Soil Fertility and Fertilizers
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Week 3
Lecture 14
Soil P and K Plant Nutrition (Contd.)

Welcome friends to this 14th lecture of NPTEL online certification course of soil fertility and fertilizers. And we are at week 3. In this week 3 we are discussing about soil phosphorus and potassium for plant nutrition. In our previous lectures we have discussed about phosphorus cycle and phosphorus availability factors in soil also we have discussed about the forms of phosphorus.

And we have discussed about the influence of organic matter pH on phosphorus availability and the species of phosphorus which and their availability, relative availability at different pH ranges. In our last lecture, we have discussed about the most common phosphoric fertilizers. So, in this lecture, we are going to start a new plant nutrient that is soil potassium, but, before going to discuss the soil potassium, I would like to discuss some other phosphoric fertilizers.

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So, these are the concepts which we are going to cover, phosphorus basic slag we are going to cover first and then we are going to cover, what are the fates of phosphorus when we apply these phosphoric fertilizers in the soil. What are the factors affecting phosphorus fertilizer management and then we are going to discuss about comparative fertilizer value of various

phosphate materials. And then we are going to start function of potassium in soil and potassium deficiency symptoms in plants. So, these are the some of the basic concepts which we are going to cover in this lecture.

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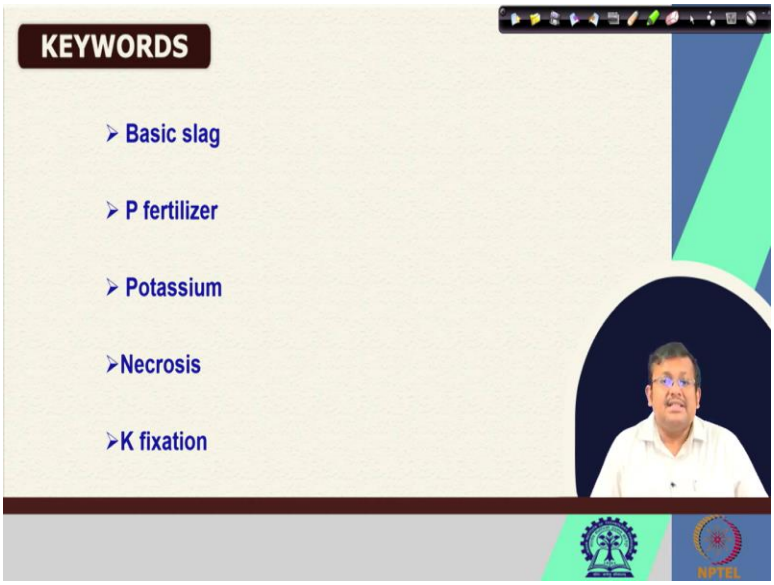

So, these are the keywords like basic slag, phosphorus fertilizer, potassium, necrosis, potassium fixation, these are some of the key words of this lecture.

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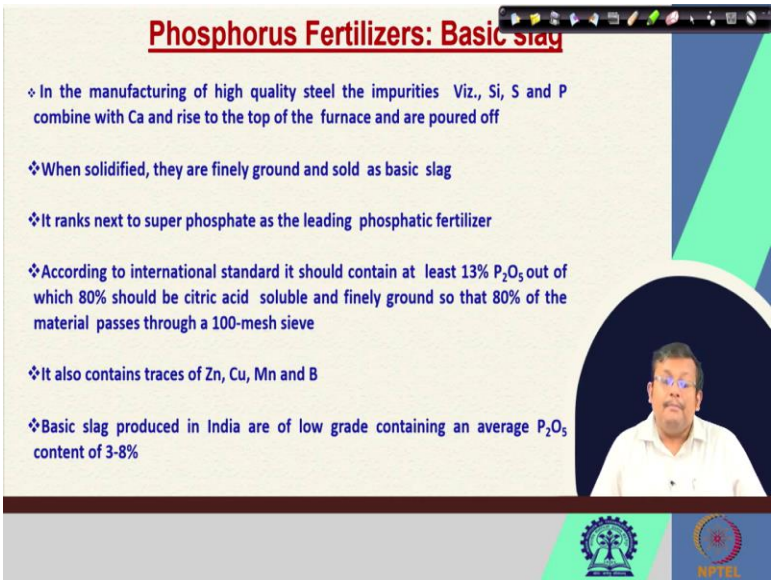

Now, let us start with the basic slag. Basic slag is a phosphoric fertilizer. Now, in the manufacturing of high quality steel, that impurities such as silicon, sulphur and phosphorus

combined with calcium and rise to the top of the furnace and are poured off. So, when solidified they are finely ground and sold as a phosphoric fertilizer, we call it as a basic slag. So, basic slag is a phosphatic fertilizer.

Now, it ranks next to super phosphate as the leading phosphatic fertilizer apart from super phosphate we apply basic slag as phosphatic fertilizer. According to the international standard, it should contain at least 13 percent P2O5 out of which a 80 percent should be citric acid soluble and finely ground so, that 80 percent of the material passes through a 100 mesh sieve. So, these are some of the quality criteria of basic slag.

It also contains traces of zinc, copper, manganese and boron. Basic slag produced in India are of low grade containing on average of P2O5 content of 3 to 8 percent. Although the international standard claims that it has to be minimum 13 percent P2O5 in basic slag. However, in India basic slag whatever we get, it contains low average P2O5 content that is 3 to 8 percent.

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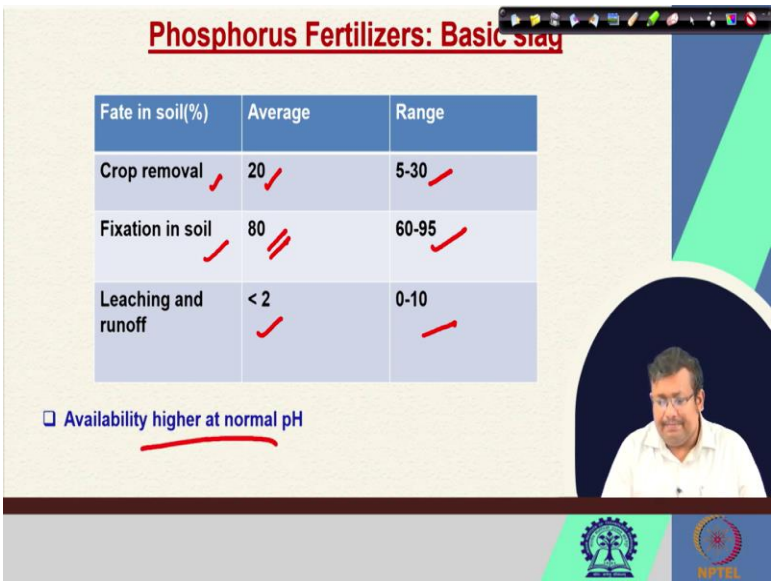

Now, if you see the what are fates of first, of basic slag in soil when we apply them. So, first of all the crop removal in an average it will be around 20 percent and range is 5 to 30 percent. Phosphorus fixation will be 80 percent in soil and the range varies from 60 to 95 percent. Leaching and runoff only less than 2 percent whereas, it ranges from 0 to 10 percent. So, the availability of phosphorus when we apply the basic slag is higher at normal pH condition.

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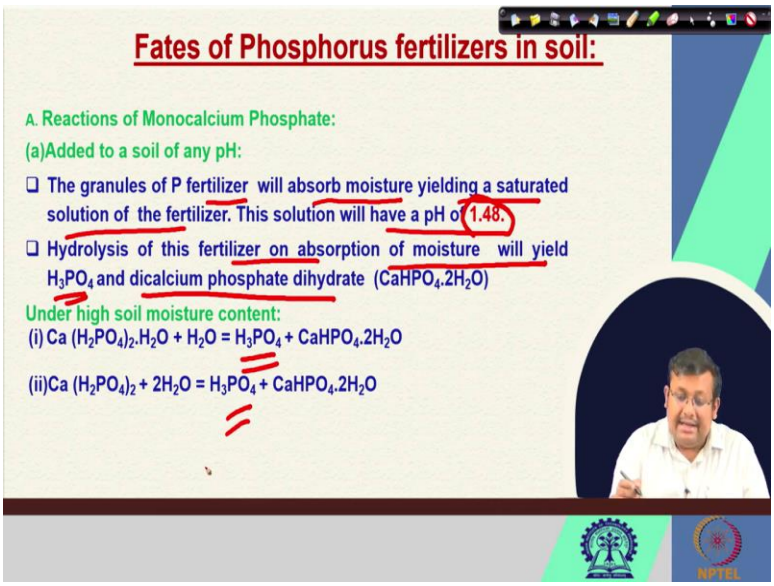

So, if we move ahead and see, what are the fates of phosphorus fertilizers in soil. Because phosphorus fertilizer is known for fixation in the soil, when we apply them. So, we have to be very very cautious when we apply this phosphatic fertilizers in the soil because phosphorus will be fixed either in the acidic condition or in alkaline condition as aluminium and iron phosphate or calcium phosphate we are already discussed.

So, it is very important to understand the fates of phosphorus fertilizer in soil. So, reaction let us consider the reaction of mono calcium phosphate. So, the reaction of mono calcium phosphate when you added to soil at of any pH that granules of phosphorus fertilizer will absorb moisture yielding a saturated solution of fertilizer.

So, when we apply these granules of phosphoric fertilizers, it will absorb the moisture yielding a saturated solution of the fertilizer and the solution will have a pH of 1.48 which is highly toxic. Now, hydrolysis of this fertilizer on the absorption of moisture will yield phosphoric acid and di-calcium phosphate dihydrate, di-calcium phosphate dihydrate. So, under high moisture content you can see this following reaction can occur. So, phosphoric acid will be formed in both these conditions.

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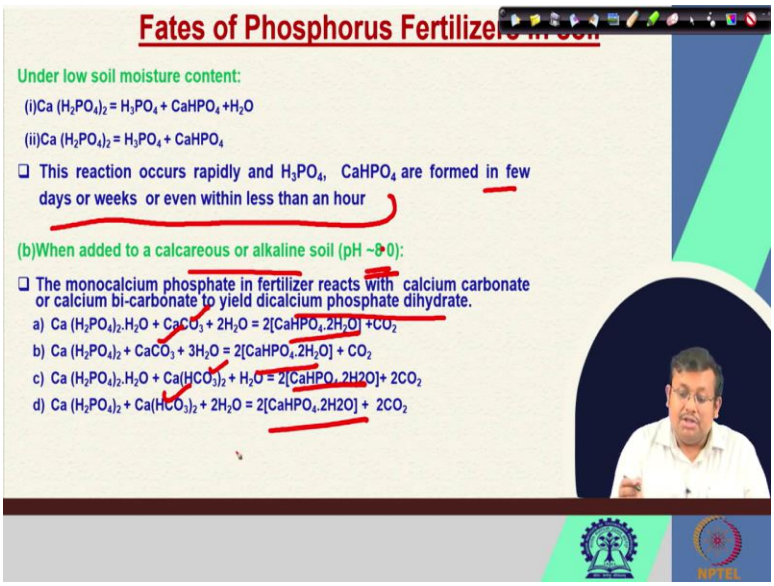

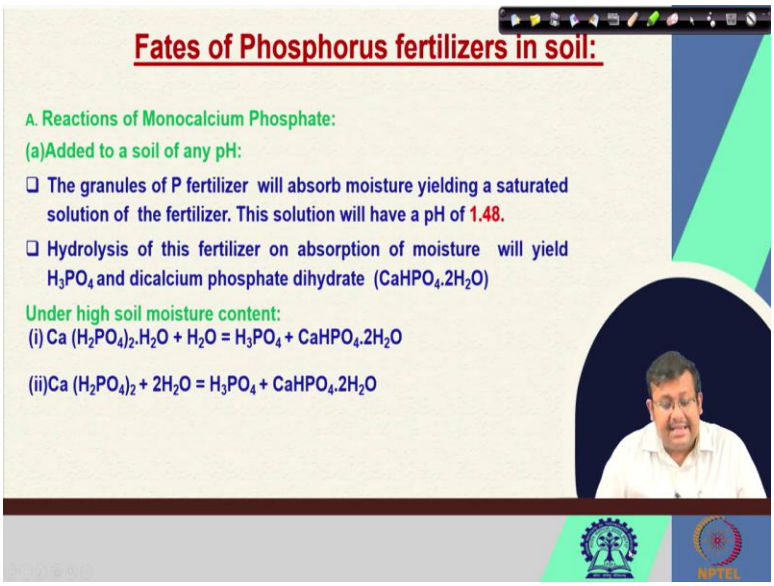

So, let us move ahead and see under low soil moisture condition what will happen. Under low soil moisture condition the Ca H2PO4 whole 2 will dissociate to form these phosphoric acid di-calcium phosphate and water. So, this reaction occurs rapidly and H3PO4 or phosphoric acid and di-calcium phosphate are formed in few day weeks or even within less than an hour.

When added to a calcareous or alkaline soil where the pH ranges between 8 to, pH ranges between around pH 8.0. So, the mono calcium phosphate in fertilizer reacts with calcium carbonate or calcium bicarbonate to yield di calcium phosphate di hydrate. So, here you can see

di calcium phosphate di hydrate are formed in all these conditions. When reacts with calcium carbonate.

So, you know in the calcareous soil calcium carbonate predominates also calcium bicarbonate, so, while reacting with the calcium carbonate and calcium bicarbonate forms these di calcium phosphate di hydrate. So, this is how these fates of you know the fertilizer determines by the presence of different factors like pH moisture content and also the presence of calcium carbonate and bi calcium carbonate, calcium bicarbonate in the soil.

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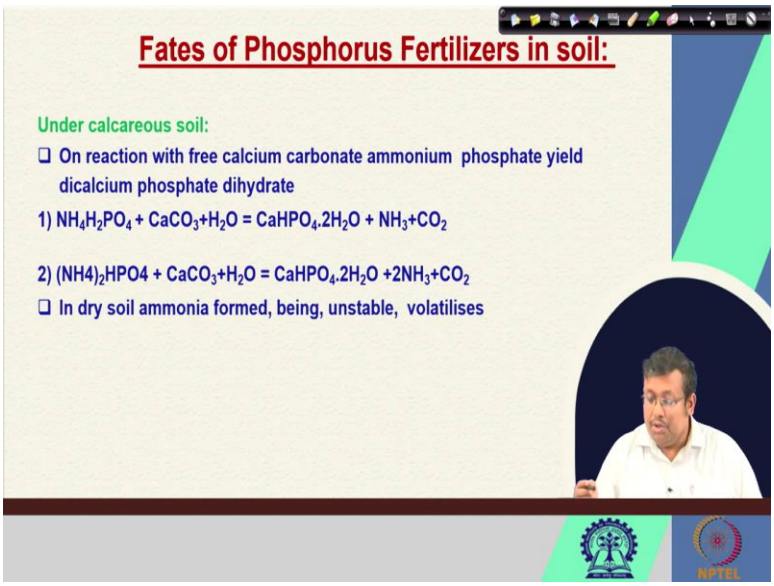

Now, let us see what will be the fate of phosphorus fertilizer when we apply the mono ammonium phosphate as well as di-ammonium phosphate in calcareous soil. So, we can see when mono ammonium phosphate reacts with the calcium carbonate that will produce di calcium phosphate di hydrate and when di ammonium phosphate reacts with the free calcium carbonate in calcareous soil that will produce again the di calcium phosphate di hydrate.

Also you can see in both these reaction ammonia is being formed and you know in case of high alkaline condition, ammonia being unstable generally volatilises. So, here there will be ammonia volatilization when the when we apply these mono ammonium phosphate or di ammonium phosphate in a calcareous soil.

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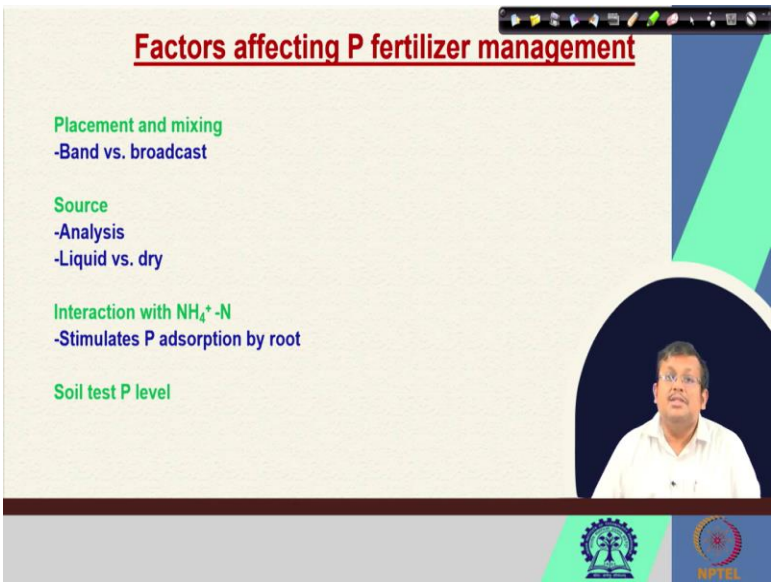

So, let us move ahead and see what are the factors affecting phosphorus fertilizer management. So, these are some of the important factors which governs the phosphorus fertilizer management. First of all, placement and mixing whether we are giving this fertilizer in band placement or we are broadcasting it.

Source of fertilizer is another important factor which affects the phosphorus fertilizer management. Interaction with ammonium nitrate is also an important phosphorus fertilizer management factor, because it stimulates the phosphorus absorption by root and soil test phosphorus level is another important factors that affects the phosphorus fertilizer management.

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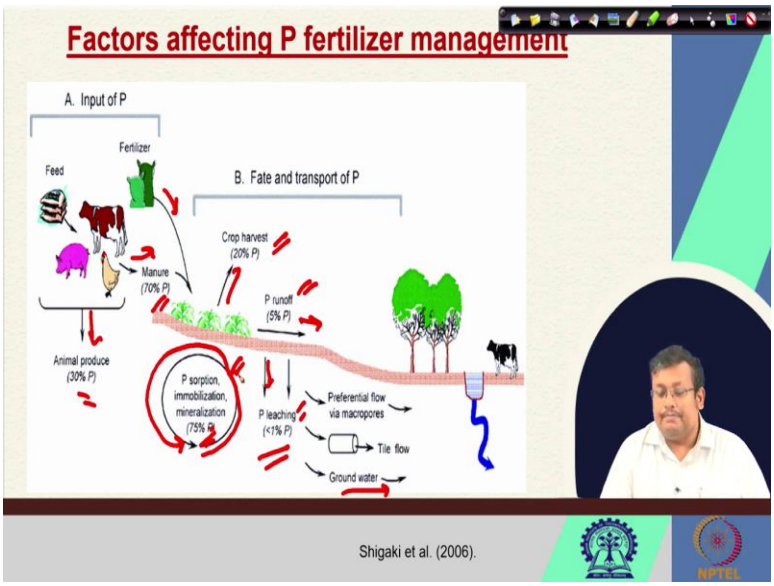

Now, if you see pictorially these factors which affect the phosphorus fertilizer management, it can be clear that there are different types of inputs of phosphoric fertilizers like fertilizers, manure which consists of which basically cumulatively add 70 percent of phosphorus and also animal produce will produce 30 percent of phosphorus. So, this phosphorus will go to phosphorus in solution and then you know moves within the soil through phosphorus sorption immobilization and mineralization.

So, 75 percent of the phosphorus will be going through this phosphorus sorption immobilization and mineralization process. Crop harvest will account for 20 percent of the phosphorus and 5 percent will be lost through runoff, less than 1 percent will be lost to phosphorus leaching through preferential flow via macrospores or via a tile flow or groundwater flow. So, this is how this phosphorus will move in different sinks. And so, you can see the fate of transport, fate and transport of P can be can be seen summarily here, where it consists of crop harvest phosphorus runoff and phosphorus leaching and different types of phosphorus sorption and fixation process.

So, different types of factors will affect this phosphorus fertilizer management. Of course, what type of fertilizers we are applying, whether it is a citric acid soluble fertilizer, whether it is a water soluble fertilizer, whether it is an insoluble fertilizer, whether we are applying them in band placement or broadcasting all these will take important role for main, for determining their fate and transport.

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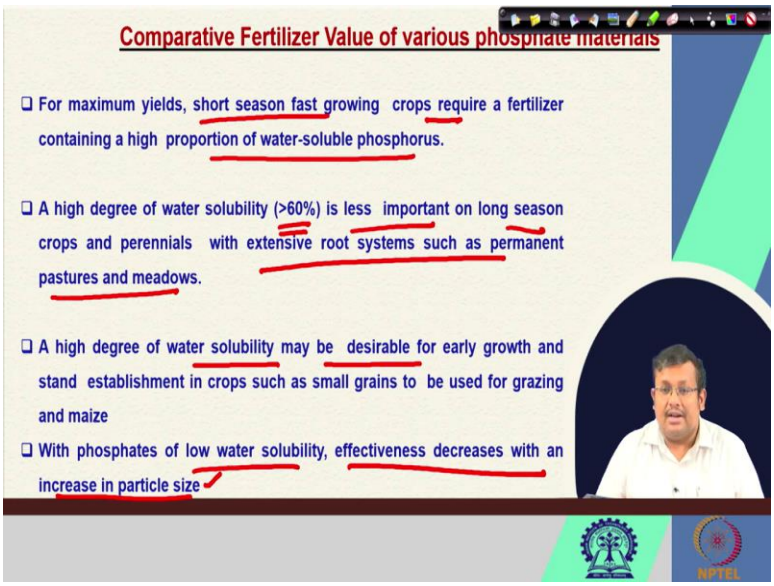

So, if we see the comparative fertilizer value of various phosphate fertilizers So, for maximum yields short season fast growing crops require a fertilizer containing a high proportion of water soluble phosphorus. Because water soluble phosphorus remains available for short duration of time. So, for short season fast growing crops for those we will go for the water soluble phosphorus fertilizers.

A high degree of water solubility which is greater than 60 percent is less important on long season crops and perennials with extensive root systems such as permanent pastures and meadows. Because for long duration crops if we apply these phosphating fertilizers, water soluble phosphoric fertilizer, they will eventually be fixed after a certain period of time and become unavailable.

Now, a high degree of water solubility may be desirable for early growth and stand establishment in crops such as small grains to be used for grazing and maize. Now with phosphates of low water solubility effectiveness decreases with an increase in particle size. So, we have to also take care of the particle size when there is insoluble phosphoric fertilizers. So, these are some of the important consideration while applying different types of fertilizers phosphoric fertilizers.

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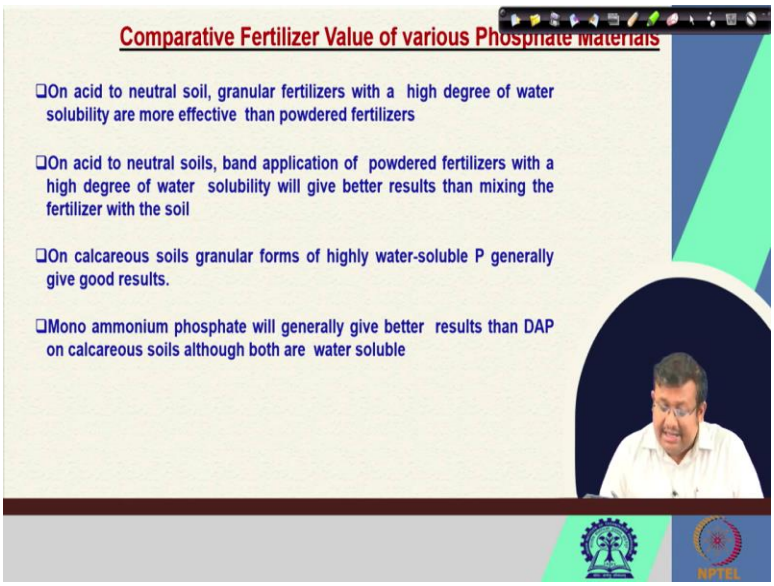

Now on acid to neutral soil and granular fertilizers with a high degree of water solubility are more effective than powdered fertilizers. Now, on acid to neutral soil banned application of powdered fertilizer with a high degree of water solubility will give better results than mixing the fertilizer with the soil.

Of course, when you mix the fertilizer in the soil that gives more chance for phosphate fixation or phosphorus fixation. However, when you give the band placement of powdered fertilizer with a high degree of water solubility, that will became more available to the blends. On calcareous soil granular forms of highly water soluble phosphorus generally give good results and mono ammonium phosphate will generally give better results than di-ammonium phosphate on calcareous soil although both are water soluble.

So these are some of the important consideration you should keep in mind while applying the fertilizer. So, you should be very very careful to select the proper phosphatic fertilizer, depending on several factors of your field like pH, whether you are, you want to grow a short duration crop or long duration crop, what type of materials are there in your soil, whether it is a calcareous, whether it is an acidic soil, whether it is a non-neutral soil, all these information's are highly important when we apply specially phosphoric fertilizer.

And also to apply the phosphoric fertilizer you have to consider which is the best process of application and depending on phosphorus fixation phenomena. So, these are some of the important consideration when you apply the phosphate fertilizers.

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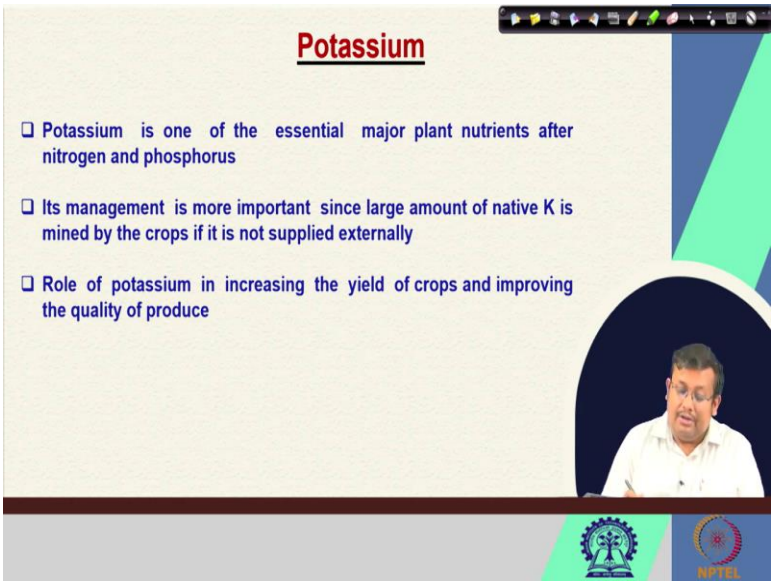

So, guys we have completed the phosphate, phosphorus for plant nutrition. Now, we are going to start potassium, this is the third primary nutrient which is taken up by the plant and this potassium is one of the essential major plant nutrient after nitrogen and phosphorus its management is more important since large amount of native potassium is mined by the crop if it is not supplied externally.

So, there are different types of crops which heavily mined this potassium from the soil and if we are not supplying this potassium in the soil to replenish that you know the loss of potassium by the or the uptake of potassium by the crop that will create potassium deficiency. Now, the role of potassium in increasing the yield of crops and improving the quality or produce is very important. Because without potassium, we cannot increase the yield of the crop or also we can improve the quality of the product why we are going to discuss.

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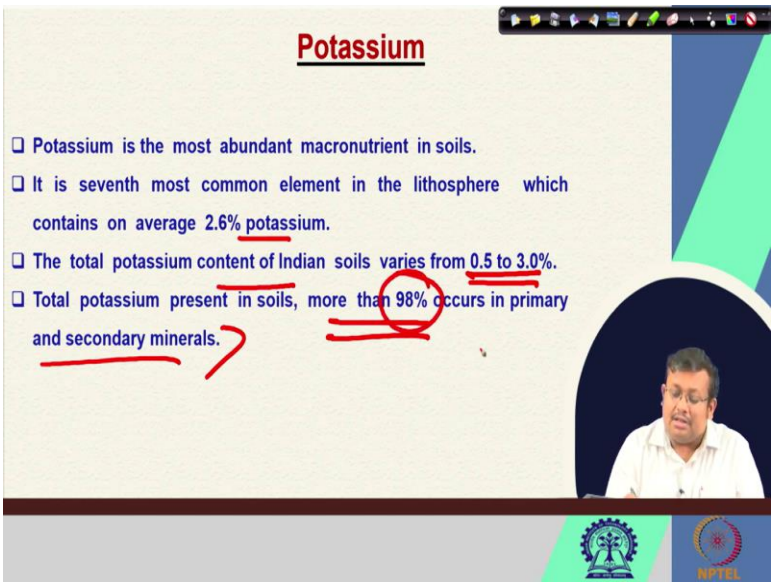

Now, potassium is the most abundant macronutrient in soils. Remember that it is the seventh most common element in the lithosphere which contains on average 2.6 percent of potassium. So, the total potassium content of Indian soils varies from 0.5 to 3 percent at the total potassium present in soil more than 98 percent occurs in primary and secondary minerals. We are going to discuss different pools of potassium soil protection, but remember that 98 percent occurs in primary and secondary minerals.

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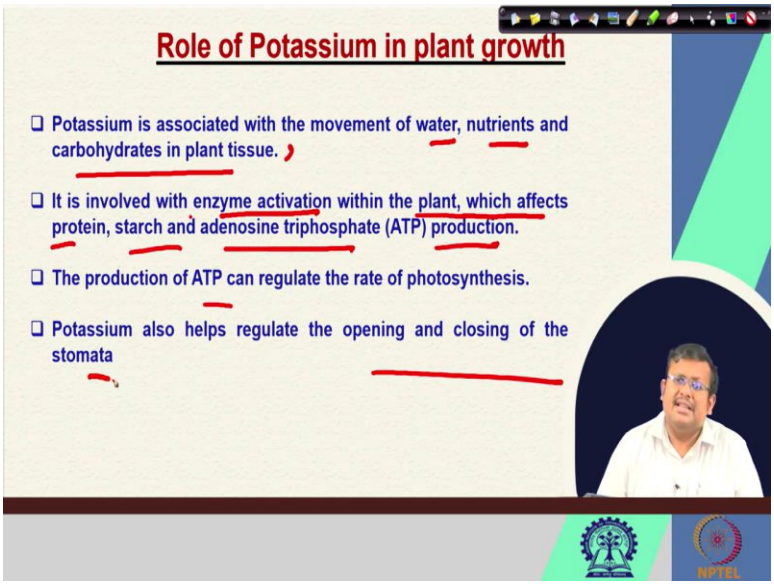

So, what are the roles of potassium in plant growth? First of all, potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. So, for proper movement of water, nutrients and carbohydrates potassium is required. Now, it is involved with enzyme activation within the plant which affects the protein starch and adenosine triphosphate or ATP production.

So, not only it affects the enzymes within the plant, it interns these enzyme affects the protein, starch and ATP production also. So, you can clearly understand why potassium is very much indispensable for plant growth. The production of ATP can regulate the rate of photosynthesis. So and potassium also helps to regulate the opening and closing of the stomata. So, all these are very important functions of potassium in plant growth.

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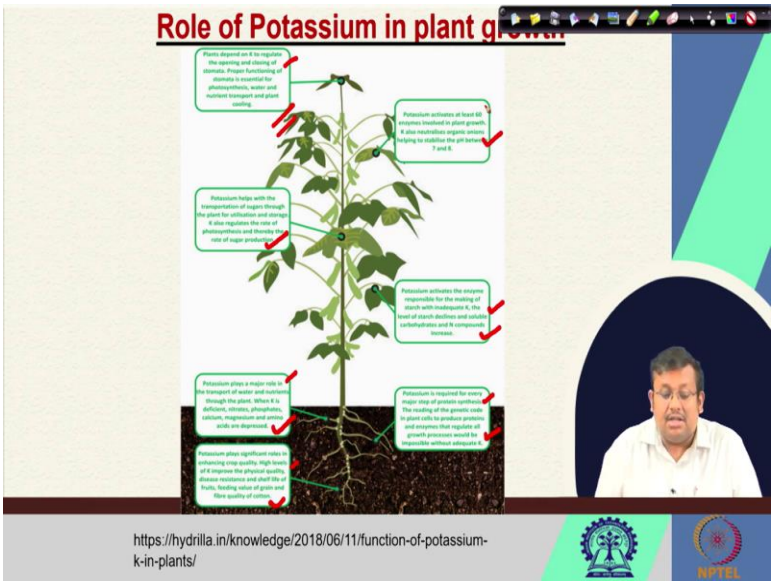

Now, if we summarize the role of potassium in plant in different parts of the plant, it will be very very clear. So potassium plays significant role in enhancing crop quality, high levels of potassium can improve the physical quality, disease resistant and shelf life of the fruits, feeding value of the grain and fibre quality of the cotton. So this one, potassium also plays a major role in the transport of water and nutrients to the plant. When potassium is deficient nitrate, phosphates, calcium, magnesium and ammonium, amino acids are deficient or depressed and potassium is required for every major step of protein synthesis.

The reading of the genetic code in plant cell to produce proteins and enzyme that regulates all growth processes would be impossible without adequate potassium. Potassium activates the enzyme responsible for the making of starch with inadequate potassium. The level of starch declines and soluble carbohydrates and nitrogen compounds increases.

Potassium activates at least 60 enzymes involved in plant growth and potassium also neutralizes organic onions you know helping to stabilize the pH between 7 to 8. So, potassium helps with the transportation of sugar through the plants for utilization and storage of and storage of potassium regulates the rate of photosynthesis and thereby the rate of sugar production.

Now, the rate of photosynthesis is controlled by the production of ATP and plants depends on potassium or to regulate the opening and closing of the stomata, proper functioning of the stomata is essential for photosynthesis, water and nutrient transport and plant cooling. So, you can see summarily huge importance of potassium for the plant growth, without the potassium or in the in the presence of potassium deficiency, it is very difficult for the plant to complete its metabolism or metabolic activities. Because all the metabolic activities depends on several enzymes and enzymes are activated by the presence of this potassium.

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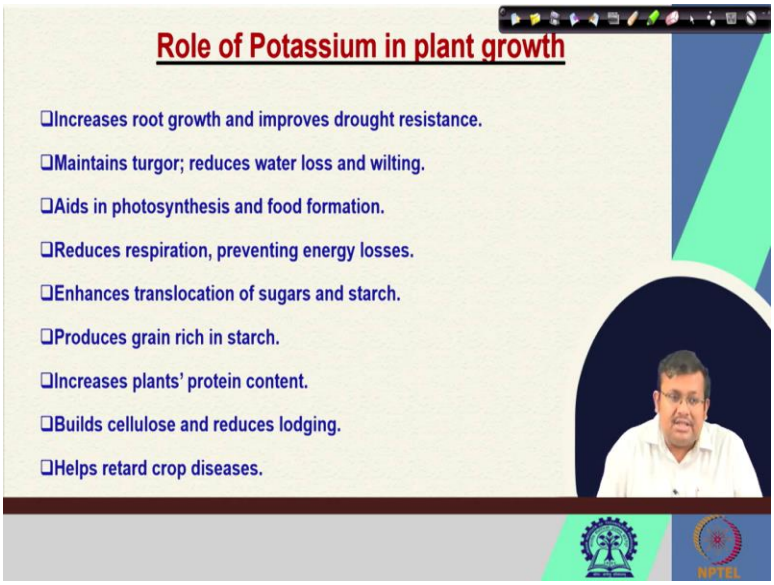

So, among the other roles of potassium in plant growth, it increases root growth and improves drought resistance. It maintains turgor, reduces water loss and wilting. it aids in photosynthesis and food formation. It reduces respiration, preventing energy loss, it enhances translocation of

sugar and starch. It produces grain reaching starch. It increases plants protein content, build cellulose and reduce lodging and finally it helps retard crop disease. So, to retard this crop disease, to prevent the crop disease potassium is very very important with the deficiency of potassium plants are more susceptible to different types of diseases.

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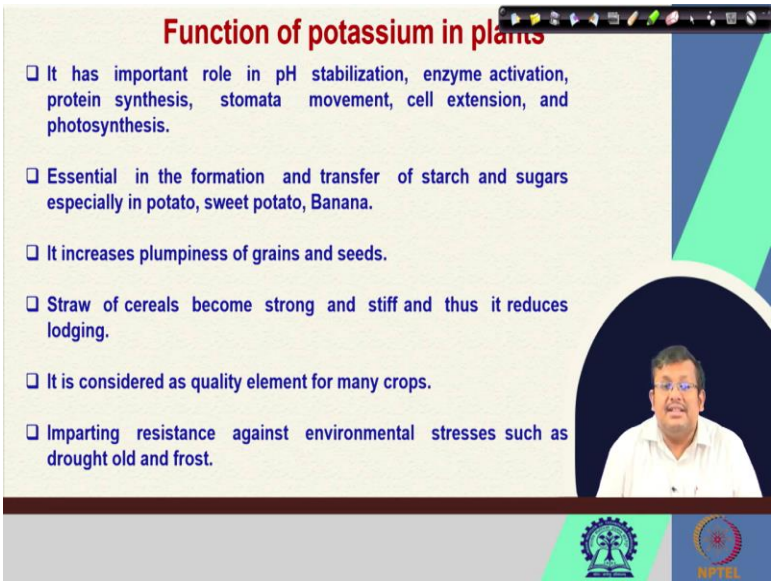

So, it has an important role in pH stabilization, enzyme activation, protein synthesis, stomata movement, cell extension and photosynthesis. It is essential for the formation and transfer of starch and sugar especially for potatoes, sweet potato and banana. It increases the plumpness of grains and seeds. Straw and cereals become strong and stiff and thus it reduces lodging otherwise, they will lodge easily. It is considered as quality element for many crops and impart resistance against environmental stresses such as draught old and frost.

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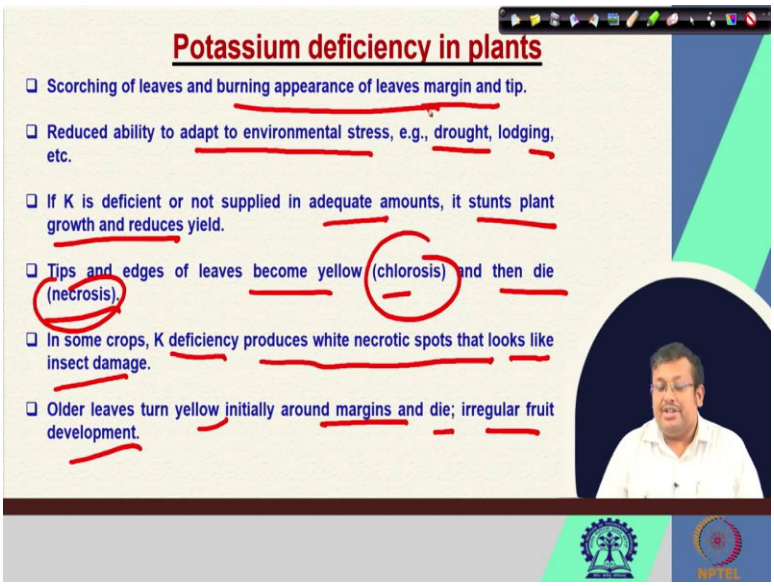

Now, what are the deficiency symptoms of potassium in the plant? First of all scorching of leaves and burning appearance of leaves, margin, leaves margin and tip is the major potassium deficiency symptom. Reduced ability to adapt to environmental stresses like drought, lodging et cetera is another symptom.

If potassium is deficient or not supplied in adequate amount, it stunts plant growth and reduce the yield. Tips and ages of the leafs become yellow which is known as chlorosis and then die which is known as necrosis. In some crops, potassium deficiency produces white necrotic spots that looks like insect damage and older leafs turn yellow initially around margins and die and also irregular fruit development.

So these are some of the common potassium deficiency symptoms. But the major deficiency symptom is chlorosis and necrosis of the leafs. You will see these necrotic tissues you know in the leaves as well as burning appearance in the leaf margin and tip. So, these are some of the very important or stark features of potassium deficiency symptoms in the plants.

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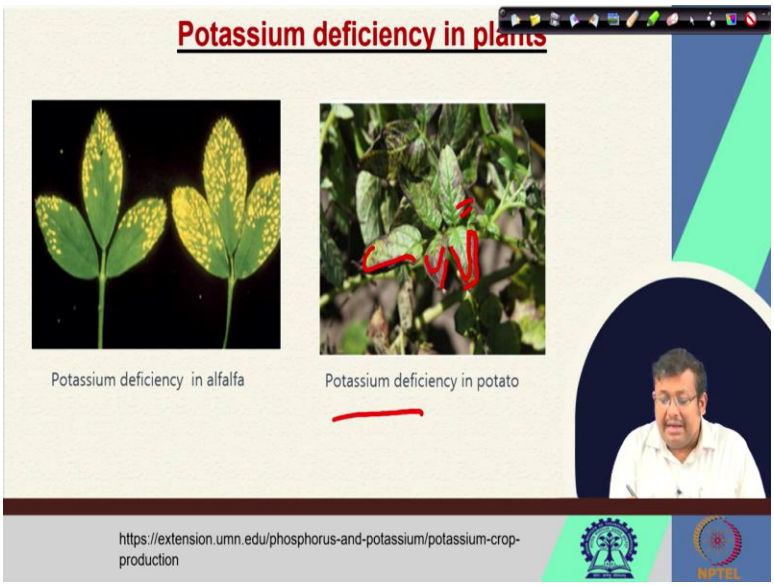

So, if we see the potassium deficiency symptoms pictorially you can see this is a potassium deficiency, you can see these are appearing the potassium deficiency symptoms are appearing in the leafs margin. And also you can see the necrosis of leaf tissue around the margin as you can see here in these zones. So these are the stark symptoms of the potassium deficiency. This is of course, potassium deficiency in potato. But you can see that the potassium deficiency ultimately shows that their symptoms in the mainly in the leaf margin.

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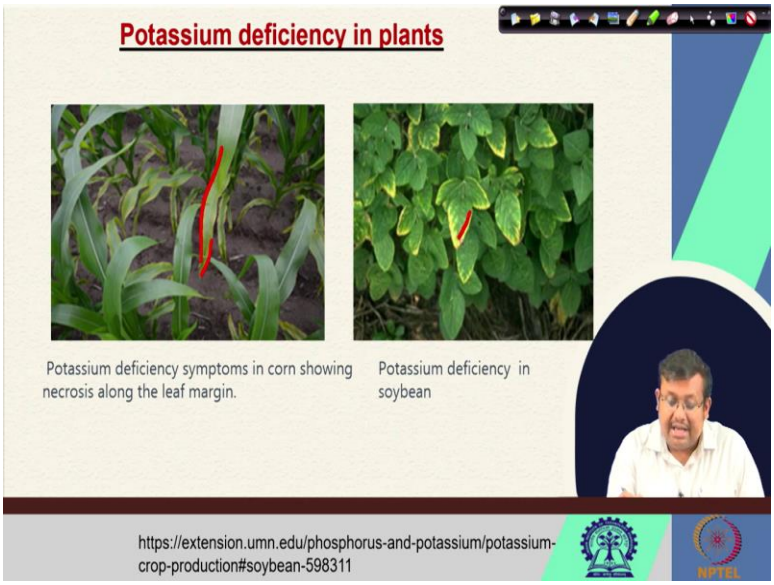

So this picture shows the potassium deficiency symptoms in corn, showing necrosis along the leaf margin so, you can see these necrotic tissues around these leaf margin, you can clearly see and also you can see potassium deficiency in soybean showing the necrotic tissues around the leaf margin. So, this is the major deficiency symptom of potassium in plant.

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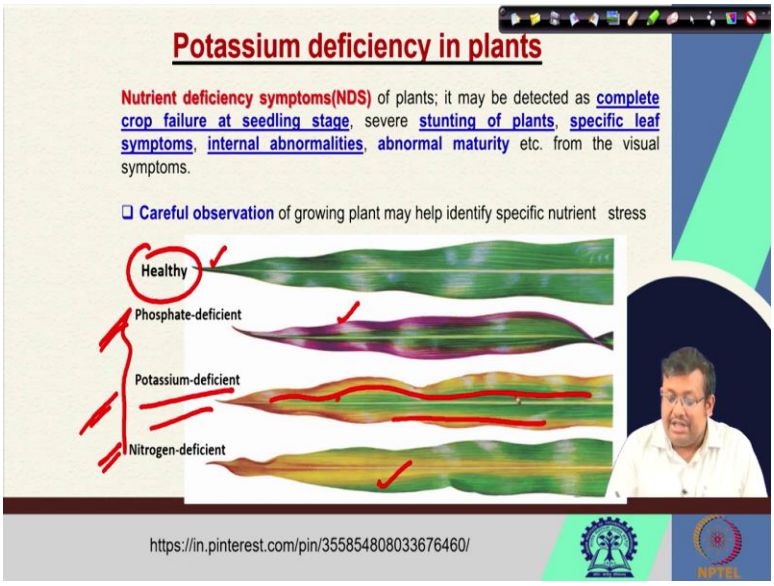

Now, if we see, if we compare the potassium deficiency in plants and their symptoms, this picture shows a very good example. So, this shows the healthy crop, you know, this is the leaf of a healthy crop and you can see, when there is a nitrogen deficiency you can see yellowing of the leaves we know that, when there is a potassium deficiency there will be, when there is a phosphate deficiency of course, reddish colour of the leaves we have already discussed this.

However, when there is a potassium deficiency, you will see that necrosis of the leaf margin. So, you can clearly differentiate between nitrogen deficiency symptoms, phosphate deficiency symptoms and potassium deficiency symptoms. Now, in nutrient deficiency symptoms of a potassium deficiency symptoms in plants may be detected as a complete crop failure at sibling stage and severe stunting of the plants and specific leaf symptoms internal abnormalities, abnormal maturity from the visual symptoms.

So, visually generally, people try to understand whether you know, their leaves are healthy, their crops are healthy or they are deficient in certain elements or not. So, for three major primary nutrients, you can see these are the major deficiency symptoms, you can see yellowing of the

leaves in nitrogen deficiency redding you know, reddish coloration in case of phosphate deficiency and potassium in case of potassium deficiency you can see necrotic tissues around the leaf margin. So, these are the symptoms of potassium deficiency.

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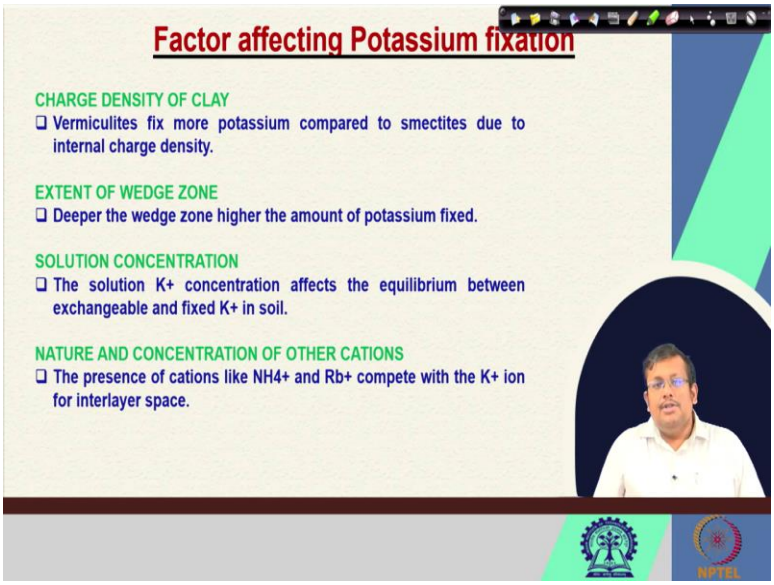

What are the factors which affect the potassium fixation? Charge density of the clay, vermiculites fix more potassium compared to smectites due to internal charge density. So, internal charge density of vermiculite is higher than smectites types. So, that is why it fixed more potassium than smectites. Extent of the wedge zone deeper the wedge zone higher the amount of potassium fixed solution concentration the solution potassium concentration affects the equilibrium between exchangeable and fixed potassium in the soil and nature and concentration of other cations.

The presence of cations like ammonium and rubidium compete with the potassium ion in the interlayer space. So, that is why some time you know rubidium can replace this potassium, rubidium can be considered as a proxy of potassium in the soil. And in the third point regarding the third point the solution potassium concentration affects the equilibrium between exchangeable and fixed potassium in the soil. We are going to discuss in our next lecture when we are going to see the equilibrium between different forms of potassium in the soil.

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So, by this we, let us wrap up this lecture these are the references which I used for this lecture and please go through these documents so, that you can have a more comprehensive overview of the potassium and phosphorus fertilizers specifically basic slag and fate of phosphorus. So, guys, I hope that you have got some new information regarding phosphoric fertilizer as well as potassium and its importance for plant nutrition.

Let us wrap up here and in the next lecture, we are going to discuss more about potassium, the potassium cycle as well as the equilibrium between different solid phases of potassium and solution phase of potassium and then we are also going to discuss some of the important potassium potassic fertilizers. So, let us wrap up here, let us meet in our next lecture. Thank you very much.