Soil Fertility and Fertilizers
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Lecture 16
Soil Secondary Nutrients and Their Role in Plant Nutrition

Welcome friends to this fourth week of NPTEL Online Certification Course of Soil Fertility and Fertilizers. And in this week we are going to talk about Soil Secondary Nutrients and Their Role in Plant Nutrition. Today we are going to start lecture number 16 and in this lecture we are going to cover the following topics.

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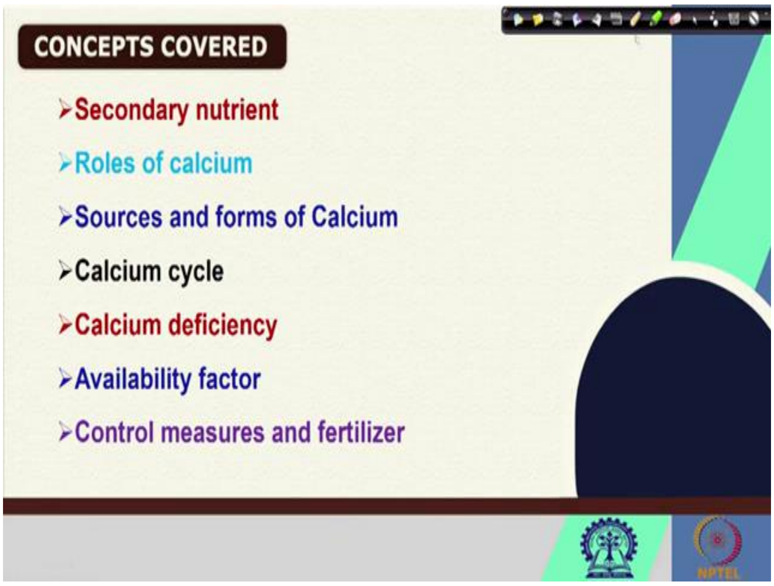

First of all, we are going to cover the secondary nutrient and also we are going to cover the roles of calcium and let me just and also we are going to cover the sources and forms of calcium and calcium cycle. We are going to discuss; we are going to see what are the calcium deficiency symptoms in plants; and also what are the factors which controls the availability of calcium to the plants. And finally, some the control measures of calcium deficiency and fertilizers.

So these are some of the major concepts which we are going to cover. In our previous week we have already discussed the macronutrients. Among the macronutrients we have already discussed the primary nutrients or nitrogen phosphorus potassium in details. We have also details their cycle, their availability, the major fertilizers, their nutrient content and different considerations while applying those fertilizer in the soil. We have discussed them.

Now today we are going to start discussing the secondary nutrients. Now you know what are the secondary nutrients. There are three secondary nutrients; one is calcium, magnesium and sulphur. Now the secondary nutrients are also macronutrients. However, they required in less quantity than primary nutrients or NPK. So first we are going to discuss calcium and then we are going to and then followed by magnesium. So in this lecture we are going to focus more on calcium and its source and also calcium cycle as well as calcium fertilizers.

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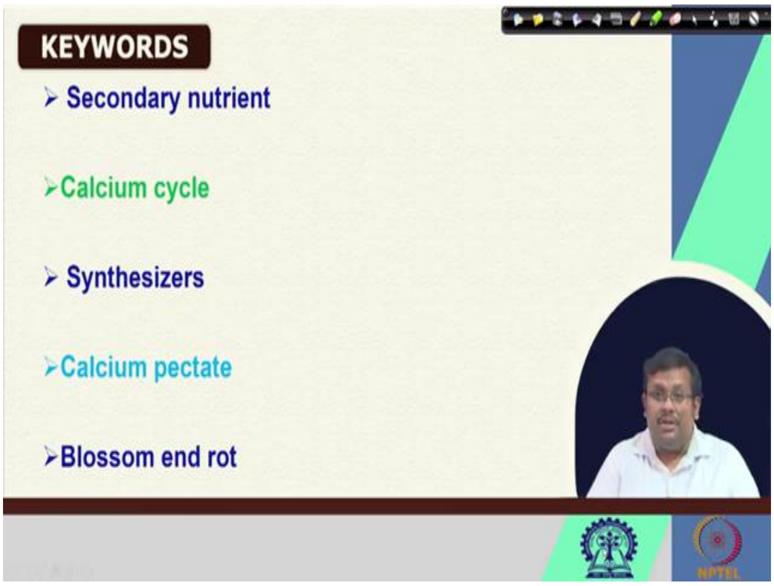

So let us move ahead and see these are the keywords of this lecture, secondary nutrient, calcium cycle, synthesizers, calcium pectate and blossom end rot. So these are the some of the words which we are going to discuss in this lecture.

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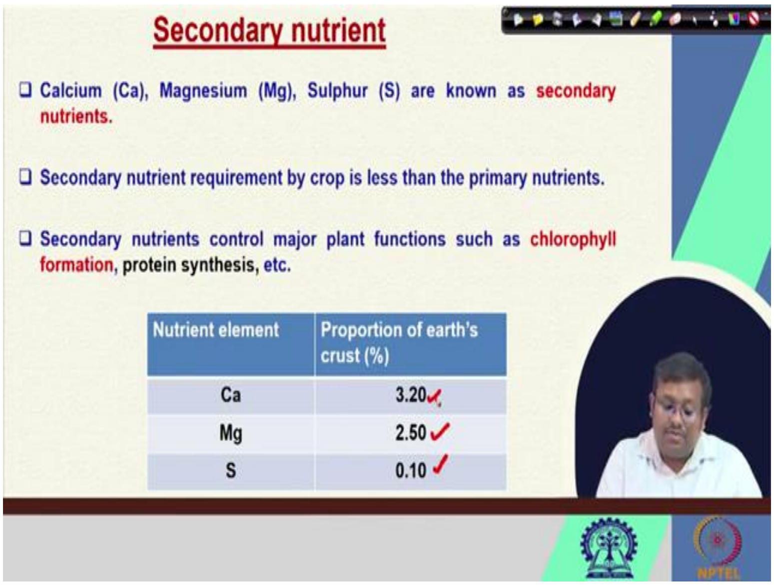

Now as I have told you that the secondary nutrients, now there are three secondary nutrients; the secondary nutrients are calcium, magnesium and sulphur and all three are known as the; although they are macronutrients but they require in relatively less quantity than nitrogen, phosphorus, potassium; that is why they are called secondary nutrient.

Now secondary nutrient requirement by crop is less than primary nutrient as I have already discussed. Secondary nutrient control major plant functions such as chlorophyll formation, protein synthesis, etcetera. So majority of the plant functions like chlorophyll formation, protein synthesis are governed; and also cell division are governed by the secondary nutrients.

So if you see the proportion of; the presence or the concentration of the secondary nutrients on the earth crust we will see calcium present in 3.2 percent, whereas magnesium present in 2.5 percent and sulphur present in 0.10 percent. So these are the proportion of nutrient contained in the earth crust.

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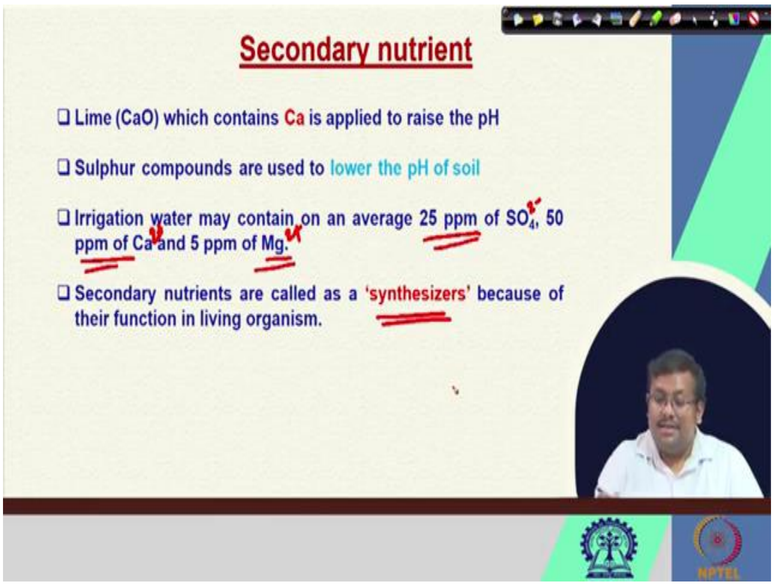

So if we see the importance of calcium you can see that lime which has a chemical formula of calcium oxide, it contains calcium and this lime is applied to the soil to raise the soil pH. and sulphur compounds are used to lower the pH of the soil. We remember that irrigation water may contain on an average 25 ppm of sulphate and 50 ppm of calcium and 5 ppm of magnesium.

When you talk about sulphate of course remember that these are ions, so calcium is 2 plus and magnesium is also 2 plus. So the sulphate ion is present in 25 ppm in irrigation water and 50 ppm, on an average 50 ppm in irrigation water, you can see calcium ion and you can see magnesium ion it is present on an average 5 ppm.

Now secondary nutrients are also called synthesizers because of their function in the living organism. Because they are required for synthesis of different biomolecules that is why they are called synthesizers. So these are some of the important punch-points which you should remember for secondary nutrient.

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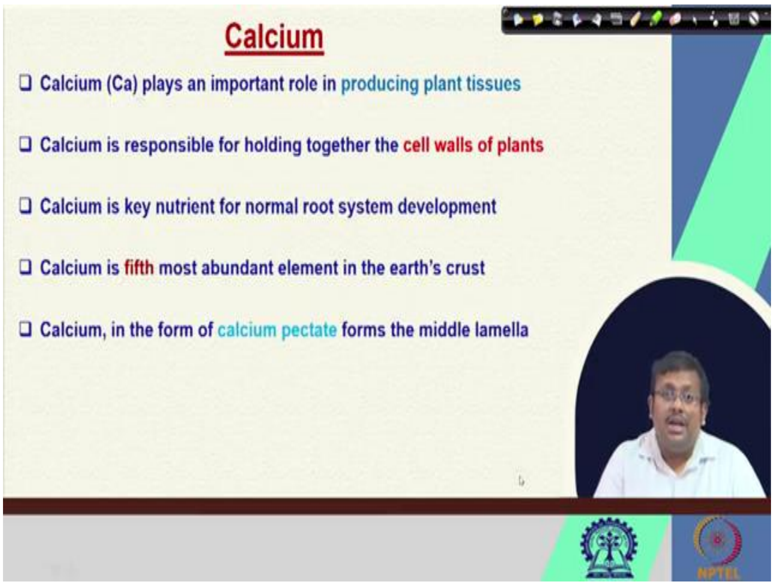

Now if we now focus on calcium only remember calcium is an secondary mineral that plays an important role in producing plant tissue. Because calcium is an important component of cell wall, so calcium is responsible for holding together the cell walls of the plants and calcium is a key nutrient for normal root system development. It is the fifth most abundant element in the earth crust. And as I have told you that it is an important component for cell division.

Because there is a form called calcium pectate, this calcium peptide compound forms the middle lamella of the cell and that is why for cell division calcium is indispensable. So that is why calcium is considered as one of the major or macronutrient and essential nutrient for plant growth and metabolism.

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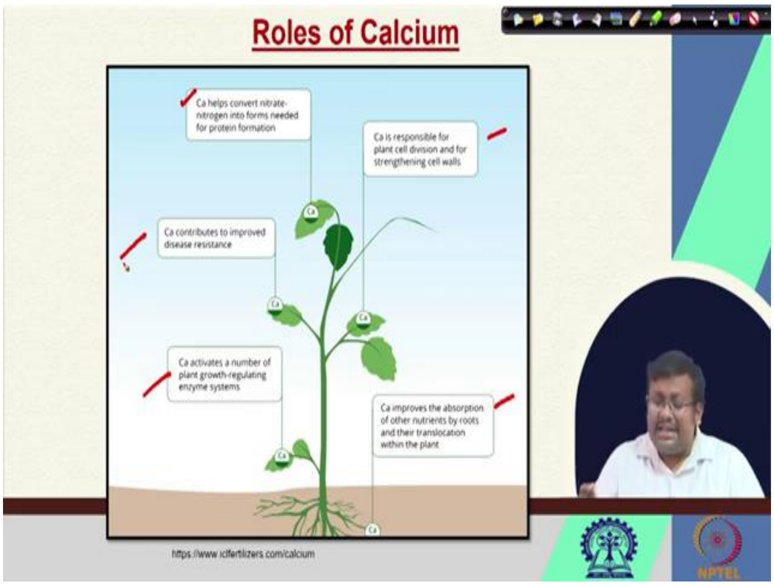

Now if you see the major roles of calcium in plant growth and metabolism, they are listed here. So first of all calcium helps convert nitrate nitrogen to form needed for protein formation. So this nitrate nitrogen is the source of protein which is taken up by the plant and ultimately the conversion of nitrate nitrogen to the protein will be mediated through calcium.

Calcium is responsible for plant cell division and for strengthening the cell wall, without the calcium the plant wall strength cannot be maintained and cell division is also dependent on the calcium. Calcium improves the absorption of other nutrients by roots and their translocation within the plants. Calcium activates a number of plant growth regulating enzyme system.

And calcium contributes to improve disease resistance. So if you see more or less calcium is very much important for cell division and strengthening the cell wall and providing resistance to different types of disease and also the absorption of other elements to the roots and their translocation within the plant and regulate some of the enzymes which are required for the growth of the plant. So you can see that is why calcium is considered as one of the most important essential element.

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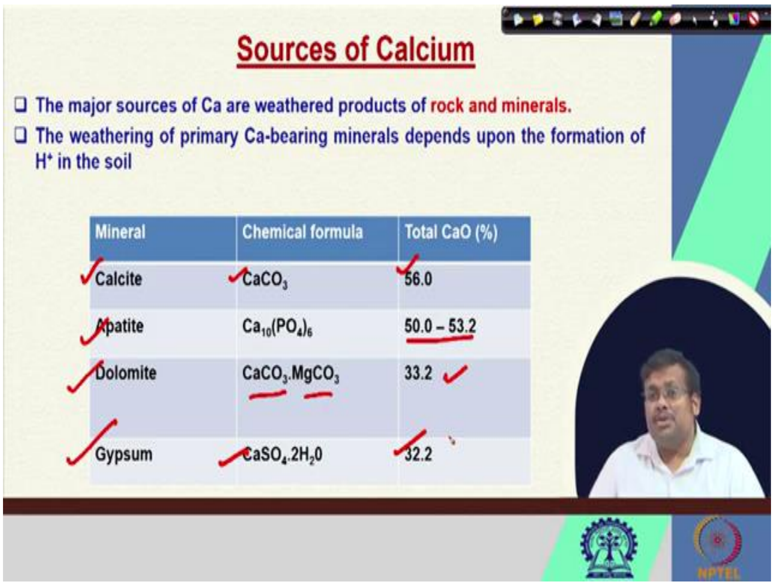

Now what are the sources of calcium? The major sources of calcium are weathered products of rocks and minerals. Now the weathering of the primary calcium bearing mineral depends upon the formation of protons in the soil. Of course, when there are this calcium bearing minerals which are present in the soil they must be weathered to supply the calcium and their weathering is dependent on some acidic condition.

And this acidic condition is dependent on the production of protons or availability of the protons in the soil system. Now if we see the some of the major mineral which are considered as a source of calcium, so calcium calcite has a chemical formula of calcium carbonate and total percentage of calcium oxide is 56 percent.

Apatite; we have already discussed apatite in our last week and also it contains calcium oxide varying from 50 to 53 percent, 53.2 percent. Dolomite is basically calcium and magnesium carbonate, so both calcium carbonate and magnesium carbonate and here the calcium oxide is around 33.2 percent whereas in case of gypsum which is calcium sulphate dihydrate is basically having 32.2 percent of calcium oxide.

So all these are sources of calcium in the soil and generally we apply this calcium for different purpose. For example, calcite is or this limestone that is calcium carbonate and also dolomite is applied to the soil to raise the soil pH when the soil becomes acidic. So this calcite and dolomite are required for reclaiming the acidic soil, whereas this calcium ion replaces the protons in the exchange complex of the soil, thereby raising the soil Ph.

On the other hand, calcium sulphate dihydrate or gypsum is being used as a amendment to correct the alkalinity of the soil. So these are some of the important sources of calcium.

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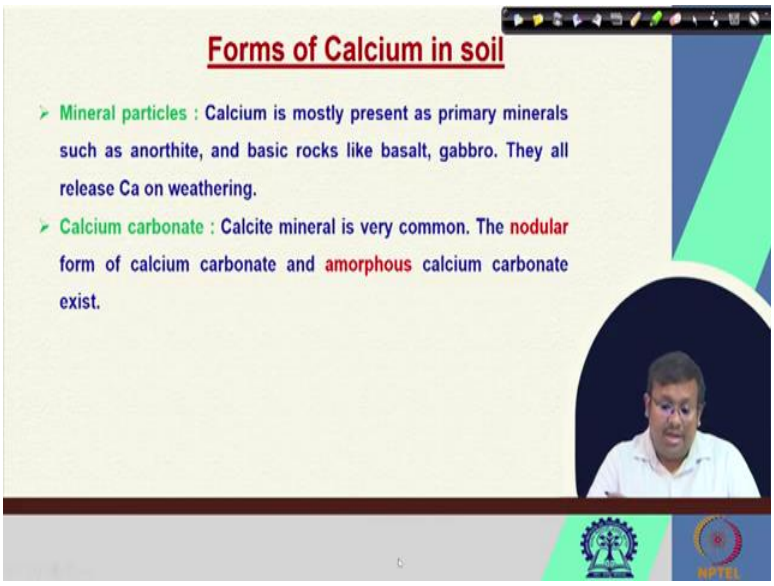

Now if we see what are the forms of calcium in the soil, there are some mineral particles, calcium is mostly present as primary minerals such as anorthite and basic rocks such as basalt and gabbro. They all release calcium on weathering. So this anorthite and then basalt, gabbro, all these release calcium during the weathering process.

And also calcium carbonate or also calcite is very common mineral and the nodular, there are two form, one is nodular form of this the calcium carbonate or calcite and there is another form that is called amorphous form of calcium carbonate exist in the nature.

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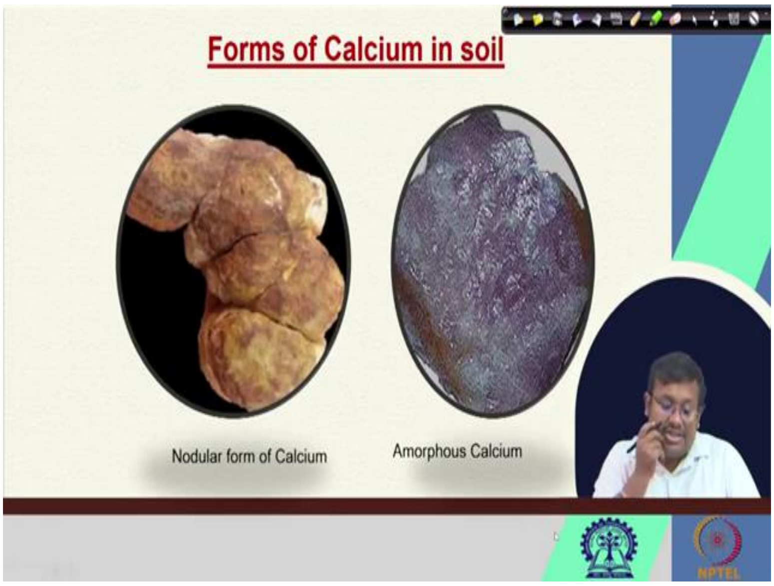

So if you see these are the nodular form of calcium, and however, these are amorphous calcium which you can see in the nature.

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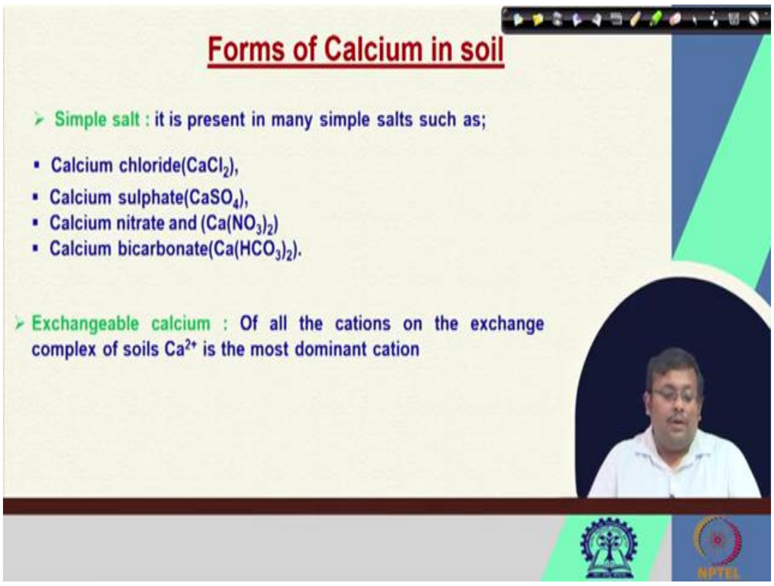

Among the other sources of calcium in the soil we can see simple salt, which is present commonly in the nature, which are commonly present in the nature like calcium chloride, calcium sulphate, calcium nitrate and calcium bicarbonate. So these are very common simple salts which we can see in nature.

And also exchangeable calcium is another form of calcium in soil. So remember that of all the cations on the exchange complex of the soil calcium is the most dominant cation. So calcium also can occur as calcium ion in the exchange complex of the soil.

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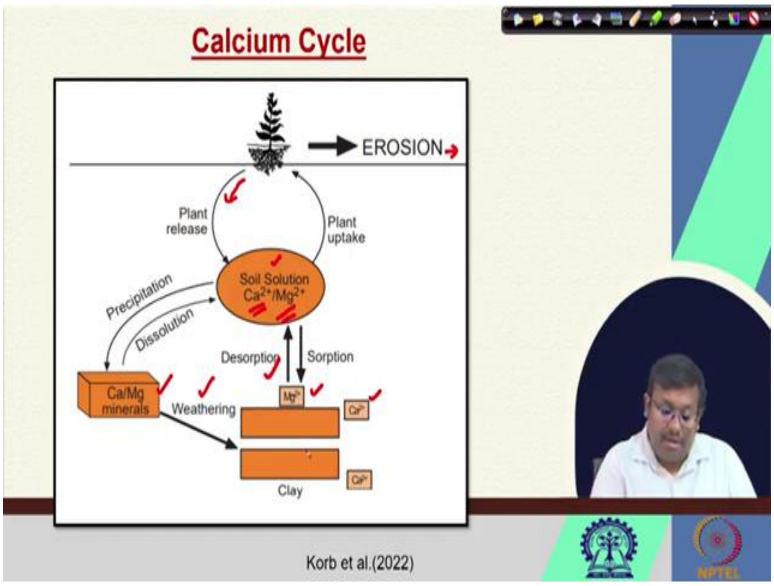

Now if we see the calcium cycle; this is the calcium cycle and we can see that plants basically uptake both calcium and magnesium from the soil solution and also when this plant die, they can release this calcium and magnesium, which can further goes back to the soil solution. Also calcium can be removed from the soil by erosion process.

And these both calcium and magnesium ion can precipitate in the form of calcium and magnesium minerals. The opposite of this precipitation, an opposite reaction of this precipitation is the dissolution where this calcium and magnesium minerals dissolve, so that this calcium and magnesium ion can come into the soil solution.

And plant will uptake these two nutrients from there and also these calcium and magnesium minerals can weather to form these; and ultimately due to the weathering this calcium and magnesium ions can also attach to the exchange sides of the clay. So these adsorbed magnesium as well as calcium can be dissolved from this exchange site of the soil and goes to the soil solution calcium and magnesium.

Opposite way from the soil solution this calcium and magnesium can be again served into the exchange complex of the soil and then they can be attached to the exchange side of the soil. So this is how the movement of this calcium and magnesium ions can be seen in the soil and weathering takes a major role in the attachment or adsorption of these minerals. They are ions; of this calcium and magnesium in the exchange complex of the clay mineral.

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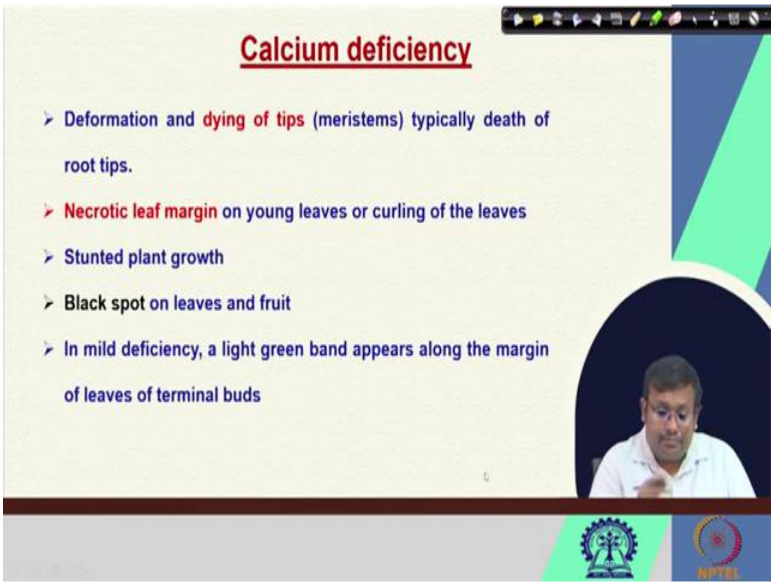

Now what are the deficiency symptoms of calcium in plant? Now deformation and dying of tips or meristems, are also typically death of root tips are some of the major calcium deficiency symptoms. Also you can see necrotic leaf margin on young leaves or curling of the leaves when there is a calcium deficiency.

Stunted plant growth is another important symptom of calcium deficiency. Black spot on the leaves and fruits are also very much important symptom for calcium deficiency. In case of mild deficiency, a light green band appear along the margin of the leaves of terminal buds.

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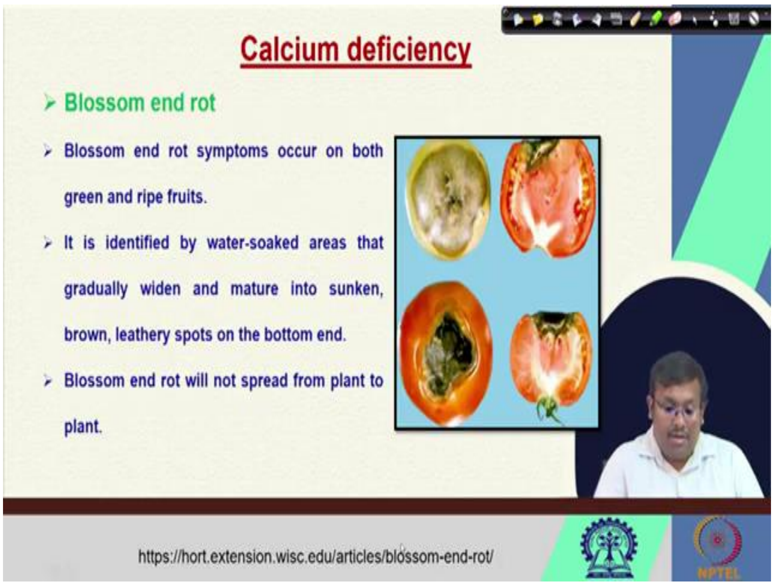

So one of the major deficiency symptom for calcium deficiency is called the blossom end rot. Now in the blossom end rot symptoms occur on both green and ripe fruits. So it is identified by water soaked areas that gradually widen and mature into sunken brown leathery spot on the bottom end. And this blossom end rot will not spread from plant to plant. So these are some of the pictures of blossom end rot, in case of tomato we can see here.

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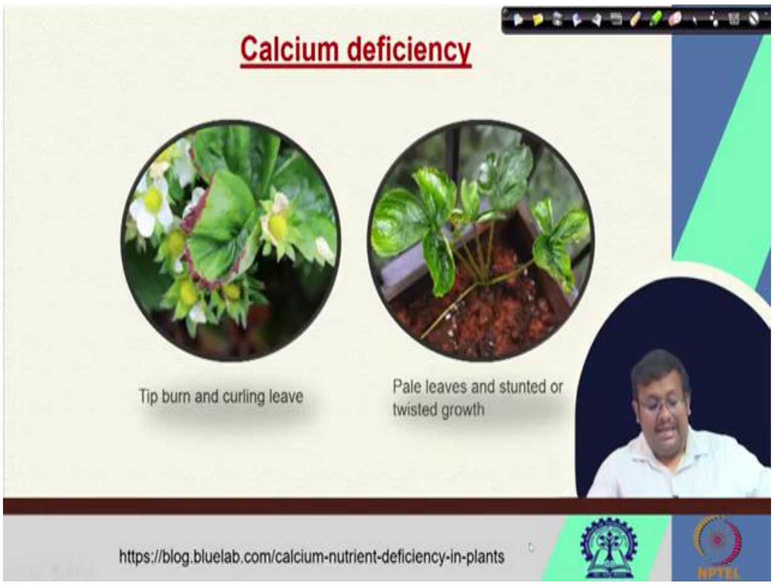

Also we can see here the tip burning and curling of leaf, you can see the tip of the leaves are burned and the leaves gets curled. And here you can see pale leaves and stunted or twisted growth you can see here. It is a pale color of the leaves as well as the stunted or twisted growth of the leaves can be seen.

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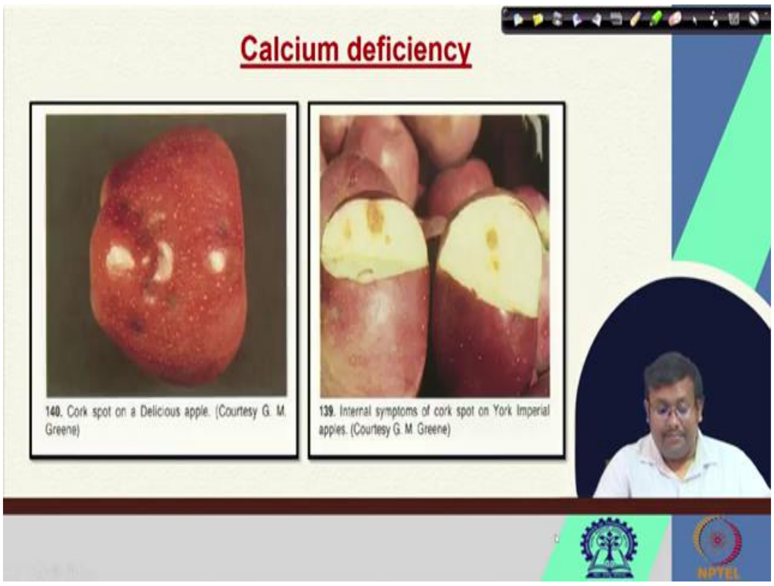

Also you can see cork spot; these are the cork spot on apple fruit and also you can see internal symptoms of cork spot. So these black spots are known as cork spot on in the apples which is due to the calcium deficiency.

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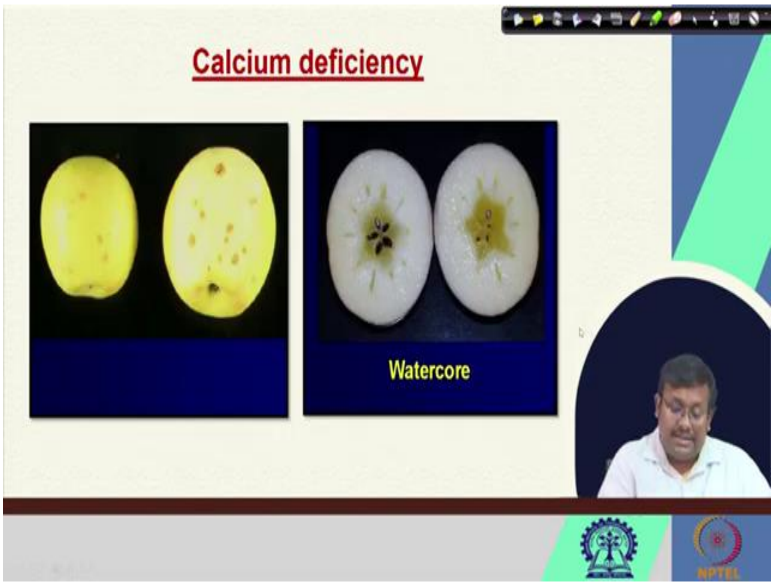

Also you can see here in the apple water core is there, so this type of symptoms is known as water core which occurs due to calcium deficiency in apple.

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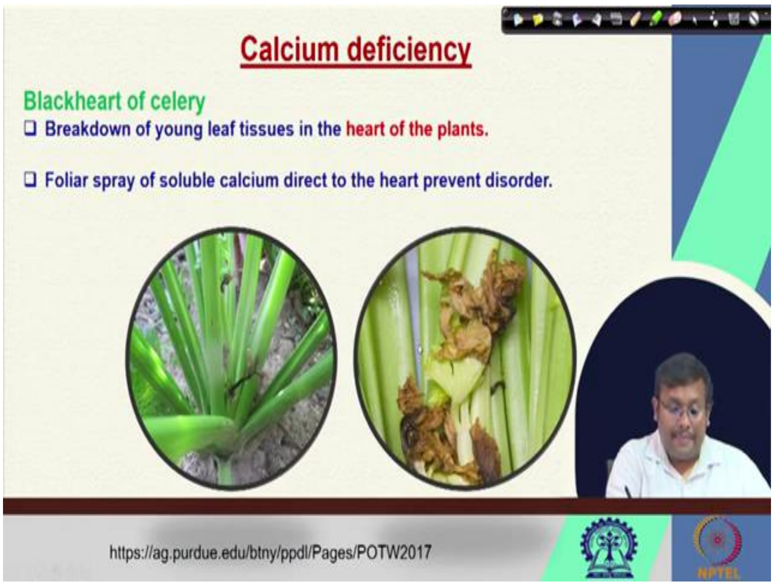

Also the other deficiency symptoms of calcium is called blackheart. So blackheart can be seen in case of celery. So basically what happens in the blackheart? Its breakdown of young leaf tissues in the heart of the plant and so here you can see these are the blackhearts. So foliar spray of soluble calcium can be given directly to prevent this the blackheart symptom so due to calcium deficiency. So these are some of the symptoms of the blackheart.

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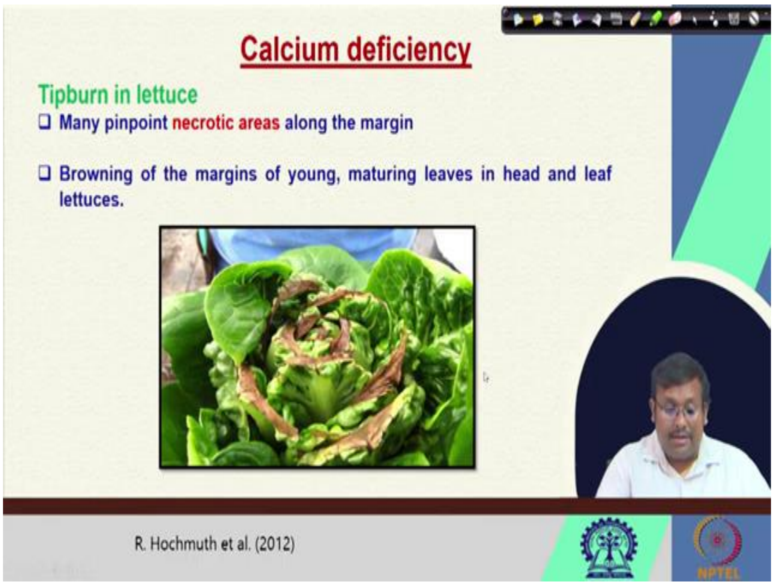

Also in case of lettuce we can see tip burn. So many pinpoint necrotic areas along the margin, so you can see these are the necrotic areas along the margin and browning of the margins of young maturing leaves in head and leaflet, leaf of the lettuce, so these are the some of the symptoms, stark symptoms of calcium deficiency.

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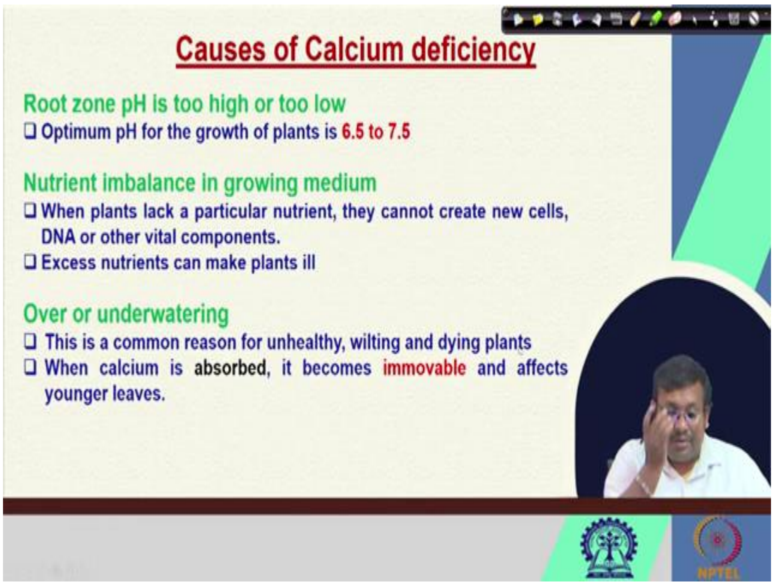

Now what are the causes of calcium deficiency? So one of the major cause, one of the major causes of calcium deficiencies if the root zone pH is too low or too high. So if the root zone pH or pH of the rhizosphere becomes too less or too low or too high that can create the calcium deficiency symptoms. So the optimum pH for the growth of the plant is 6.5 to 7.5.

And nutrient imbalance in growing medium is another reason for calcium deficiency. So when plants lack a particular nutrient they cannot create new cells, DNA or other vital components. And also if we are applying excess nutrient that also can create nutrient toxicity. So nutrient imbalance can create the calcium deficiency.

Over or under watering is another reason of calcium deficiency. So this is a common reason for unhealthy, wilting and dying plants. When calcium is absorbed, it becomes immovable and affects the younger leaves. So unlike the nitrogen calcium within the plant is immobile and as a result we can see the deficiency symptoms in the younger leaves.

Remember in case of nitrogen we saw the deficiency symptoms in the older leaves because nitrogen is mobile. So however, just opposite can be seen in case of calcium, where deficiency symptoms can be seen in the younger leaves.

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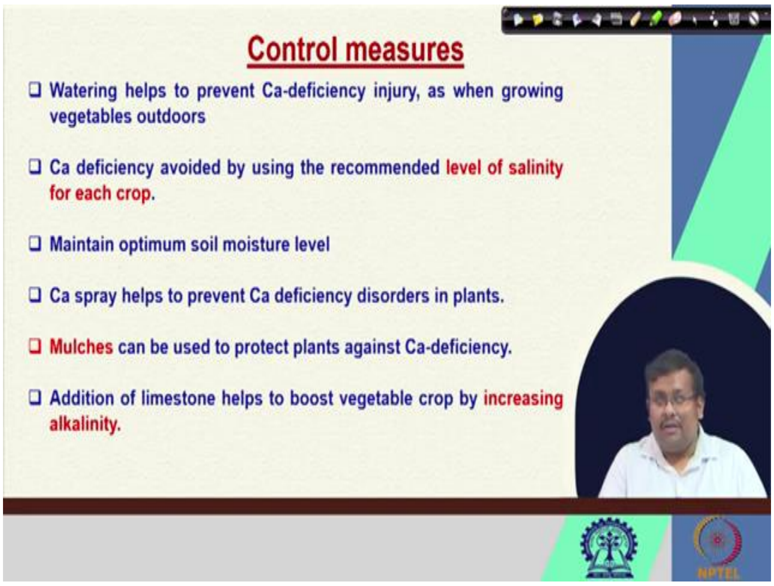

Now what are the control measures of calcium deficiency? So watering help in preventing the calcium deficiency injury, as when growing vegetables outdoor. And calcium deficiency can be avoided by using the recommended level of salinity for each crop and we can maintain the optimum soil moisture level. And we can also apply calcium spray to prevent the calcium deficiency disorder in the plants.

Mulching can be used to protect the plants against calcium deficiency and addition of limestone can help in boosting the vegetable crop by increasing the alkalinity.

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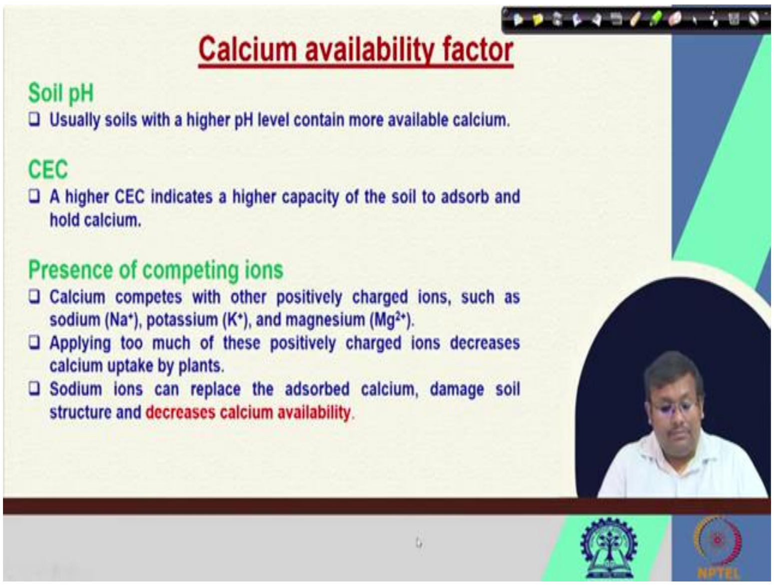

Now what are the factors which affects the calcium availability in the plant? So you soil pH is the most important factor. Of course, usually soils with higher pH level contain more available calcium, so that is why calcium is considered as; where there is a high concentration of calcium we can assume that the soil pH will be alkaline.

Now another important factor is cation action capacity or CEC. Generally higher CEC indicates a higher capacity of the soil to adsorb and hold calcium. Of course, when there will be high amount of negative charge due to either isomorphous substitution or pH dependent charge that can attract this positive charge cations.

So higher CEC will always tend for to adsorb high quantity of calcium. Presence of competing ions is another factor. So calcium compete with other, competes with other positively charged ions such as sodium, potassium, and magnesium. So applying too much of this positively charged ions decreases the calcium uptake by the plants.

So sodium ions can replace the adsorbed calcium and damage the soil structure and decreases the calcium availability. So what happens? When due to alkalinity the sodium ion can replace the calcium and thereby, dispersing the soil and destroying the soil structure and that can decrease the calcium availability.

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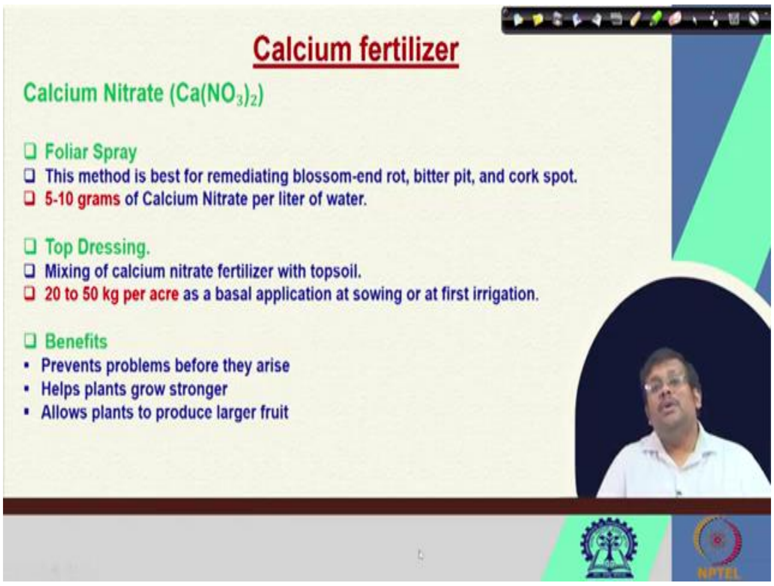

So let us see what are the calcium fertilizers. So calcium nitrate is one of the important calcium fertilizer. Generally, we can give it as foliar spray. So in case of foliar spray this method is best for remediating the blossom end rot, bitter pit and cork spot. And 5 to 10 grams of calcium nitrate per liter of water, we generally apply. And then for top dressing, top dressing means mixing of… In case of torque dressing we mix the calcium nitrate fertilizer with top soil.

So what happens guys? In case of, so there is a concept, one is basalt application another is top dressing. So basal application generally are given, in case of any fertilizer basal application are generally given before the planting and top dressing is the application of fertilizer in a standing crop. So when the crop is growing, whenever we apply the fertilizer that is known as top dressing.

So calcium nitrate can be also applied as top dressing where we can mix the calcium nitrate with the top soil and 20 to 50 kg per acre as a basalt application also can be given at the time of sowing or at fast irrigation. So both as top dressing as well as basal application you can apply this calcium nitrate. What are the benefits?

First of all, it can, it prevents the problem before they arise. Secondly, it helps plant grow stronger. And thirdly, it allows plants to produce larger fruit.

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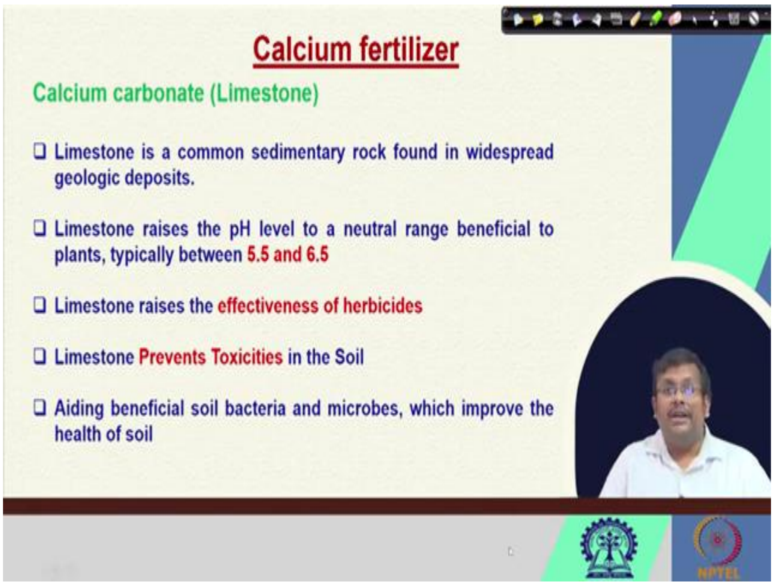

Second one is calcium carbonate or limestone. So limestone is a common sedimentary rock found in widespread geologic deposit. So limestone raises the pH level of a neutral range beneficial to the plants, typically between 5.5 to 6.5. So when there is a acidic soil we generally apply this lime stone so that we can raise the soil pH.

And the optimum pH range for most of the nutrient uptake is 5.5 to 6.5 and limestone raises the effectiveness of herbicides and limestone prevents the toxicities in the soil also and also aiding beneficial soil bacterial microbes can be achieved by calcium carbonate, which improves the health of the soil.

Now how we can improve the health of the soil? So basically this, when there is a complete dispersion or structural dispersion due to the, in the sodic soil the sodium ion from the exchange complex can be replaced by calcium and thereby, they improve the structure of the soil. And improve the soil health.

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So guys by this we wrapped, let us wrap up this lecture and I hope that you have gathered some of the important knowledges, which are related to calcium. And so if you have any questions please feel free to email me or post your question in the forum and I will be happy to answer your queries. These are some of the references, which I have followed.

So you can take a look and consult these references for more comprehensive understanding of calcium and their role in plant nutrition. Thank you very much.