soil, majorly micronutrient fertilizers are applied either to soil or foliar application or by dipping the seedling or coating the seeds. So, these are the three methods of micronutrient fertilizer application in the soil.

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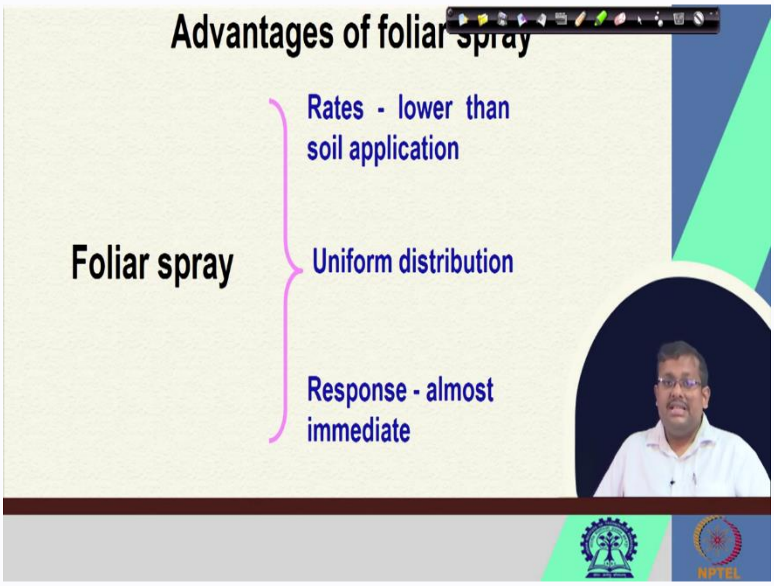

What are the advantages of foliar spray? So, foliar spray first of all, the first advantage of foliar spray, it is it require lower rate than soil application. Secondly foliar spray ensures uniform distribution. And thirdly, in case of foliar spray, the response is always almost immediate as compared to the soil application because you are directly applying the fertilizer on to it the crop surface. So, these are some 3 advantages of foliar spray.

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However, at the same time, there are several disadvantages of foliar spray. First of all, leaf burn may occur if the salt concentration of the spray is too high. So, when these are, when we apply these micronutrients, these are basically micronutrients salts, basically sulphates so, sometimes sulphates and all these things. So, when you apply these salts, if their concentration of the salts are too high, that can cause leaf burn.

Secondly, nutrient demand often is high, when the plants are small, then the leaf surface is insufficient for foliar absorption. So, what happens when the leaf surface is small when the plants are small and then when the nutrient demand is high, but the plant is small. So, the leaf surface which is insufficient, which becomes insufficient for foliar application because we cannot give the recommended dose to those small or limited leaf surface which is required because in that case nutrient demand will be high.

So, again when there is a high nutrient demand, but the plant is small, so, of course the leaf surface will be also limited. So, along this leaf surface, we using this leaf surface spray, foliar spray, we cannot meet the high nutrient demand of the crop. And third one is maximum yields may not be possible if spraying is delayed until deficiency symptoms appear. So, that is another disadvantage because once the deficiency symptoms appear, even if you give the foliar application but you will not get the maximum yield.

Of course, there is a little residual effect from foliar sprays also and application costs have are higher if more than one spray is needed unless they can be combined with pesticide spray application. So, generally this foliar spray is generally combined with pesticide applications so, that the application cost can be minimised otherwise, if you have to spray solely for the micronutrient fertilizer that can increase the application cost and cost of cultivation.

So, that is another disadvantages of foliar spray. So, keeping in these all these in mind and we have to identify the best practice, management practice and application practice of micronutrient fertilizers.

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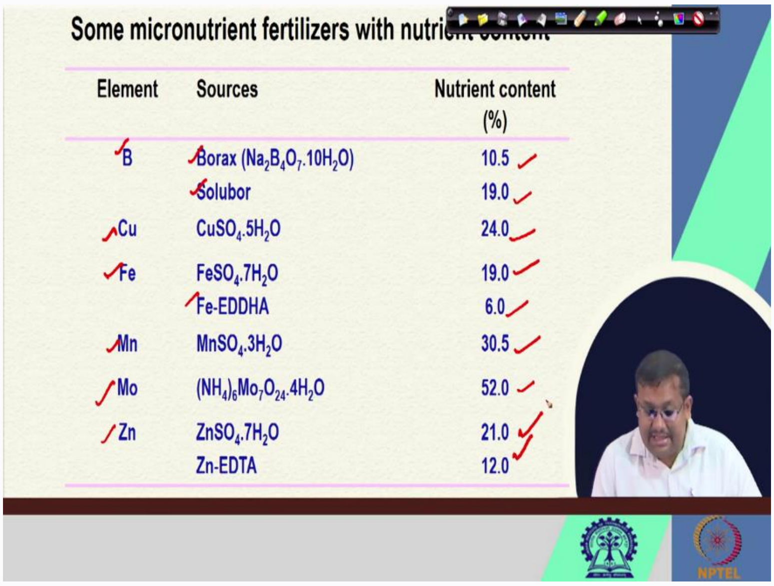

Now, let us see some micronutrient fertilizers with nutrient content, we can see here, boron, which is borax and solubor and you can see we in case of borax, the boron concentration is 10.5 percent in case of solubor is 19 percent in case of copper, copper sulphate pentahydrate is 24 percent, iron, iron sulphate heptahydrate is 19 percent iron, Fe-EDDHA is 6 percent iron, manganese is manganese sulphate trihydrate that is 30.5 percent, molybdenum is ammonium molybdate this 52 percent of molybdenum and zinc is zinc sulphate heptahydrate 21 percent, zinc and zinc EDTA that is 12 percent of zinc. So, these are the micronutrient fertilizers which we generally apply.

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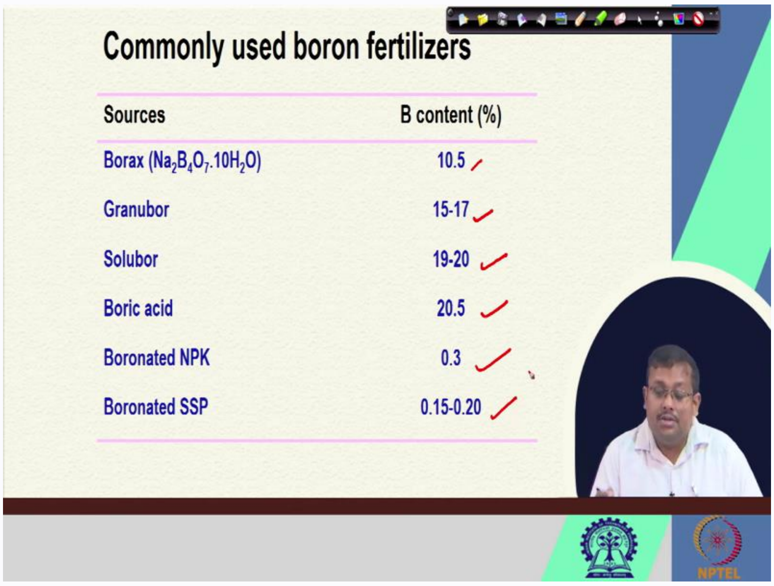

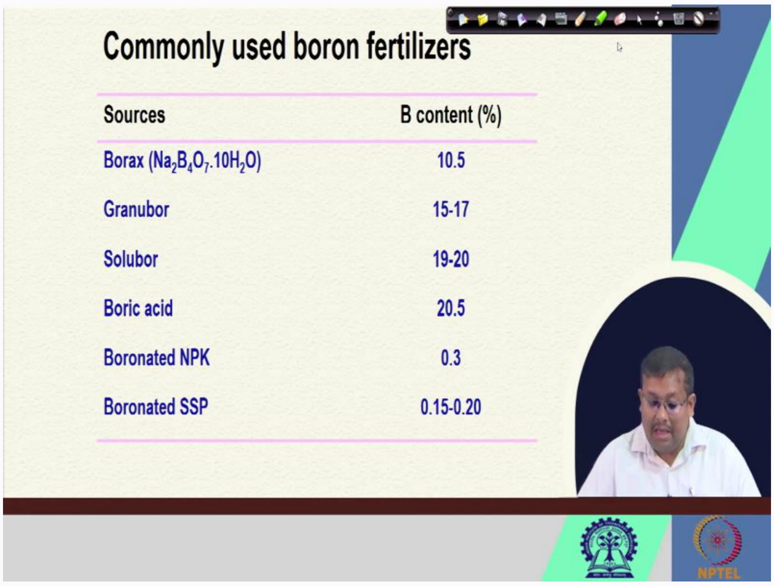

So, commonly used boron fertilizer if we talk about boron, borax is a commonly used boron fertilizer which 10.5, granubor with 15 to 17 percent of boron, solubor 19 to 20 percent, boric acid 20.5 percent, boronated NPK 0.3 percent, and boronated single super phosphate it contains boron traces, it contains 0.15 to 0.20 percent of boron.

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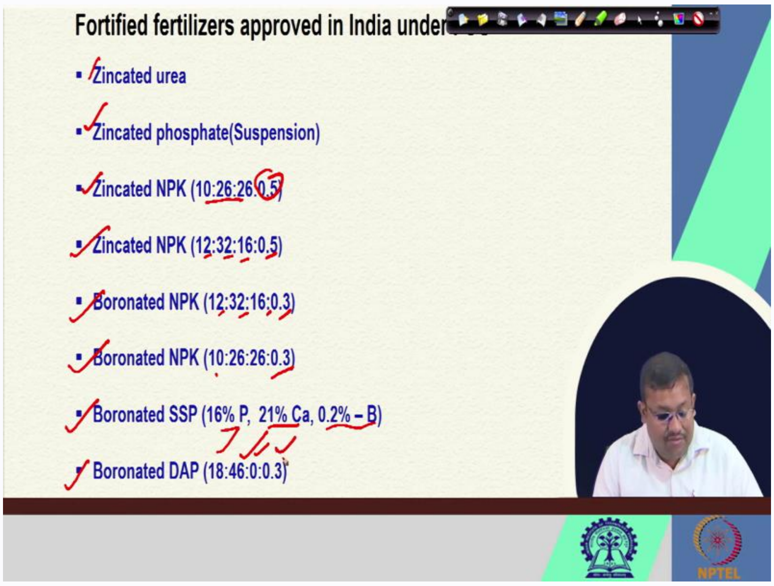

There are some fortified fertilizers approved in India under fertilizer control order. So, these are mentioned here like zincated urea, zincated phosphate, which is in the form of suspension zincated NPK. So, the NPK is here and the zinc is 0.5 percent and zinc at NPK at 12, 32, 16, 0.5. Boronated NPK and 0.3 percent boron, boronated NPK 10, 26, 26, 0.3, boronated single super phosphate which contains 16 percent phosphorus and then 21 percent calcium and 0.2 percent boron and boronated DAP which contains 18 percent nitrogen, 46 percent P25 and 0 percent K2 and 0.3 percent of boron. So, these are the fortified fertilizers which are approved under fertilizer control in order, fertilizer control order in India so, these fertilizers are also very popular.

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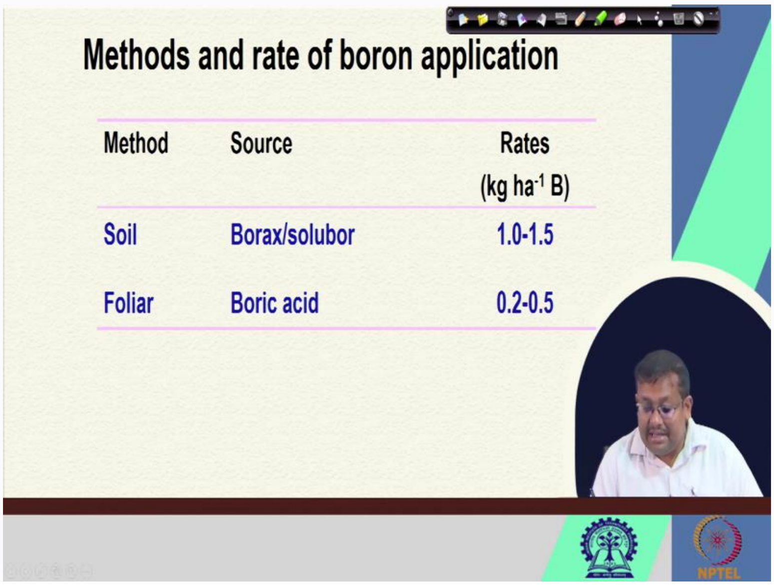

Methods and rate a boron application we can see that when we apply borax or solubor we can apply one to 1.5 kg per hectare of boron, in case of foliar we can apply boric acid from 0.2 to 0.5 kg per hectare of boron.

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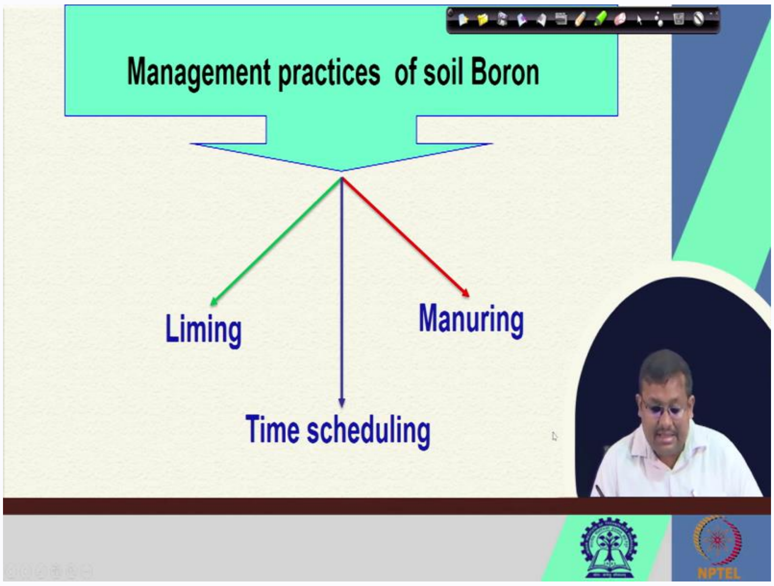

Now management practices of soil boron we can see there are 3 management practices one is liming and then time scheduling and manuring these are the three management practices of soil boron.

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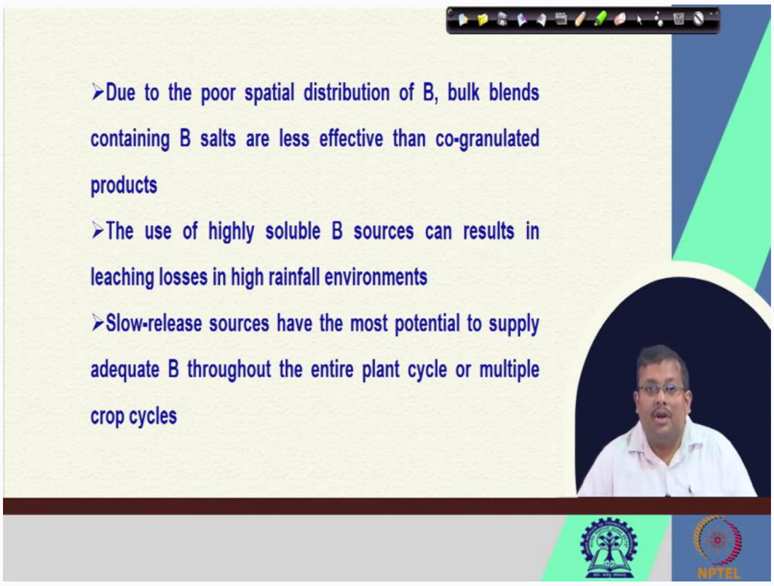

Due to poor special distribution of boron bulk blends containing boron salts are less effective than co-granulated products and the use of highly soluble boron sources can results in leaching losses in high rainfall environments and slow-release sources have the most potential to supply adequate boron throughout the entire plant cycle or multiple crops cycle.

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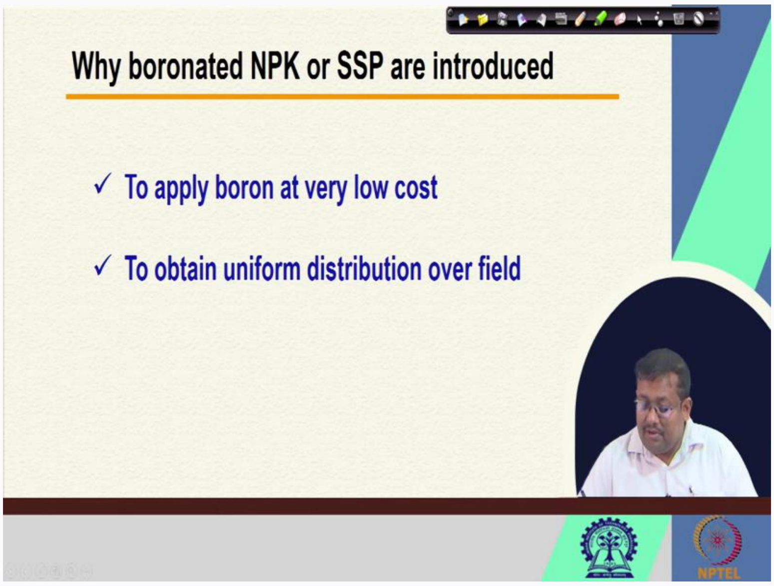

Now, why boronated NPK or SSP are introduced. There are two reason, first of all to apply the boron at very low cost and to obtain the uniform distribution over the field. So, these are the reason behind these coordinated NPK or boronated SSP are introduced for micronutrient fertilisation.

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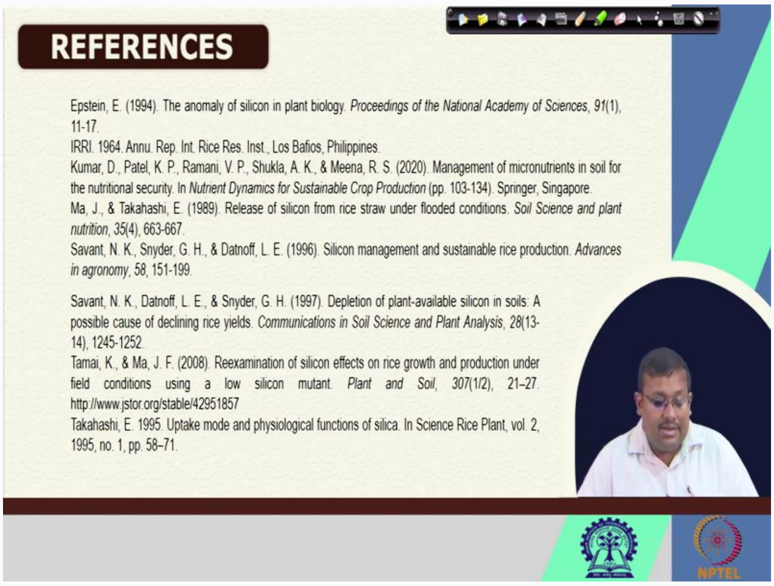

So, guys, we have completed this lecture and these are the references please go through, please go through these references and if you have any doubt just feel free to ask your question in the forum and we will be more than happy to answer your queries. Thank you very much.