Soil Fertility and Fertilizers

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Lecture: 34

Soil Health and Quality, Problem Soil, Land Capability Classification (Contd.)

Welcome friends to this 34th lecture of NPTEL online certification course of soil fertility and fertilizers. And we are at currently week 7 lecture and in this week we are discussing about soil health and quality and problems soil and land capability classification.

So, in this week we have already discussed about soil health and soil degradation soil health indicators, and then we have discussed about soil health card scheme by government of India, what are the benefits of soil health card scheme, what are the different aspects of soil health scheme, and also we have discussed about the soil quality, soil quality index in details, how to calculate soil quality index, how to identify the minimum dataset, how to score those indicators, linear scoring nonlinear scoring then how to calculate those indices. So, we have already discussed those in our previous lectures.

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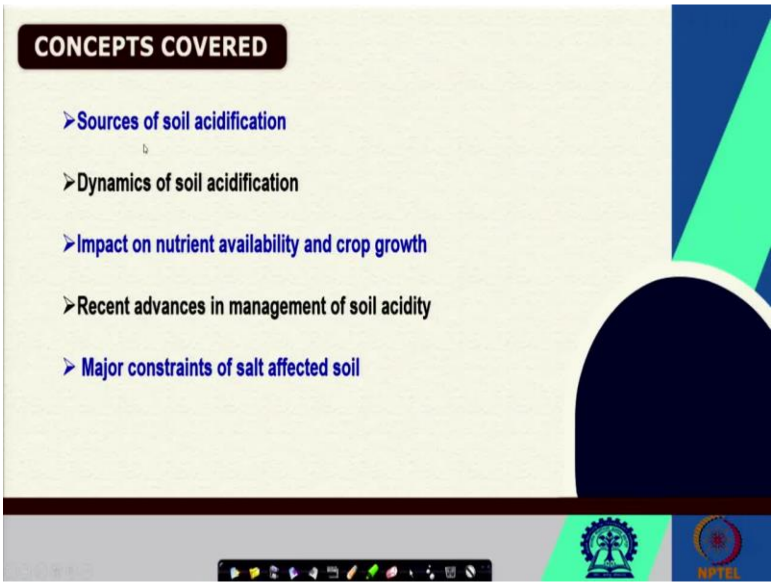

In this lecture we are going to cover these following concepts. So, first of all we are going to discuss the sources of soil acidification then we are going to discuss the dynamics of soil acidification and then we are going to discuss the impact on natural availability and crop growth basically the impact of soil acidity and then we are going to discuss recent advances in management of soil acidity. And finally, we are going to discuss major constants of salt affected soils. So, these are the concepts which we are going to discuss in this lecture.

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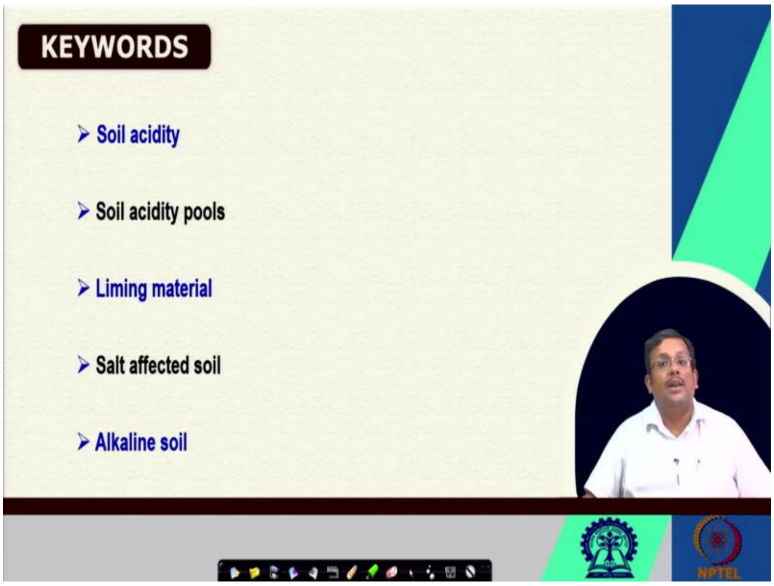

Apart from that, these are the keywords like soil acidity, soil acidity pools, liming materials, soil then salt affected soil, and alkaline soil these are some of the key words of this lecture.

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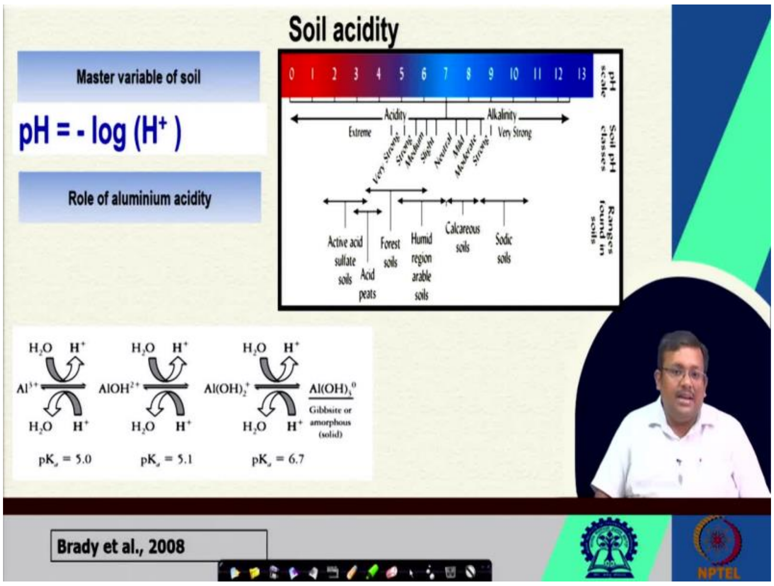

Now, we all know that definition of pH, pH is basically the negative logarithm of hydrogen ion concentration and in soil apart from the hydrogen ion, the aluminium also acts as a source of soil acidity. So, below pH 5 around pH 5.5 aluminium generates the protons in the soil thus behaving like acidic ion. Now, that is why whenever we talk about soil acidity, we generally indicate the submission of both hydrogen ion as well as the aluminium ions.

As you can see in this picture, it is quite clear that as aluminium hydroxides ultimately goes towards aluminium ion it consumes the protons however, this aluminium ions at pH 5 generally hydrolyzed to form these it goes towards these gibbsite from the aluminium ion and as a result of this conversion from this aluminium ion to this gibbsite or amorphous solid aluminum hydroxide it generates these hydrogen ions or protons and thereby decreasing the pH of the soil.

So, that means, in acidic soil not only we can see the dominance of H plus ions also we can see the dominance of aluminium ion and these aluminium ion concentration can lead to aluminium toxicity, ultimately impacting the root growth. So, soil acidity can be also differentiated into different grades.

Like very strong, strong, medium, slight in neutral and then pH can be of mild moderate, strong alkaline and very strong alkaline. Now if we see the sodic soils which we are going to discuss, so sodic soils are basically showing high or strong alkalinity. Calcareous soil can show the mild to strong alkalinity.

However, humid region arable soil generally shows the strong to around neutral acidity and in case of forest soil, forest soils can show very strong to slightly acidic pH. Acid peats soils can show very strong to extreme low pH or extreme high acidity and active acidity sulfate soil should generally shows extreme amount of soil acidity. So, these are different types of ranges of soil acidity which you can see in in soils.

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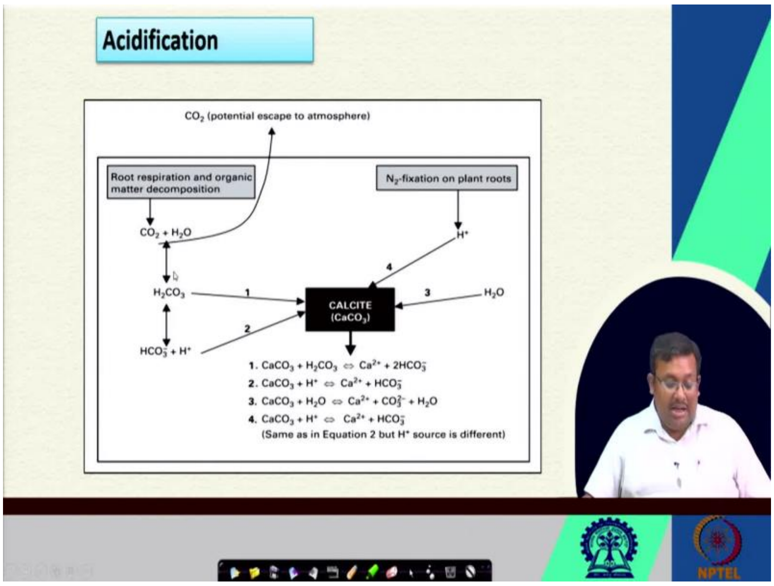

Now, acidification can be caused by different processes. First of all, if you see the root respiration and organic matter decomposition, these are 2 major sources of carbon dioxide. Now, due to the organic matter decomposition or root respiration there is higher carbon dioxide or higher partial pressure of carbon dioxide in the soil layer.

And when this carbon dioxide reacts with water, it forms the carbonic acid, the carbonic acid reacts with the calcite or calcium carbonate which is present in the soil and they are were dissolving. So, you can see calcium carbonate when it reacts with H2CO3 it produces calcium ion and bicarbonate ion. Apart from that these H2CO3 can also produce bicarbonate ion and produce the protons.

So, these can also impact this calcite and ultimately can produce and dissolve this calcite. So, this calcium carbonate when it reacts with H plus ion, it can also produce these calcium ion and bicarbonate ion. So, these are the reactions you can see calcium carbonate reacts with carbonic acid to form the calcium ion and bicarbonate ion. Also the calcium carbonate when it reacts with proton it produced the calcium ion as well as bicarbonate ion.

Also, calcium carbonate reacts with water molecules to produce this calcium and carbonate ions and water molecules. Also these nitrogen fixation on plant roots can also generate H plus ion, these H plus ion reacts with calcite to produce these calcium and bicarbonate ion. So, this is how these acidity soil acidity generates and after producing the soil acidity, they can react to dissolve this calcium carbonate or calcite in the soil.

Sometime this carbon dioxide can also exist into the atmosphere or escape into the atmosphere. So, these are some of the potential reaction which occurs due to acidification.

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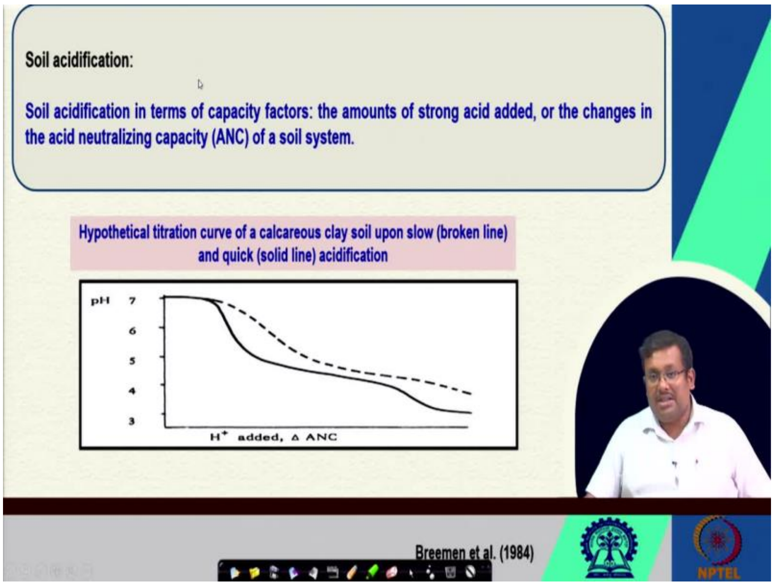

Now soil acidification in terms of capacity factors, we can define that the amounts of strong acid are added or the changes in the acid neutralizing capacity of a soil system. Now the acid neutralizing capacity can be also denoted by ANC. So soil acidification is basically the changes in the acid neutralizing capacity of a soil system.

Now, if we see this hypothetical titration curve of a calcareous soil upon slow and quick acidification, so you can see the slow shows these broken lines or dashed line. However, this is the reaction or this is the curve which shows the quick acidification of a higher pH calcareous clay soil. So as we are going to increase these hydrogen ions, the pH will steadily decrease in case of quick acidification and slowly decrease in case of slow acidification.

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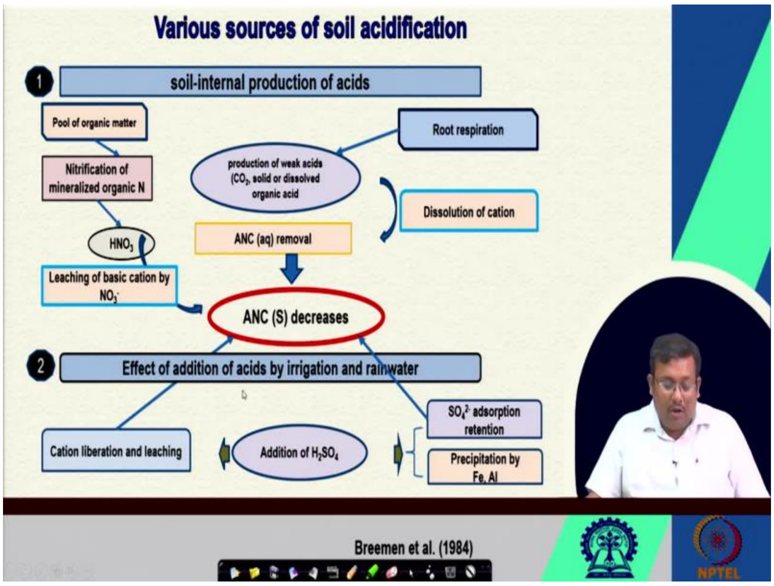

Now, let us see various sources of soil acidification. So one of them is pool of organic matter. So, this pool of organic matter, that produce nitrification of more mineralized organic nitrogen, which can produce this nitric acid and ultimately that contributes to this ANC decreases or increasing of acidity. Also these HNO3 basically impact these ANC by leaching these basic cations by nitrate so, this is one process.

Also that root respiration can produce the weak acid which you have just covered that is carbonic acid and this carbonic acid can also that helps in dissolution of cation like in calcium carbonate and also finally, it helps in building the soil acidity.

And also the cation liberation and leaching can also impact the soil acidity. So, if we broadly classify soil internal production of acid, we can say production or decomposition of organic matter is one of the reason and root respiration is another reason. However, when you talk about the effect of addition of acid by irrigation and rainwater, then we can see that cation liberation leaching can impact the soil acidity.

So, for example, when we add the sulfuric acid that can help in cation, liberation and leaching and ultimately that impact the soil acidity by reducing it. Also, this addition of H2SO4 can help in sulfate absorption retention or precipitation by iron and aluminium. So, that also impact the acidity. So, these are some of the various sources of soil acidification.

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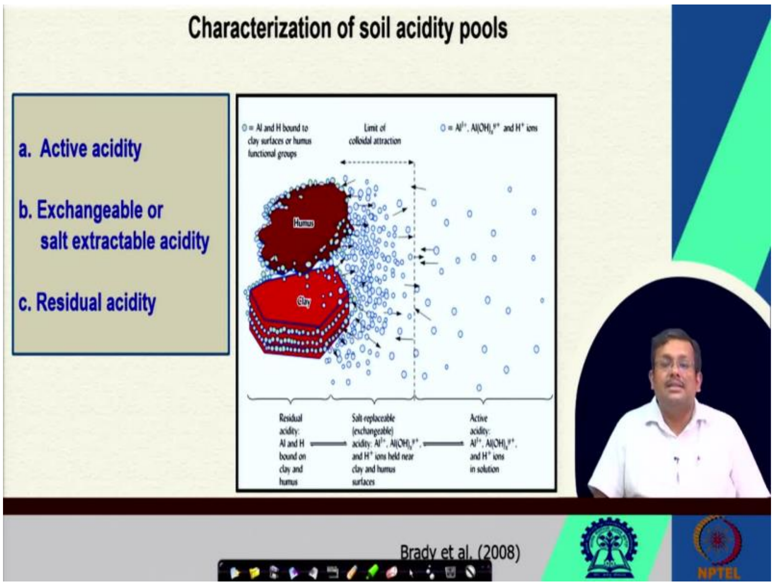

Now, let us see different types of soil acidity pools. So, in generally, we have we generally define 3 different pools of soil acidity, one is called active acidity, second one is called exchangeable or salt extractable acidity and third one is residual acidity. Now, from our knowledge of diffused double layered, we know that clay surface generates negative charge and these positive charge cations are strongly adsorbed onto this negatively charged surface.

Just adjacent to this clay surface there is a swarm of cations. And ultimately as we go farther away from the surface of the clay mineral, the cation distribution generally goes down into the bulk of soil solution. Now, there are 3 different terms, one is called active acidity, second is exchangeable acidity, and third one is residual acidity.

Now, what is activate acidity? According to this good picture you can see that activate acidity is basically accounts, the concentration of aluminium and H plus ion in the soil solution. That means, whatever H plus ion and Al3 plus ion are present in the bulk solution surrounding the clay mineral, these are generally accounting for the active acidity.

The second one is salt replaceable or exchangeable acidity. So, salt replaceable or exchangeable acidity is basically the acidity which is generated by the Al3 plus ion and H plus ion held near the clay and humus surface not only the clay surface, but also humus surface also can adsorb these cations.

Now these adsorbed cations which are held near the clay and humus surface are responsible for the salt replaceable or exchangeable acidity. The third one is residual acidity that means the aluminium and H bound on clay and humus. So, the aluminium and proton which are bound on clay and humus are responsible for residual acidity. So these are 3 different types of acidity pools of soil.

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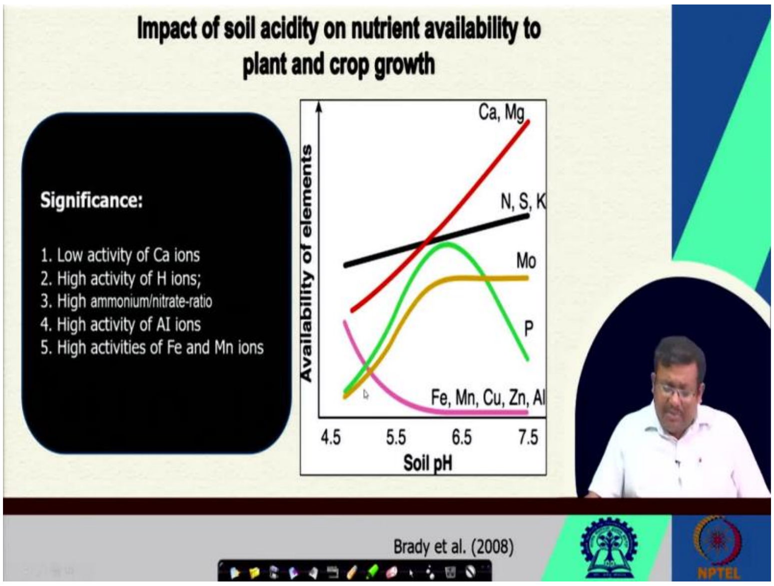

Now what are the impact of soil acidity or nutrient availability to plant and crop growth? We have already discussed this thing a couple of times however, I am going to repeat the same thing. So, we know that with the increase of the soil pH we can get higher availability of calcium and magnesium. So, that means in the acidic soil we can see low activity of calcium ions and high activity of H ions or protons.

And also we can see high ammonium to nitrate ratio and also we can see high active acidity of the ions. And also we can see this is the high activity of aluminium ions, and also we can see high activities of iron and manganese ions. And also we can see in the pH soil, the availability of calcium and magnesium are reduced and the availability of different micronutrients are increased.

So, we can see in case of acidic soil, we can see high activities of hydrogen and aluminium ion and iron and manganese ions.

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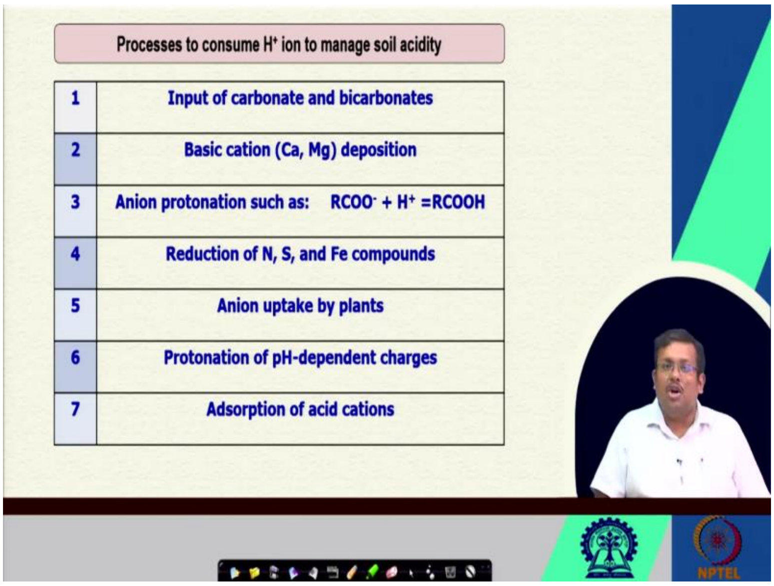

Now, what are the processes to consume these protons ions to manage the soil acidity? Whatever strategy you must add up all these are generated towards consuming these H plus ion to improve or to enhance the pH of the soil. First of all, we can either input carbonate or bicarbonate to enhance the soil pH or consume these H plus ion and we can also deposit the basic cations like calcium magnesium.

There is another possibility of anion protonation where these H plus and reacts with the anion to get, to help in consumption of H plus ion to increase the soil pH or reduce the soil acidity. Also anion uptake by plants are is another way, protonation of pH dependent charge is another way of consuming these H plus ion. You remember that when there is a protonation of H plus ion that can also increase the soil pH.

And finally, absorption of acid cations like H plus Al3 plus these are the acidic cations. So, adsorption of these acidic cations can help in managing the soil acidity.

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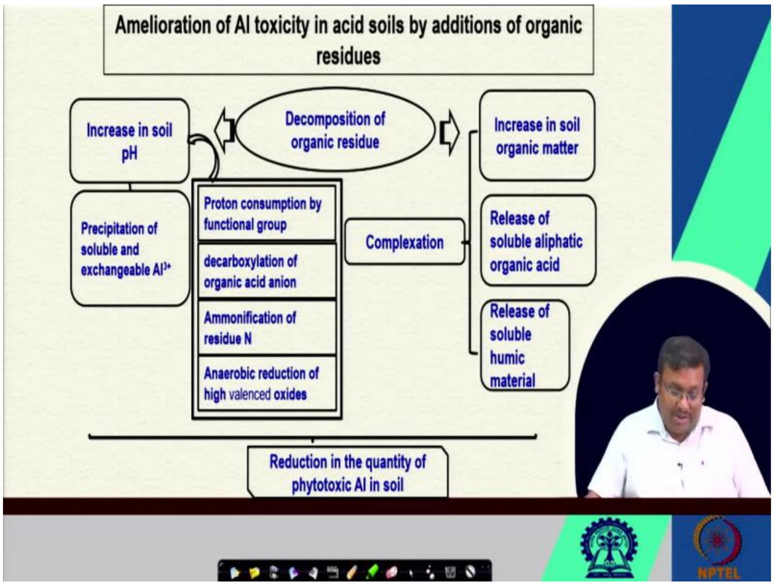

The amelioration of aluminium toxicity in acid soils can be done by adding different organic residues. Now, how these organic residues impact the amelioration of aluminium is given here, so, when there is a decomposition of organic residue that can increase the soil organic matter and release of different types of aliphatic organic acids and release a soluble humic material. All these in turn help in complex session of aluminium and thereby reducing their toxicity.

Also decomposition of organic residue can increase the soil pH and helps in precipitation of soluble and exchangeable aluminium ion. Now, when there is an increase of the soil pH there that helps in proton consumption by different functional groups, decarboxylation of organic acid anion and ammonification of residue and anaerobic reduction of high valenced oxides.

So, basically, these are responsible for increasing in soil pH, like ammonification of residue nitrogen, anaerobic reduction of high valence oxides, which ultimately helps in precipitation of soluble and exchangeable aluminium ion. And ultimately, all of these will help in either a reduction in the quantity of phytotoxic aluminium in soil.

Again, we can see decomposition of organic residue can help in reducing the aluminium toxicity either by complexation or by increasing soil pH by different processes, like proton consumption, decarboxylation of organic acid anion, ammonification of residual nitrogen and anaerobic reduction of high valenced oxides.

So, these are some of the ways through which amelioration of aluminium toxicity can be done by the addition of organic residues.

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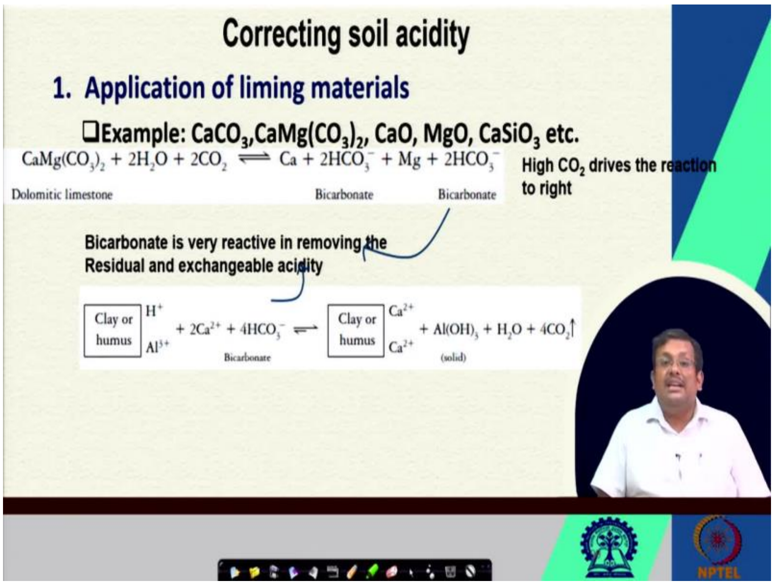

Now, let us see how to correct the soil acidity. Now, first and most important way of correcting the soil acidity is the application of liming materials, what are the liming materials? You can see here calcium carbonate, calcium magnesium carbonate or dolomites, calcite, dolomite, calcium oxide, magnesium oxide, calcium silicate et cetera so, when we add this dolomitic limestone we can see it reacts with water and carbon dioxide to produce these calcium bicarbonate ions.

So, bicarbonate is very reactive in removing the residual and exchangeable acidity. So, you can see wherever they are H plus and Al3 plus ions are absorbed onto the clay, then this bicarbonate ion basically will remove these H plus and Al3 plus and ultimately replacing them with calcium. So, this is a way through which application of liming material can correct soil acidity.

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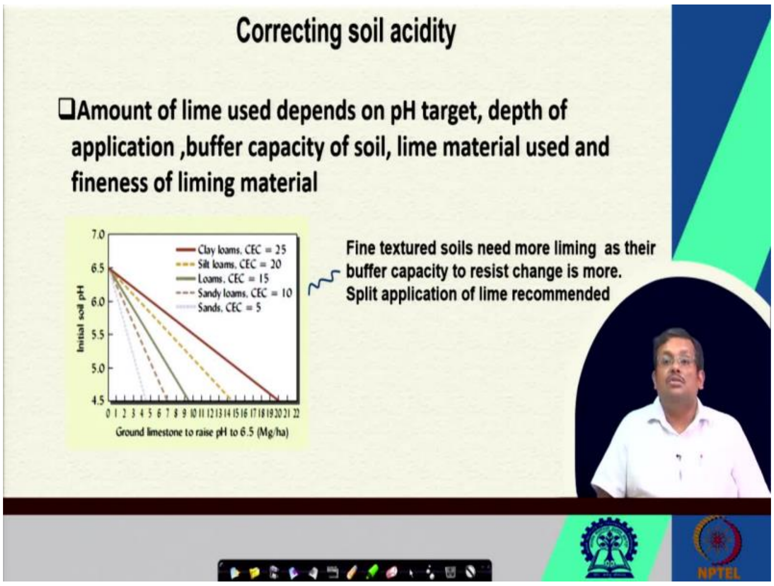

Amount of lime use depends on pH target of course and depth of application, buffering capacity of the soil liming material used and fineness of the liming material. So, you can see in this graph, fine textured soil need more lining as their buffering capacity to resist the pH is more. So, that is why split application of lime is recommended.

So, of course, you can see there are different types of so, there is an initial soil pH and when we add this ground limestone you can see clearly that clay loams require higher quantity of ground limestone and the reduction of soil pH is also less steep than other soils where clay content is less.

So, since this clay loams contain higher clay content which has higher buffering capacity than silt loams, loams, sandy loams and sands that impact in the slow reduction of soil pH.

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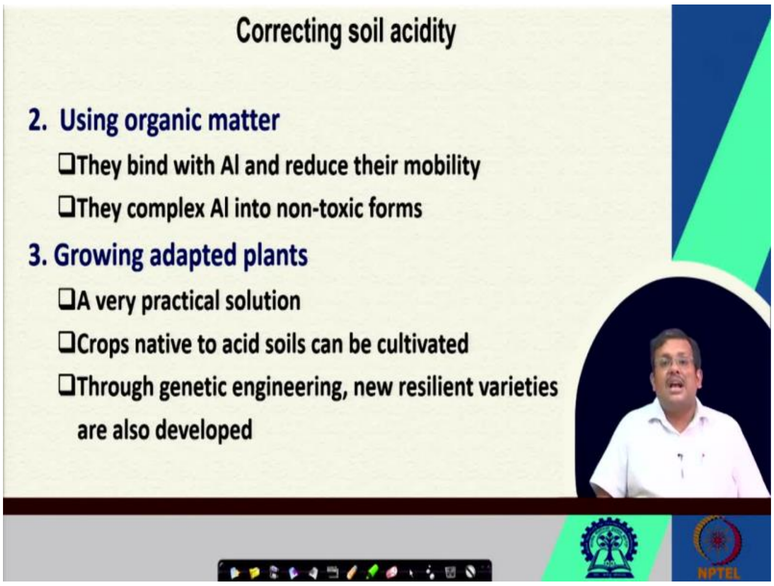

Another way of correcting soil acidity is using organic matter. So, when we add this organic matter, they bind with the aluminium and reduce their mobility and they complex aluminium into non-toxic form we have already discussed that.

Third is growing adapted plants. So, it is a very practical solution and crop native to acid soils can be cultivated and through genetic engineering new resilient varieties also can be developed.

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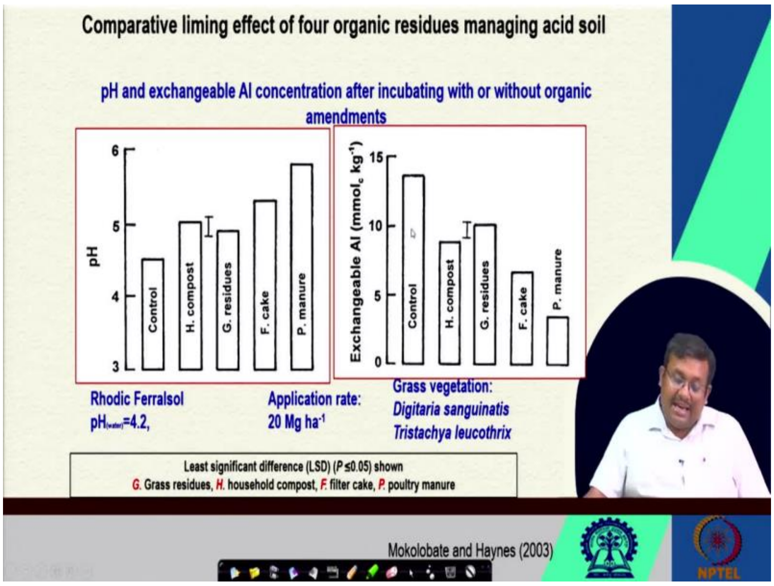

Now, if you see comparative liming effect of 4 organic residues managing acidic soil, so, you can see here there are 4 different organic residues like compost residues and then filter cake and then poultry manure and you can see their impact in raising the soil pH we can see the poultry manure can impact the raise of can significantly impact the soil pH.

Also, we can see that when we add this thing, exchangeable aluminum gets reduced. So, the impact of poultry manure in changing or fixing the soil acidity is quite, quite obvious. So, here the application rate and different grass vegetations are also mentioned. So, the basic idea is when we add organic matter that can correct this problem of soil acidity by different ways. And different types of organic matter has their own capacity to reduce the soil acidity.

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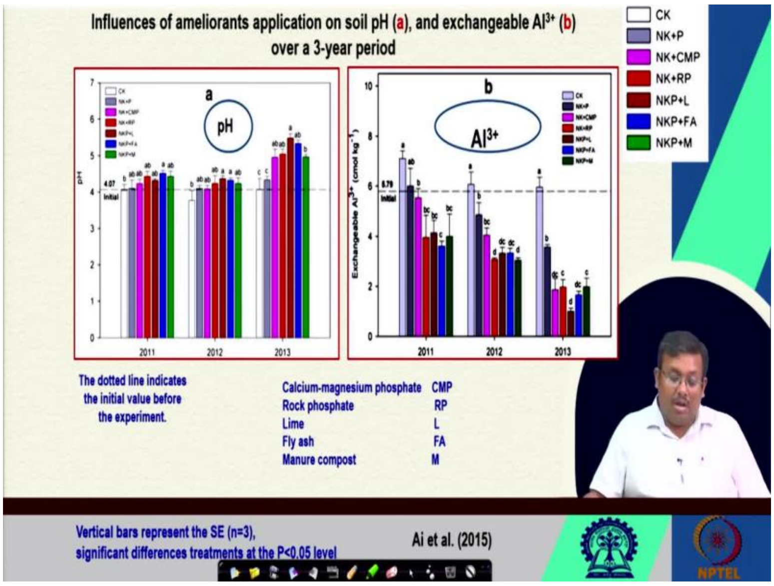

Now, this is also influences of ameliorants application on soil pH and exchangeable Al3 plus ion over a period of 3 years. So, you can clearly see that with the application of different ameliorants, then we can see the pH of the soil is increased and also exchangeable Al3 plus ion gets reduced. So, different types of ameliorants can help in reducing the soil pH or reducing the soil acidity or increasing the soil pH.

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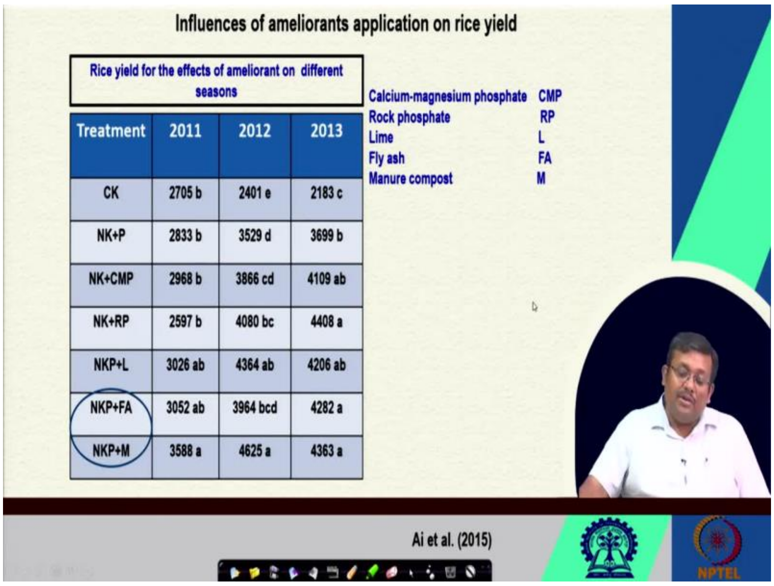

So, if we see the influence of application ameliorants on rice yield, we can see that when these NPK was applied with fly ash and manure, we can see there is a considerable increase in soil, in rice yield as compared to the other treatments in all 3 years. So, that shows the importance of ameliorants on rice yield or crop yield.

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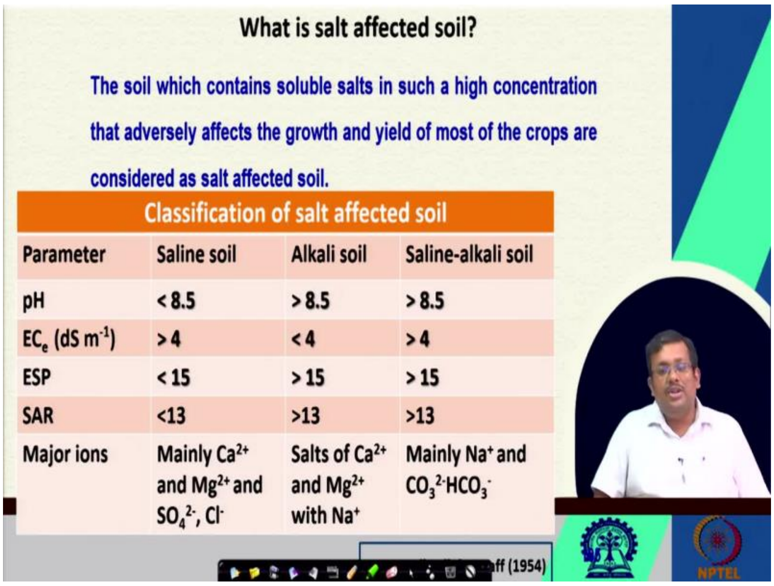

Now, let us see another type of important problematic soil that is called salt affected soil. Salt affected soil can be defined as a soil which contains soluble salts in such a high concentration that adversely affects the growth and yield of most of the crops.

Now, remember that the salt affected soils can be also classified into 3 categories, one is saline soil, second is alkali soil, third is saline alkali soil. Now, what are the differences? So, the saline soil the pH is less than 8.5 whereas, in case of alkali and saline alkali soil pH is greater than 8.5.

In case of saline soil, the electrical conductivity of saturation extract is greater than 4 decisiemens per meter whereas, in case of alkali soil it is less than 4, in case of saline alkali soil, it is again greater than 4. Exchangeable sodium percentage is less than 15 in case of saline soil whereas, in case of alkali soil and saline alkali soil it is greater than 15. Sodium absorption ratio is less than 13 in case of saline soil whereas, it is higher than 13 in alkali soil and saline alkali soil or saline sodic soil.

What are the major cations the major ions are mainly in case of saline soil the major ions are calcium and magnesium and sulfate and fluoride in case of alkali soil salts of calcium and magnesium with sodium and saline alkali soil mainly sodium and carbonate and bicarbonate salts. So, these are the distribution of major ions and their properties in different, 3 different types of salt affected soils.

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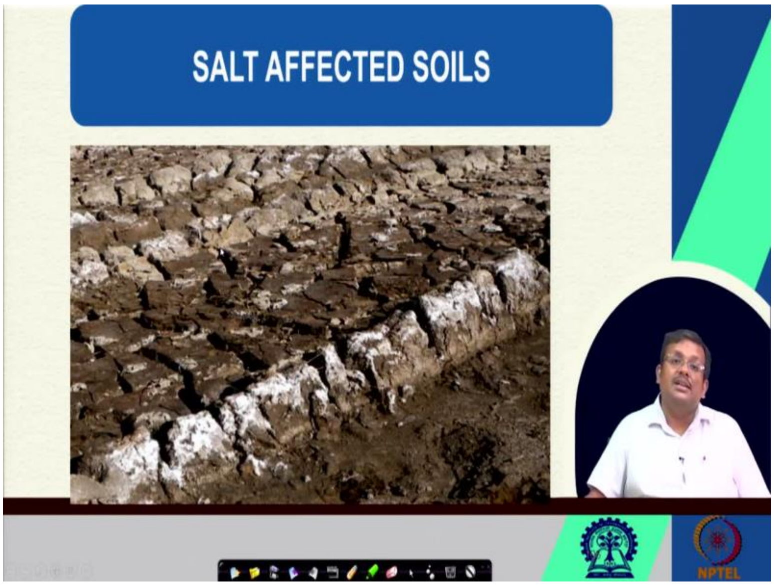

So, this is a picture of a salt affected soil you can see here that there is salt crust white soil crust which is deposited over the soil surface. So, this is a perfect example of salt affected soils.

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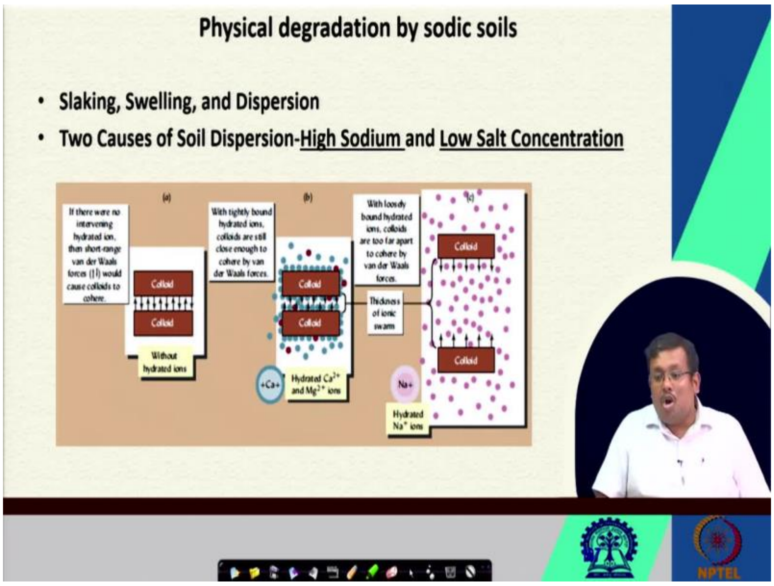

Another type of soil is called sodic soils. So, sodic soils are those soils which contain high amount of sodium. So, these sodic soils shows these are very unfavorable soil for plant growth. So, because it shows slaking, swelling and dispersion and 2 causes of soil dispersion so sodic soil is high sodium and low soil concentration.

Due to the presence of low soil concentration and high sodium the flocculation of the colloidal particles do not occur and they remain suspense in the colloidal solution. Ultimately creating an impervious layer which is very harmful for the germination of the seedling. So, the physical degradation we can see clearly in case of sodic soil.

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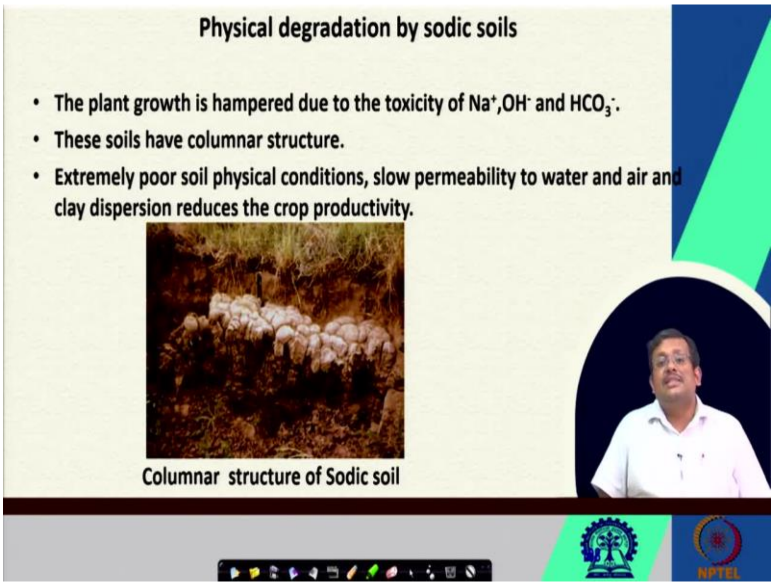

Now, the plant growth is severely hampered due to the toxicity of sodium hydroxyl and bicarbonate ions in case of sodic soil. These soils have also columnar structure as you can see here, these are the columnar structure and these are characterized by extremely poor soil condition physical condition, slow permeability to water and air and clay dispersion reduces the crop productivity.

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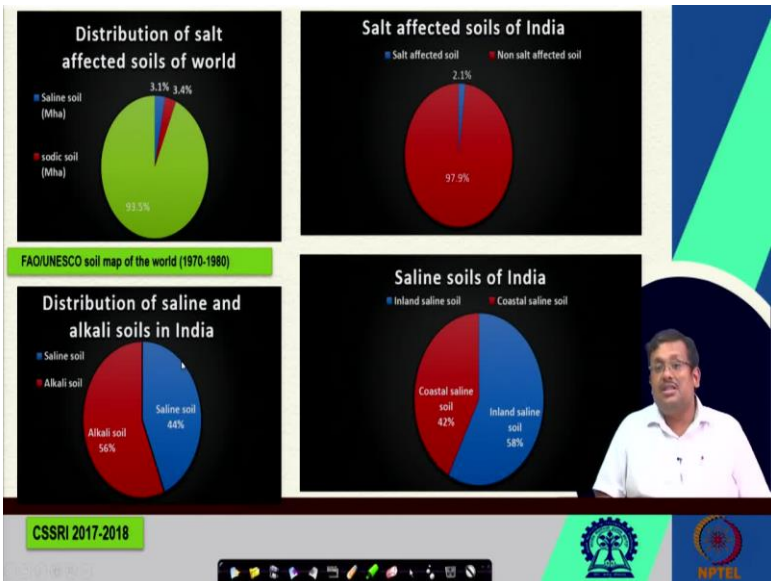

So, these are the some of the features of sodic soil or alkali soil remember alkali soil and sodic soils are used synonymously. So, these are the distribution of salt affected soils of the world we can see saline soil and sodic soil content say some small part whereas saline soil we generally in the world is around 3.1 percent and also in case of sodic soil that is also 3.4 percent.

Salt affected soils in India you can see that non salt affected soils accounts for 97.9 percent. However, 2.1 percent of the salt soils are salt affected soils in India. This shows the distribution of saline and alkaline soils in India we can see that alkali soil is 56 percent whereas saline soil is only 44 percent and saline soils of India you can see that inland saline soil is 58 percent whereas, coastal saline soil is 42 percent.

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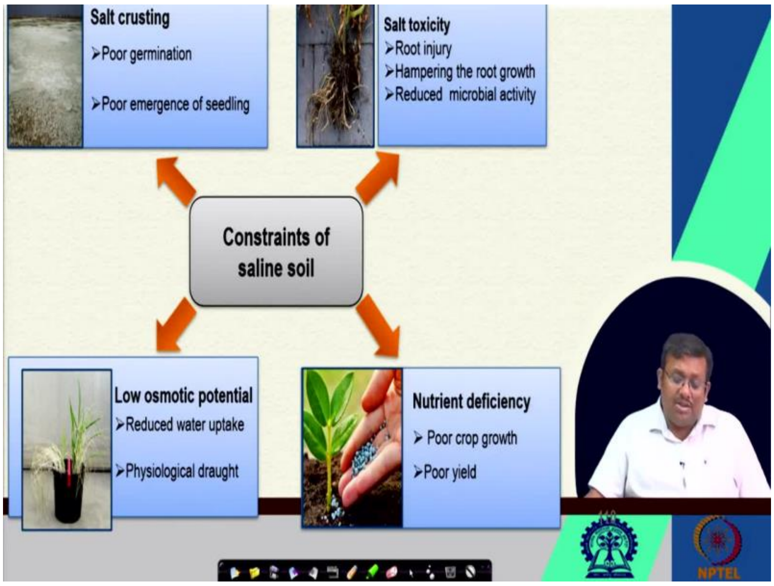

So, what are the constraints of saline soil? First of all, you can see poor germination, salt crusting, and as a result there is a poor germination and poor emergence of seedling and also salt toxicity like root injury, hampering the root growth or reduced microbial activity you can see. Nutrient deficiency you can see in case of saline soil like poor crop growth poor yield. Low osmotic potential like reduced water uptake and physiological drought. These are some of the constraints of a saline soil.

What is physiological drought? Physiological drought means, when the soil has enough moisture, but plant cannot take it because of the higher salinity in the soil or high salt concentration as a result that is called physiologically dry soil.

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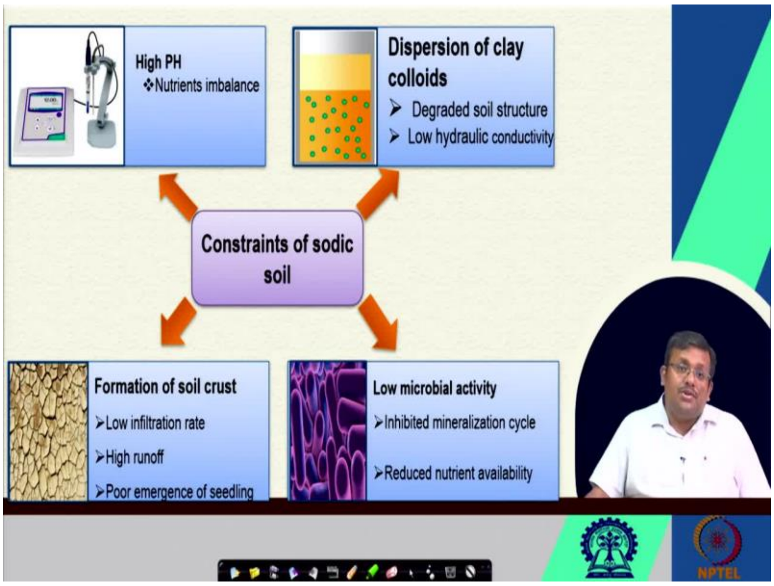

Also, these are the constraints of the sodic soil like nutrient imbalance, degraded soil structure, low hydraulic conductivity and then due to the formation of soil crust that impact the infiltration rate that increases the runoff and also poor emergence of seedling that also impact the low microbial activity by inhibiting the mineralization cycle and reduce nutrient availability. So, these are the some of the constants of sodic soil or yield effects of sodic soil.

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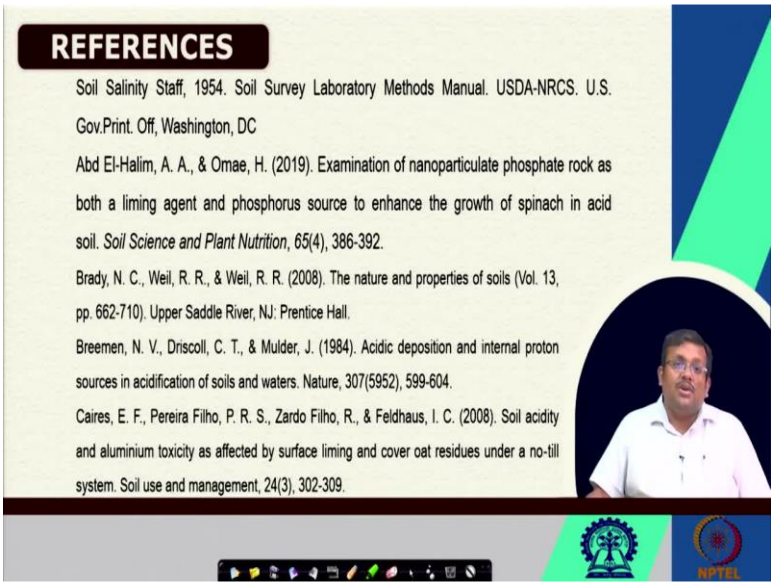

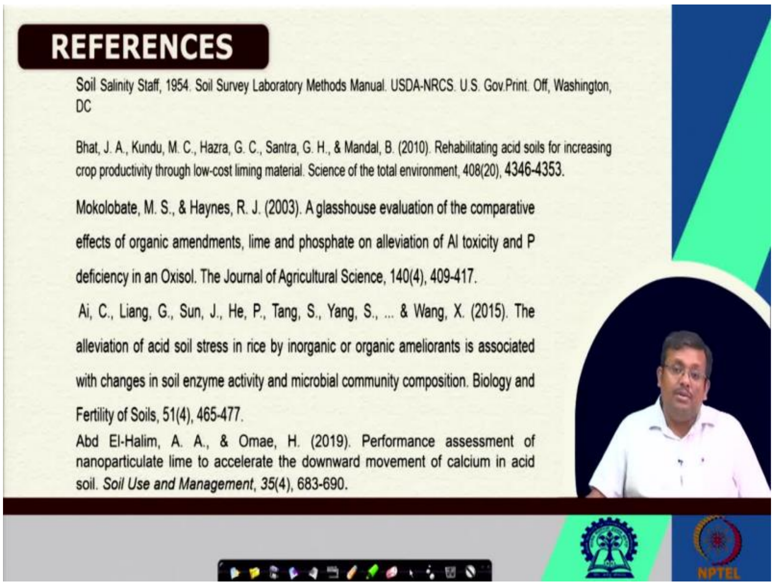

So, guys, this makes the end of this lecture these are the references for this lecture. I hope you have learned something new. If you have any queries, please let me know. And let us meet in our next lecture. Thank you.