Soil Fertility and Fertilizers
Professor Somsubhra Ckakraborty
Department of Agricultural and Food Engineering
Indian Institute of Technology Kharagpur
Week 3
Lecture 15
Soil P and K Plant Nutrition (Contd.)

Welcome friends to this last lecture of week 3 of NPTEL online certification course of soil fertility and fertilizers. And we are at week 3, where we are discussing the soil phosphorus and potassium for plant nutrition.

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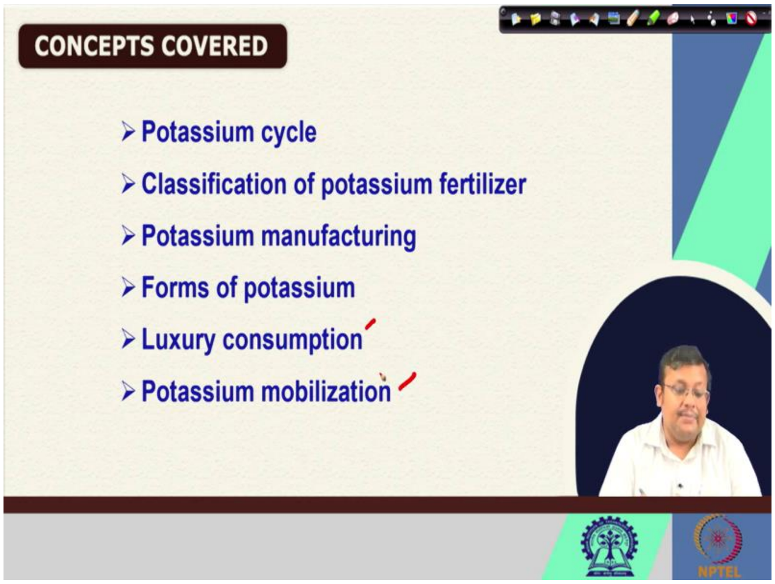

And in this lecture, we are going to discuss this following topics potassium cycle and then we are going to discuss the classification of potassium fertilizers. We are also going to discuss the potassium manufacturing, forms of potassium and then luxury consumption of potassium and potassium mobilization. So, these are the major concepts which we are going to discuss in this lecture.

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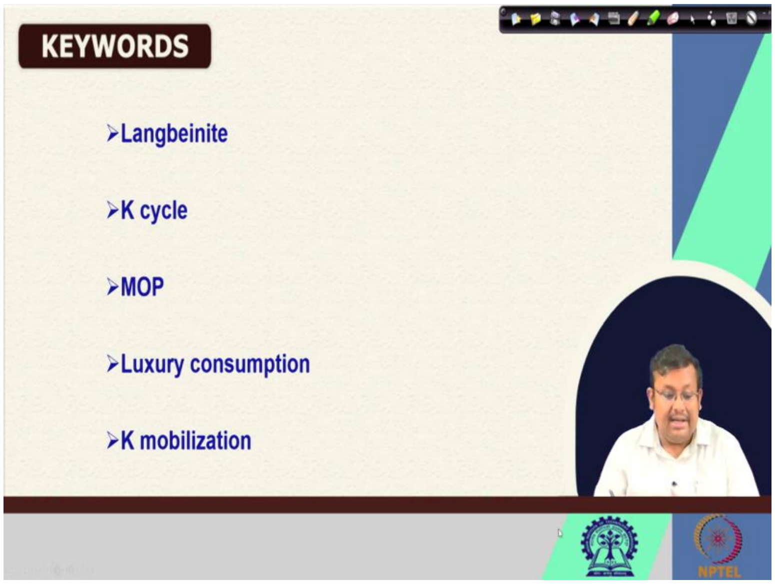

Also, these are the key words of this lecture like langbeinite, potassium cycle, MOP or Muriate of potash, then luxury consumption, Potassium mobilization these are some of the key words of this lecture.

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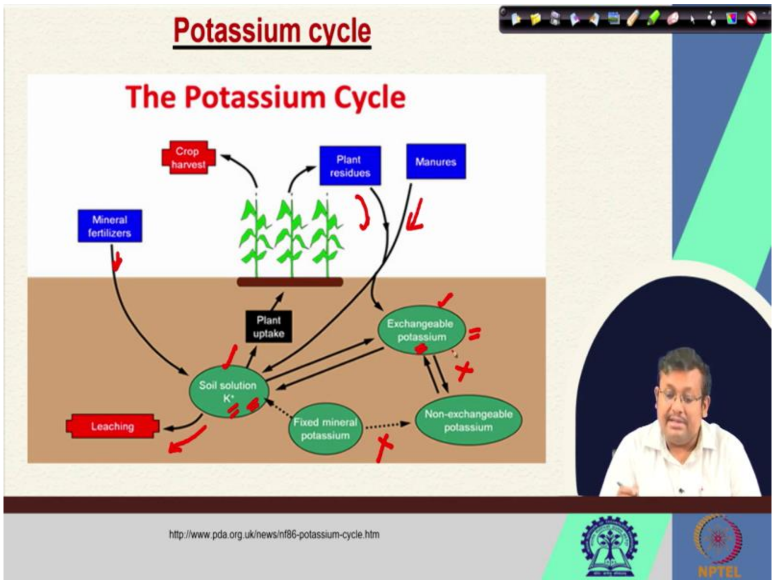

So, in the previous lecture, we have already seen what is the importance of potassium for plant growth, we have seen that plant growth as well as quality of the produce is mostly dependent on potassium in the soil without the potassium presence in the soil, you know plants growth is severely restricted, not only that drought resistant as well as other you know, and also lodging and all these things are being controlled by potassium in soil.

Now, if we see the potassium cycle, this potassium cycle is also dependent on different types of solution form as well as solid forms of potassium. So, if we start you know, let us see the, what are the inputs? So, here the inputs of potassium in the soil can be either mineral fertilizer or through manures or through different plant residues.

Now, these plant residues when you apply these plant residues as well as manures and mineral fertilizer that can add to soil solution potassium. Now, remember in case of potassium plant uptake the K plus form. So, this is the available form of potassium for in soil. Plant can only take this K plus form from the soil.

Now, a some portion of soil solution potassium can be lost through leaching. Also these soil solution potassium is in equilibrium with exchangeable potassium. Now, in case of exchangeable potassium, one of the source of this exchangeable potassium is decomposed plant residues and there is an equilibrium between non exchangeable potassium and an exchangeable potassium. And there is another phase that is fixed mineral potassium.

Now, remember that the conversion or the availability of potassium from the fixed mineral potash fixed mineral to non exchangeable potassium is very slow. So, this is very slow and also the conversion of non exchangeable potassium to actionable potassium is also very slow. However, as far as the availability of the potassium is concerned, soil solution potassium and exchangeable potassium are the two available forms of plant potassium. So, plant potassium is more or less governed by the soil solution potassium and also the potassium which are attached to the exchangeable site. So, this is how the potassium cycle maintains in the soil.

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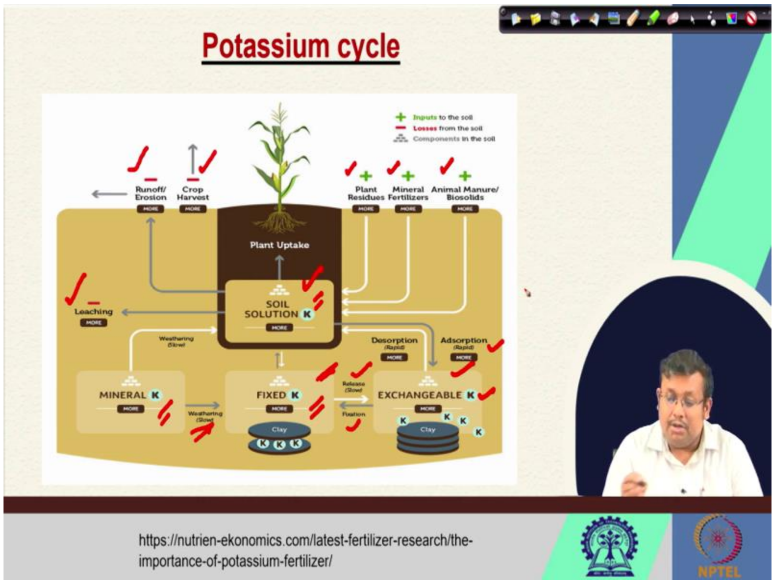

So, if we see in more detail way, it will be more clear. So, here you can see these plus signs are showing the inputs to the soil. So, we can see here plant residues as well as mineral fertilizers and animal manure or bio solids we can see here. So, all these are considered as input in the soil solution potassium. So, from the soil solution potassium plant uptake their required potassium nutrition. So, these three are inputs however, what are the losses? Crop harvest is one of the losses of potassium and also runoff or erosion is another loss of potassium, also leaching is a form of potassium loss.

So, let us see how the soil solution potassium is maintained. So, soil solution potassium has an equilibrium, they are in equilibrium with exchangeable potassium, these exchangeable potassium are generally present in the exchangeable sides of clay minerals or secondary minerals and the soil solution potassium ions can either adsorbed rapidly adsorbed onto these exchangeable sides of the clay minerals or the opposite is desorption.

So, these adsorb potassium get dissolved, which is also a rapid process. So, this adsorption and desorption of potassium from soil solution to clay and vice versa is a rapid process and these are governed by the concentration of the potassium in the soil solution. Also, you can see that potassium is also present in mineral form and fixed from in the interlayer space.

So, the weathering of the mineral potassium to fixed potassium is very slow, and also the release of these fixed potassium from the interlayer space we have, we already know that there are interlayer potassium, if we follow my soil science course, you will see that the interlayer potassium is present in soil science and technology course.

So, you will see that the interlayer potassium is present in illite structure. So, these interlayer potassium are very tightly bound and they are very slow, they can be released very slowly. So, the conversion of fixed potassium to exchangeable potassium is a very slow process and opposite process is a fixed session, where the exchangeable potassium get fixed in the interlayer space.

So, you can see here the mineral potassium the conversion of mineral potassium to fix potassium is quite a slow process also the conversion of fixed potassium to exchangeable potassium is a further slow process. However, the conversion of exchangeable to soil solution and so, through the process of desorption and opposite process is adsorption is a rapid or rapid process.

So, also we can see there is a input of potassium by the weathering of this potassium mineral which goes to the soil solution and also there is a equilibrium between the fixed potassium and also the soil solution potassium. However, this movement is very very slow. The major potassium available firms are soil solution potassium and exchangeable potassium which governs the potassium availability to the plant.

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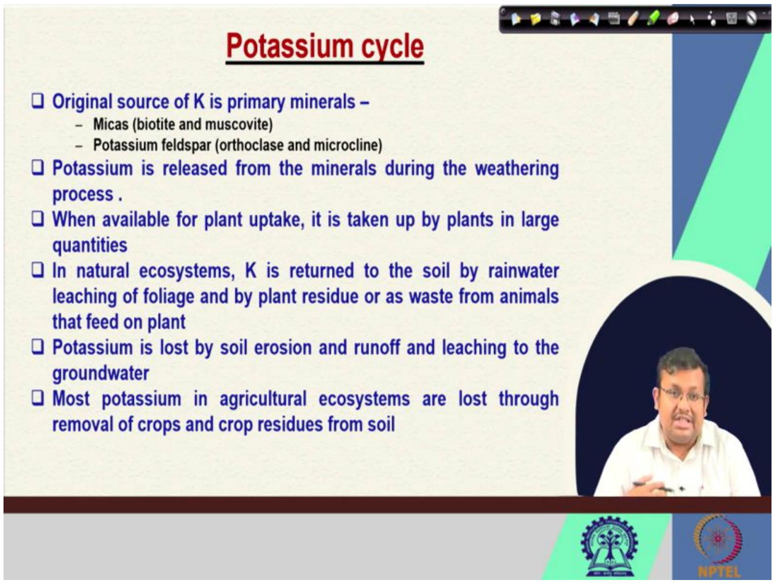

Now, if we see the potassium cycle some of the major points will let us discuss original source of potassium is basically the primary mineral. So, whatever we can see here, the original source is the primary minerals, what are the primary minerals? Micas is like biotite and muscovite also potassium feldspar like orthoclase and microcline. These are the major source of potassium. In soil they are primary minerals.

Potassium, is released from the minerals during the weathering process and when available for plant uptake, it is taken up by the plants in large quantities. In natural ecosystem potassium is returned to the soil by rainwater leaching of foliage and by plant residue or as waste from animals that feed unplanned.

Remember that potassium is lost by soil erosion and runoff and leaching to the groundwater. Most potassium in agriculture ecosystem are lost to removal of the crops and crop residues from the soil. So, crop removal or crop based mining of potassium is the major source of potassium loss from the soil.

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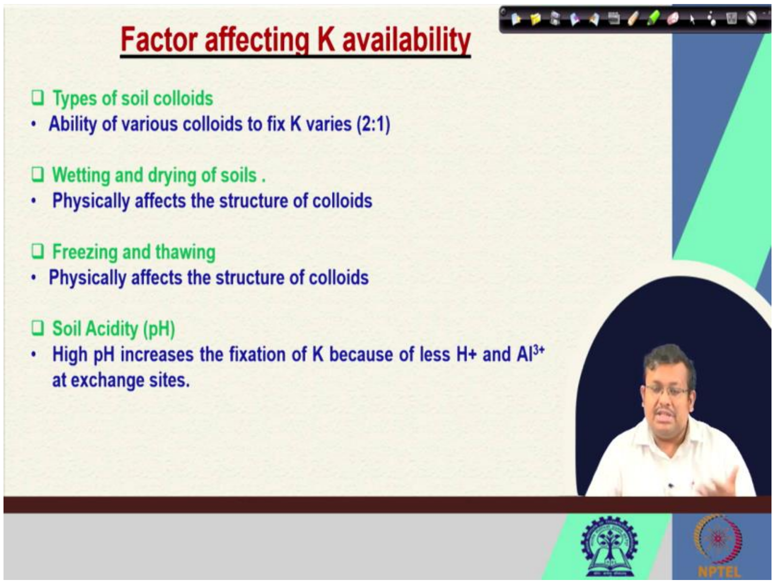

So, what are the factors which affects the potassium availability in the soil? First of all, type of the colloids. Because type of the colloids determine whether how much amount of potassium will be fixed by the colloids structure. So, ability of various colloids to fix potassium varies from one colloid to another colloid and generally they are fixed by 2 is to 1 type of clay minerals. And also waiting and drying up the soil is another important factor of phosphorus potassium availability. So, physically affect which physically affects the structure of the colloids. Freezing and thawing also physically affects the structure of the colloids and thereby they governs the potassium availability.

Soil acidity is another factor because it increases high pH increases the fixation of potassium because of less proton and aluminium ions at the exchangeable side. So, when there is a high pH of course, there will be less proton as well as aluminium ions in the exchange side. So, they will be replaced by the potassium ions, which is also a positively charged cation.

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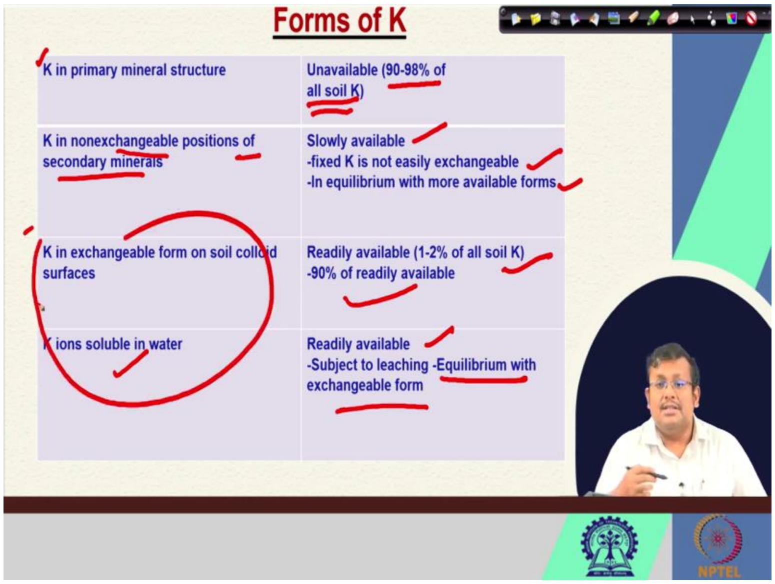

Now, if we see the forms of potassium in the soil we have already discussed, but let us discuss in more detail. So, potassium in the primary mineral structure we have already discussed, this is basically unavailable so, 90 to 98 percent of the soil potassium are present in this unavailable form that is, primary mineral structure.

Second form is potassium is non exchangeable position in non exchangeable position of secondary minerals. So, these are also slowly available. Fixed potassium is not easily exchangeable and in equilibrium with more available forms. However, their conversion is very slow. Third one is potassium in exchangeable form from soil colloid surface they are readily available as I have already told you, they constitutes around one to 2 percent of the all soil potassium and 90 percent of this fraction or form is readily available.

And finally, potassium ions soluble in water, they are readily available and subjected to leaching and also they are at equilibrium with actionable form. So, these two forms governs as I have told you previously, these two forms governs the potential nutrition of the crop. Because the other two forms are largely un-accessible and they are also very slowly, they convert to other forms very slowly.

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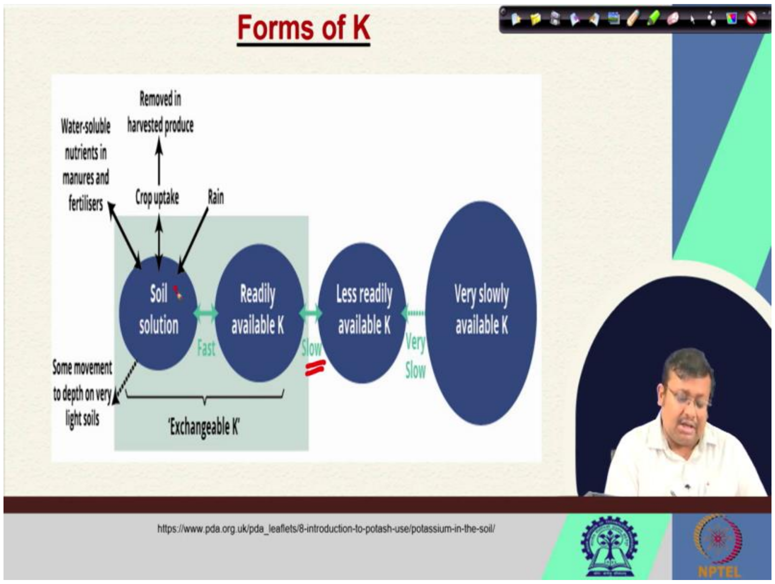

So, this is also another representation so you can see the conversion from mineral to non exchangeable is very slow and also from conversion of non exchangeable to exchangeable is also slow however, the conversion or the equilibrium between the soil solution and readily available potassium or exchangeable potassium is very rapid and plant generally take up the potassium ion from this soil solution forms.

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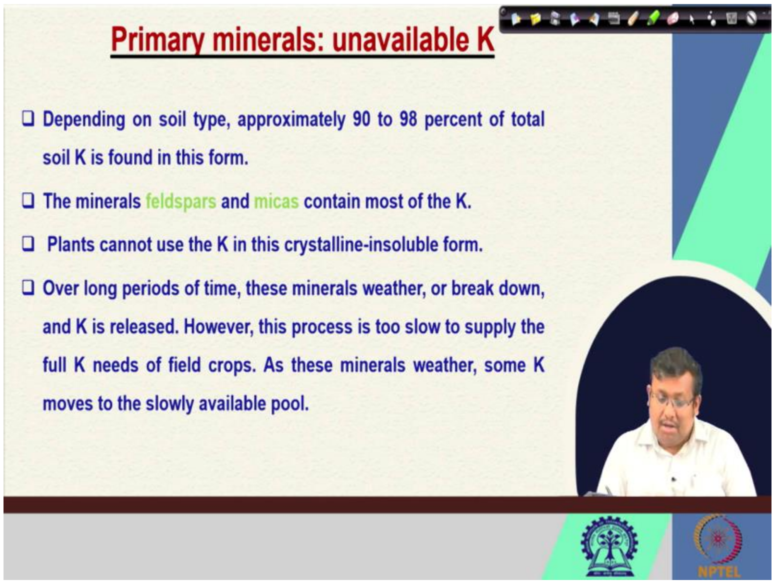

Now, these primary minerals they are basically unavailable forms of potassium depending on soil type approximately 90 to 98 percent of total soil potassium is found in this form and the minerals feldspars and mica contain most of this potassium and plants cannot use the potassium in this crystalline insoluble form. So, it is not being so, since most of these potassium are present in this form in crystallize crystalline form. So, plant cannot take this form you know plant can only take potassium ions from the soil solution.

So, over a long period of time these minerals weather or break down and potassium is released. However, this process is too slow to supply the full potassium needs of the crop as this mineral weather some potassium moves to this slowly available pool. So, we can clearly see that although they can very slowly weather and goes to the other pools, plant availability of the potassium is not governed or dependent on this primary minerals or unavailable form some potassium.

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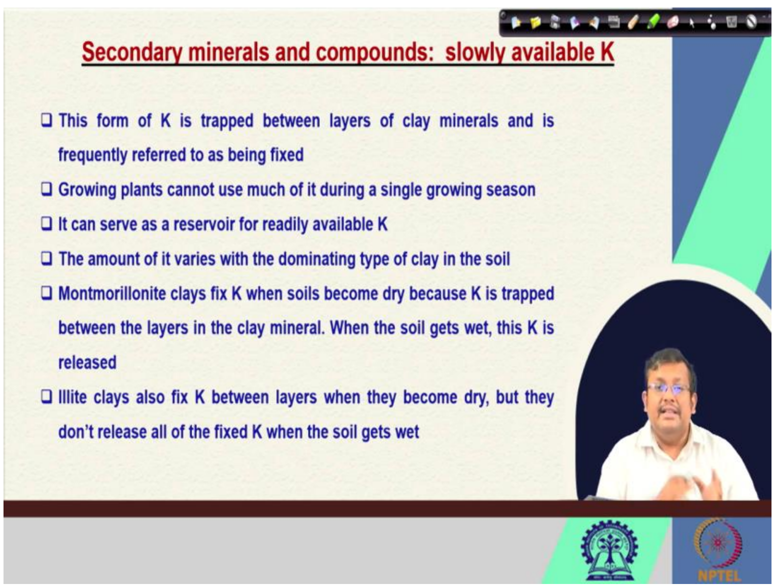

Now, the second form that is slowly available potassium, this is secondary minerals and compounds. So, this form of potassium is trapped between layers of clay minerals like illite and is frequently referred to as being fixed. So, growing plants remember that in the illite structure, the interlayer space is almost negligible because they are being occupied by these small potassium ions and thereby locking the structure.

So, they are so tightly fixed in this interlayer space of illite they cannot be easily replaced. So, that is why they are very slowly available or almost unavailable. So, growing plant not plants cannot use much of a during the single growing season and it can serve as a reservoir for readily available potassium

It can be served as a resolver for readily available potassium but growing plants cannot use much of it. The amount of it varies with the dominating type of clay in the soil of course, the more the potassium containing or entrapping mineral will be there in the soil more potassium this form that is secondary these unavailable forms will be there. Montmorillonite clays fixed potassium when soils become dry because potassium is trapped between the layers in the clay minerals when the soil gets wet this potassium is released.

However, illite clays also fixed potassium between the layers when they become dry, but they do not release all the fixed potassium when the soil is gets wet. Part of the reason is, this potassium has high charge density and they are not expanding. So, they do not release this potassium from the interlayer space and ultimately what happens this potassium gets more tightly fixed in the interlayer space.

If you remember the structure of the illite, all the isomorphous substitution occurs in the tetrahedral sheath and ultimately negative charge which develops in the illite structure gets occupied by these potassium ions which are small, which are tightly fixed in the interlayer space and ultimately, they are not easily released from this mineral.

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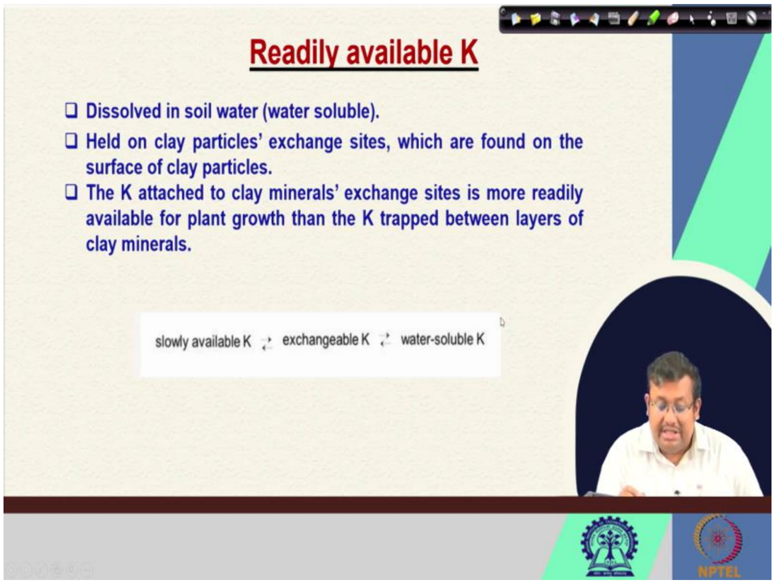

The third form is readily available potassium, these are dissolved in soil water which are water soluble in nature and held on clay particles exchange sites, which are found on the surface of the clay particles due to different types of charge development in the clay there are the external sites the exchange sites where different types of cations can be adsorbed.

So, these readily available potassium are basically absorbed in the exchange sites of the clay minerals or surface of the clay minerals, from where they can be readily available, the potassium attached to clay mineral exchange sites is more readily available for plant growth than the potassium trapped between the layers of the clay minerals.

Of course, when the potassium is trapped between the layers, it is very difficult to remove them from the interlayer space. However, this readily available potassium is fixed or not fixed or attached or adsorbed onto the surface of the clay minerals and that is why they are readily available. So, you can see here slowly available potassium, they remain in equilibrium with the exchangeable potassium which is also remain in equilibrium with the water soluble potassium.

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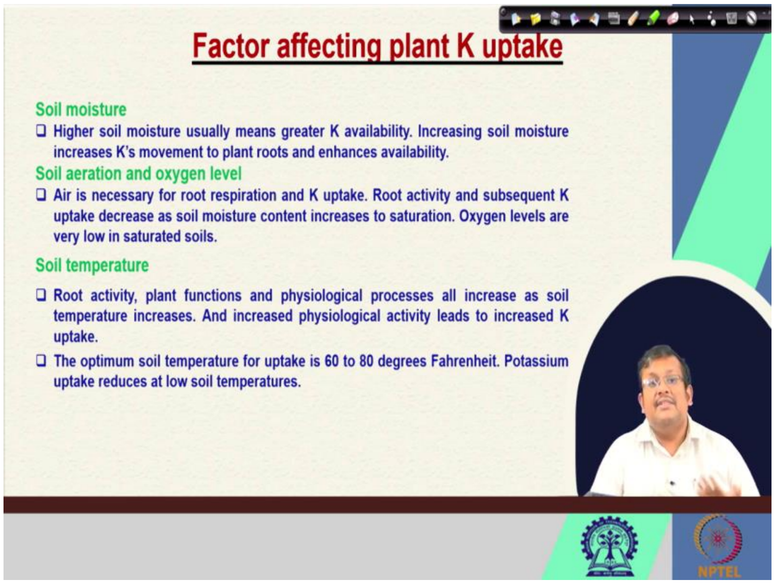

Now, what are the factors which affect the potassium plant potassium uptake. These are some of the factors like soil moisture soil aeration, and soil temperature these are the major factors which affects the plant potassium uptake. Let us, discuss soil moisture, higher soil moisture usually means greater potassium availability, increasing soil moisture increases potassium movement to plant root and enhances availability of course, because plant can take up these potassium which are present in soil solution, more water means higher soil moisture means higher potassium availability.

Secondly, soil aeration and oxygen level, air is necessary for root respiration and potassium uptake, root activity and subsequent potassium uptake decreases as soil moisture content increases to saturation. Oxygen levels are very low in saturated soil. Third is root temperature, root activity plant functions and physiological processes all increase as soil temperature increase and increased physiological activity leads to increased potassium uptake. So, the optimum soil temperature for uptake is 60 to 80 degree Fahrenheit and potassium uptake reduces as low soil temperature, at low soil temperature. So, these are some of the important factors of which affects the plant potassium uptake.

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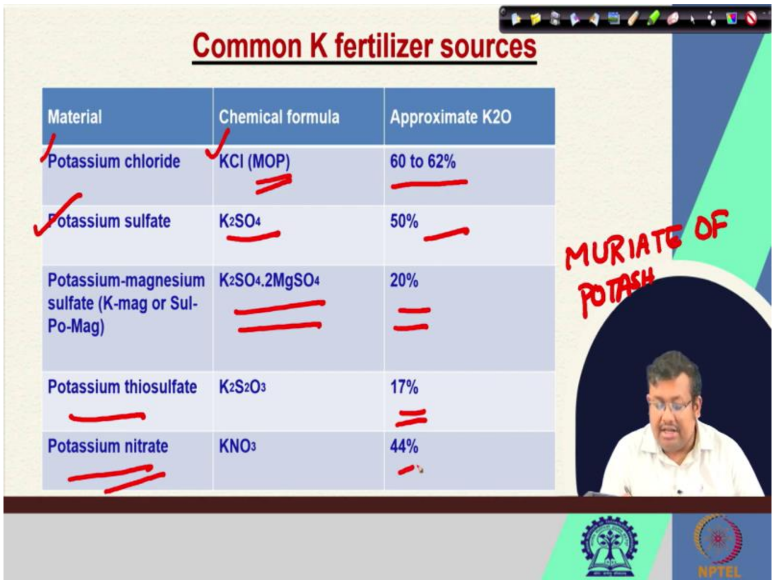

Now, let us see, what are the common fertilizers of potassium? So, you can see the most common potassic fertilizer is potassium chloride, the chemical formulas KCL we also know these as MOP or Muriate of potash. So, the spelling is Muriate of potash. So, Muriate of potash is basically potassium chloride and it contains 60 to 62 percent of K2O and another important you know potassic fertilizer is potassium sulfate, the formula is K2SO4 contents 50 percent of K2O, potassium magnesium sulfate is also the chemical formula is this contains 20 percent K2O potassium thiosulfate contains 17 percent of K2O and potassium nitrate contains 44 percent of K2O.

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Now, let us discuss the potassium chloride or Muriate of potash. Now, potassium chloride or Muriate of potash is a white or red crystal containing 60 percent of potassium oxide or K2O it is completely soluble in water and therefore readily available to the crops it is not lost from the soil as it is absorbed onto the colloidal surface and it can be applied through (())(20:34) sorry.

Let us discuss the potassium chloride then, so potassium chloride or Muriate of potash is a white or red crystal containing 60 percent of K2O it is completely soluble in water and therefore readily available to the crops, it is not lost from the soil as it is adsorbed on the colloidal surface, it can be applied at sowing or before or after the sowing. The chlorine content is about 47 percent and potassium chloride is the most common potassium source used. So, this is the most common potassic fertilizer which people use in their field.

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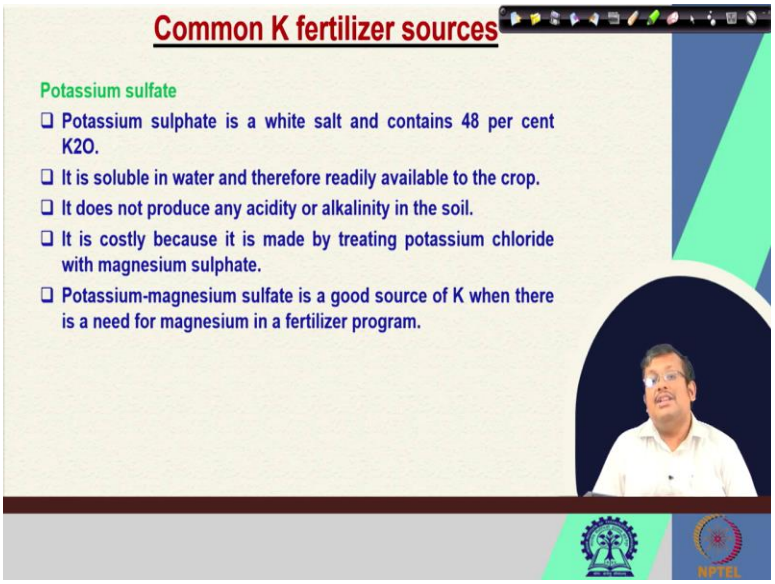

Second is potassium sulfate, potassium sulfate is a white salt and content around 48 to 50 percent of K2O. It is soluble in water and therefore readily available to the crop, it does not produce any acidity or alkalinity in the soil, it is costly because it is made by treating potassium chloride with magnesium sulfate and potassium magnesium sulfate is a good source of potassium when there is a need for magnesium in a fertilizer program.

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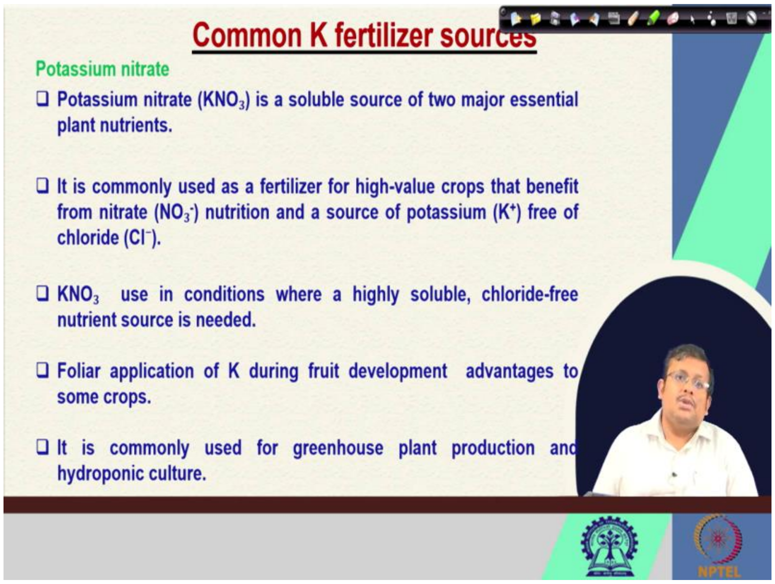

Third one is potassium nitrate. Now, to this potassium nitrate or KNO3 is a soluble source of two major essential plant nutrient. It is commonly used, two major plant nutrient means potassium and nitrogen. So, it is commonly used as a fertilizer for high value crops that benefit from nitrate nutrition and a source of potassium free of fluoride. So, potassium nitrate used in conditions where a highly soluble chloride free nutrient source is needed and foliar application of potassium during fruit development produce the advantages to the advantage to some crops. So, for foliar application, we apply this potassium nitrate now it is commonly used in greenhouse plant production and hydroponic culture. Now, availability of the potassium nitrate is somewhat restricted because potassium nitrate is an explosive material. So, it is not very commonly used as a potassic fertilizer.

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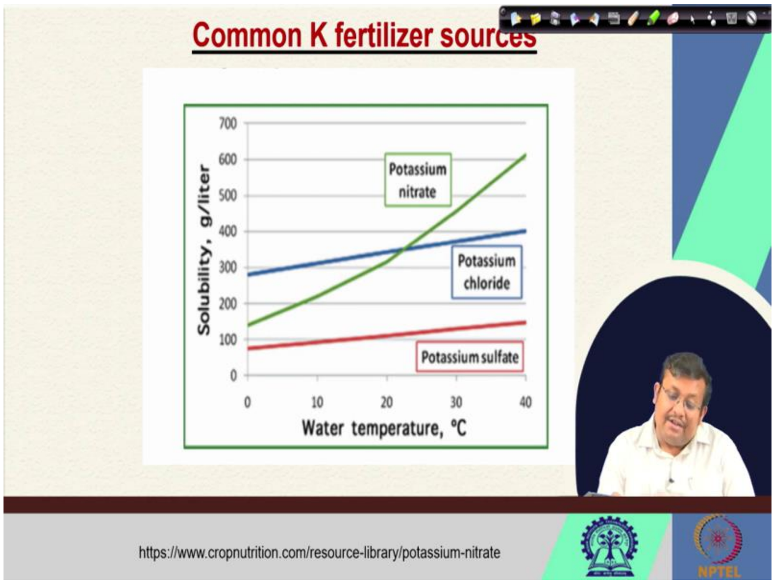

So, if you see the solubility of different potassic fertilizers you can see with increase in temperature, the solubility of potassium nitrate is increased as compared to potassic muriate of potash and potassium sulfate. However, the solubility of potassium sulfate is lowest among these potassium nitrate, potassium chloride and potassium sulfate these three potassic fertilizers.

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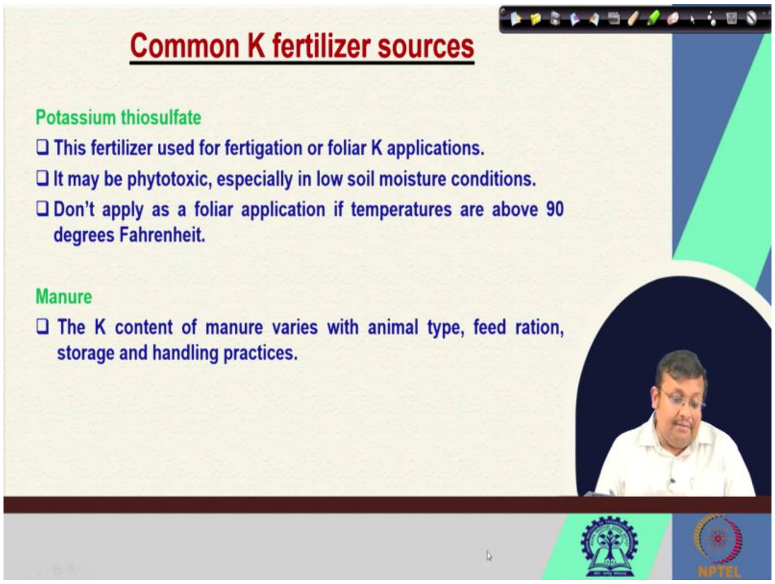

Now also potassium thiosulfate is used for fertigation or for foliar potassium application, it may be phytotoxic especially low soil moisture conditions, and it is recommended to not apply these as a foliar application if temperatures are above 90 degree Fahrenheit and manure is another source of potassium, the potassium content of manure varies with animal type, feed ration storage and handling practices. So, apart from these synthetic fertilizer manure can be another source of potassium in the soil.

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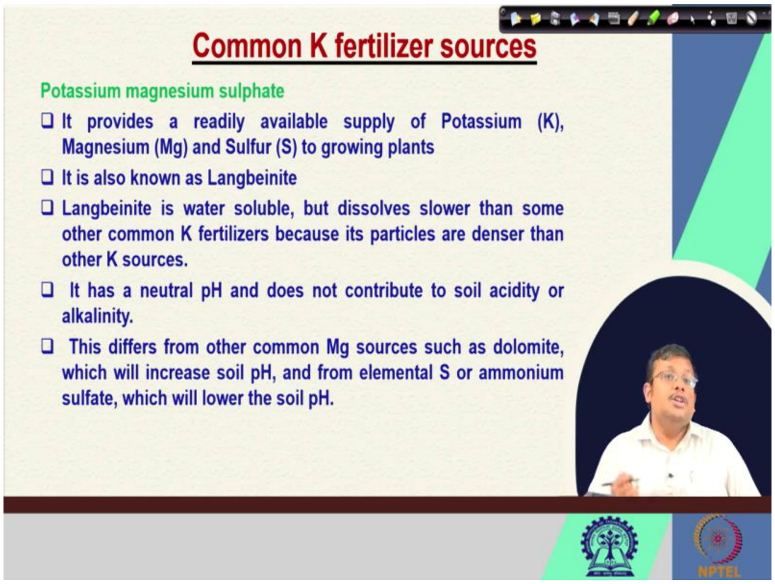

Also potassium magnesium sulfate it provides a readily available supply of potassium magnesium and sulphur to growing plants it is also known as langbeinite. So langbeinite is a water soluble but dissolve slower than some other common potassic fertilizers because it is particles are denser than other potassium sources. So, it has a neutral pH and does not contribute to soil acidity or alkalinity. And this differs from other among magnesium sources such as dolomite, which will increase soil pH and from elemental sulphur or ammonium sulfate, which will lower the soil pH.

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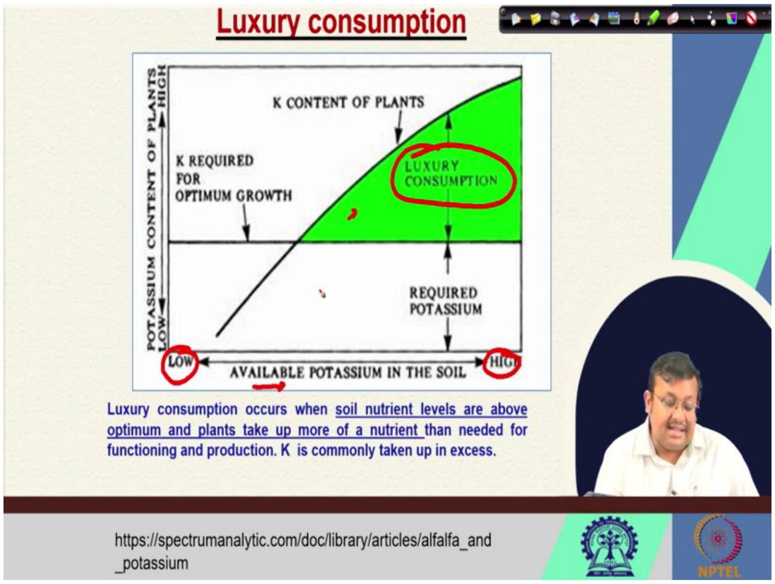

Now, there is a very important concept of luxury consumption, luxury consumption occurs when soil nutrient levels are above the optimum, and plants take up more of a nutrient than needed for functioning and production and potassium is commonly taken up in excess. So, here you can see in this graph, these luxury consumption can be seen in in case of potassium.

So, here there is a low available potassium in the soil and there is a high available potassium in the soil. So, as the availability of the potassium is increasing, you can see this is the threshold level of potassium requirement for optimum growth.

However, as the availability of the potassium is increasing in this direction, you can see plant can still uptake this potassium from the soil and this is known this excess amount of consumption of potassium is known as luxury consumption. So, ultimately you can see the plan do not need these portion of potassium for their optimum growth however, they continue to uptake this potassium and that is known as the luxury consumption. So, in case of potassium we get these luxury consumption.

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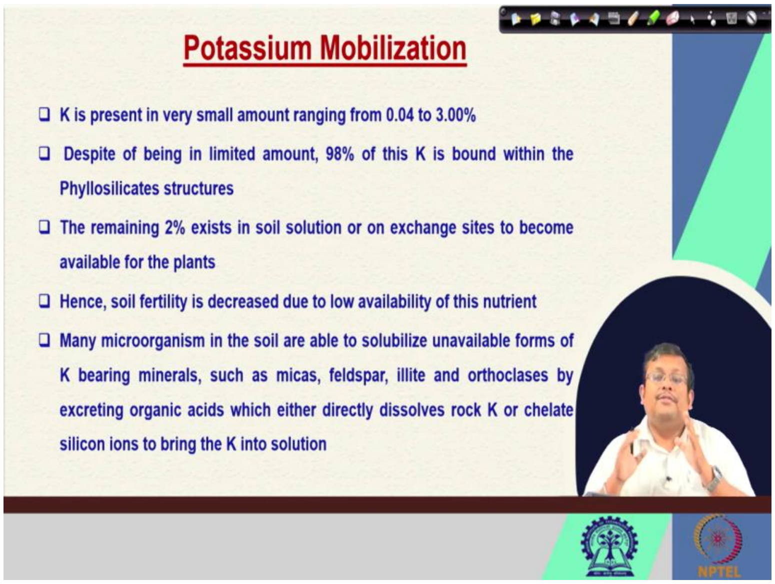

Now, what are the consideration or potential mobilization. Now, potassium is present in very small amount ranging from 0.04 to 3 percent. Despite of being limited in limited amount 98 percent of these potassium is bound within the phyllosilicates structure and the remaining 2 percent exist in soil solution or exchange site to become available for the plants.

Hence, the soil fertility is decreased due to low availability of this nutrient. Many microorganisms in the soil are able to solubilize unavailable forms of potassium bearing minerals such as Micas, feldspar, illite and orthoclase by excreting organic acids which either directly dissolves the rock potassium or chelate silicon ions to bring the potassium into the solution.

So, we can see that the available portion is very small only 2 percent which exist in the soil solution or exchangeable form and 98 percent are present in unavailable forms and many microorganisms play an important role for making these potassium available from these unavailable forms.

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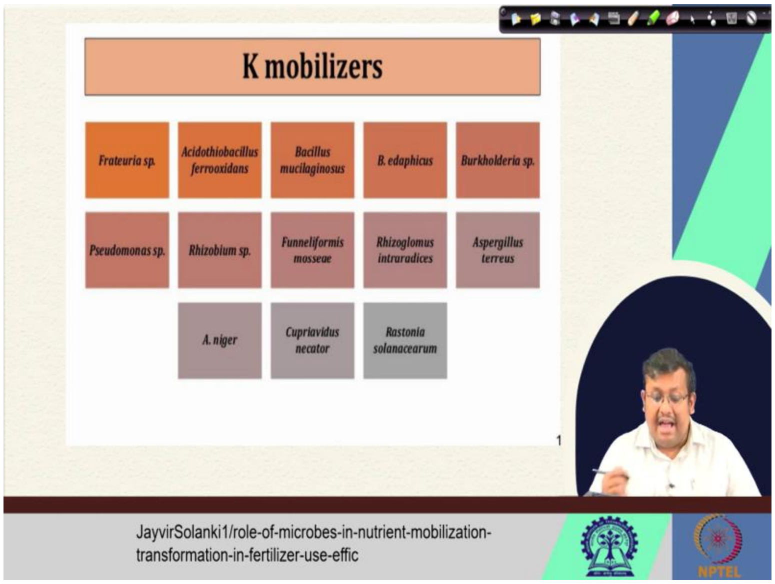

So, these are some of the potassium mobilizers like, Bacillus species and then Burkholderia and then Pseudomonas, rhizobium and so many Aspergillus, so, rastonia. So, they are different types of microorganisms which are known as potassium mobilizer in the soil because they help in converting the unavailable forms of potassium to available forms of potassium.

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So, guys, this makes the end of this whole week of lectures. So, we have completed the week 3 of lectures where we have discussed the phosphorus and potassium, their importance phosphorus and potassium cycle, and also the major phosphatic as well as potassic fertilizers, which you generally apply in the soil and their general characteristics. Hopefully, you have learned something new in these lectures, and we will discuss these fertilizers and their application strategy in more detail in our upcoming weeks. However, let us wrap up this week 3 here, and let us move to week 4. Thank you very much.