Soil Fertility and Fertilizers
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Lecture 10
Soil Nitrogen for Plant Nutrition (Contd.)

Welcome friends to this, tenth lecture of NPTEL online certification course of soil fertility and fertilizers, and we are at week 10, and this is the last lecture of week 10. That is fifth lecture of week 10 and, in this week, we are talking about soil nitrogen for plant nutrition. And in our previous lectures, we have discussed about basics of soil nitrogen dynamics. What are the important sources of soil nitrogen?

We have discussed different steps and different links in the soil nitrogen cycle. We have also discussed different processes which are involved in soil nitrogen mobilization. for example, we have discussed mineralization, nitrification, then volatilization, denitrification, and we have also discussed biological nitrogen fixation. We have discussed what are the factors which are involved or which control the nitrogen cycle.

And also, we have discussed different types of efficiency terms like agronomic efficiency, apparent recovery efficiency, and so on so forth. We have also discussed different types of nitrogenous fertilizers. So, in this lecture, we are going to cover the following concepts.

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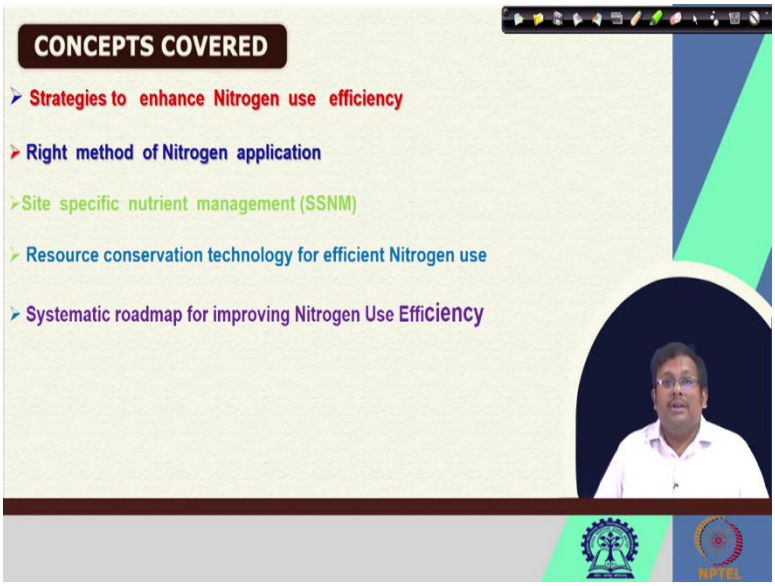

First of all, we are going to cover the strategies to enhance nitrogen use efficiency. And also, we are going to cover the right method of nitrogen application. And we are going to discuss about site specific nutrient management or SSNM. And also, we are going to cover the resource conservation technology for efficient nitrogen use. And finally, we are going to cover the systemic roadmap from improving nitrogen use efficiency.

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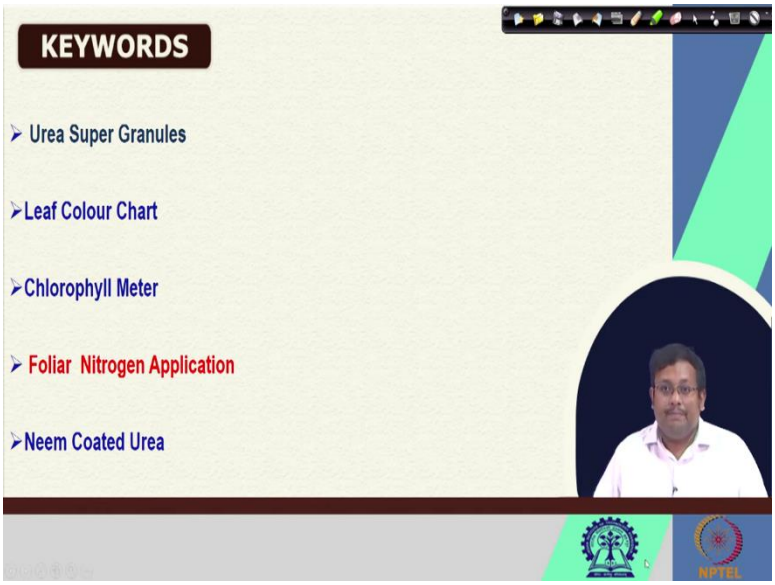

So, these are some of the keywords for this, lecture urea super granules, leaf colour chart, chlorophyll meter, foliar nitrogen application, and neem coated urea. So, we are going to discuss all this in this lecture.

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So let us start with the strategies to enhance nitrogen use efficiency now for an to agronomist or soil scientist, nitrogen use efficiency is a very important aspect because nitrogen is one of the most important plant nutrient or macronutrient, which governs the growth of the plant. And also, nitrogen, generally requires in huge quantity for the planned growth.

So, at the same time, nitrogen is generally lost from the soil through different processes, which we have already discussed, like nitrogen leaching, denitrification. So, there is a focus on, efficient nitrogen use so that the nitrogen use efficiency can be enhanced. And, there are a couple of ways to which we can increase the nitrogen use efficiency.

First of all, we have to select the right method of nitrogen application. What are the right methods of nitrogen application? Deep placement of urea super granules or foliar application of nitrogen fertilizers. We are going to discuss both of them apart from that balanced application of fertilizers and there are certain site-specific nutrient management tools, which you can use for enhanced nitrogen use efficiency.

For example, leaf colour chart or LCC, or, SPAD or chlorophyll meter. These are some the tools which can help in soil specific nutrient management. Soil specific nutrient management helps in reducing the loss of nutrient and, it increases the nutrient use efficiency.

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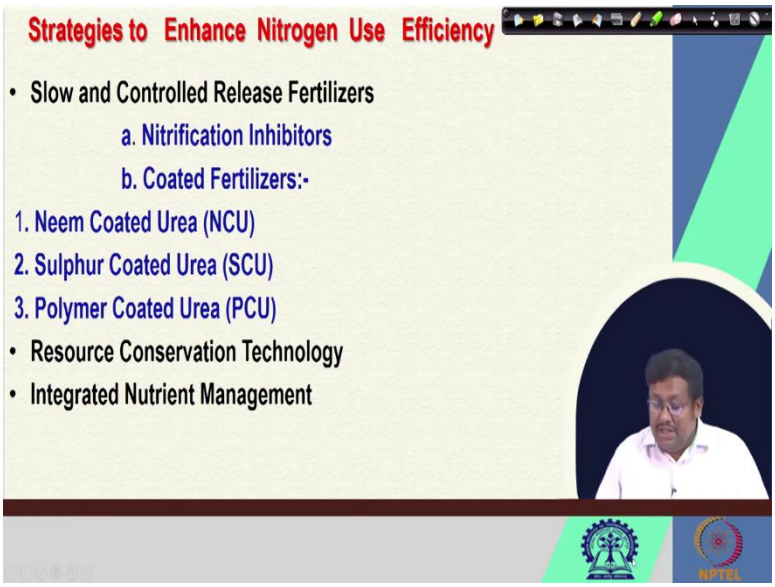

So, there are also some slow and controlled release fertilizers specific nitrogenous fertilizers like nitrification inhibitors and coated fertilizers. So, these coated fertilizers are of several types. For example, name coated urea, sulphur coated urea, polymer coated urea. So, the basic idea behind these coated fertilizers is to decrease or prevent the nitrification process or slow down the nitrification process so that the nitrate formation gets reduced and as a result, there will be less nitrate depletion or less nitrate loss from the soil.

There are certain resource conservation technology, which we are going to discuss. And apart from that, of course, there are some there is an important concept called integrated nutrient management. So, these are some of the strategies to enhance the nitrogen use efficiency.

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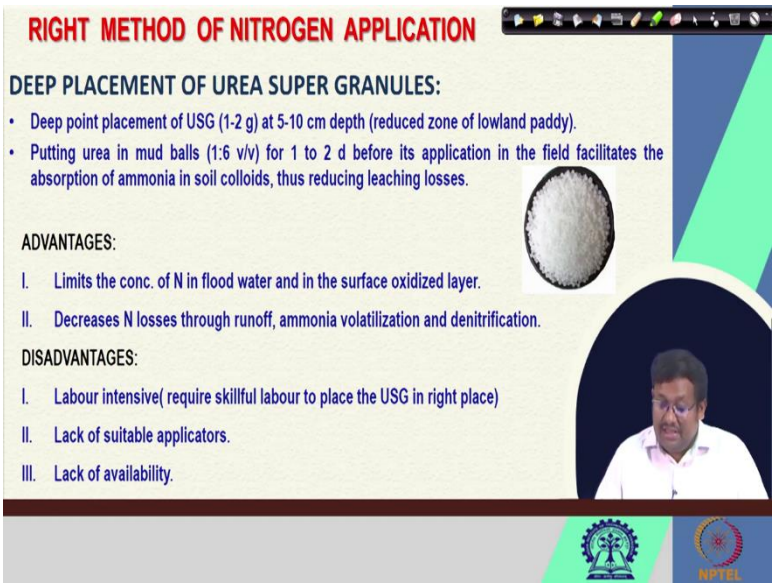

Now let us talk about the right method of nitrogen application. Now, one of the right methods of nitrogen application in the field is deep placement of urea super granules, as you can see in this picture, these are the urea super granules they are granulated. So, this deep placement of these urea super granules 1 to 2 gram of urea super granules at 5-to-10-centimetre depth in the lowland paddy, reduced zone, in the lowland paddy there a stagnant water.

So, there is a reduced zone in the soil. So, if we place the urea super granules or granulated urea in 1 or 2 grams at 5-to-10-centimetre depth, that will reduce the loss of nitrogen by, through, by reducing the runoff or ammonia volatilization or denitrification. Now, putting this urea in mud balls in 1 is to 6 volumetric basis for 1 or 2 days before its application in the field also facilitates the absorption of ammonia in soil colloids, thus reducing the leeching losses.

Now that soil colloids, the have different soil colloids, have the capability of absorbing or absorbing the ammonium ions by which we can reduce the loss of nitrogen. So, what are the benefits of these deep placement of urea super granules? First of all, it limits that concentration of nitrogen in flood water and in the surface oxidized layer, when you place the urea super granules in deep, in the reduced zone of lowland paddy, that will first of all, reduce or limit the concentration of nitrogen in the surface oxidized layer.

Secondly, it decreases the nitrogen losses through run of ammonia volatilization or denitrification, as I have already mentioned. However, simultaneously there are certain disadvantages also. first of all, this deep placement is labour intensive, it requires skilful labour to place these urea super granules or USG in right place. Secondly, there is a lack of

suitable applicators for deep placement of urea super granules, and finally, the lack of availability of urea super granules in some places also limits its use.

So, these are some of the aspects of urea super granules. These are some of the advantages and disadvantages and benefits of using the so urea super granules.

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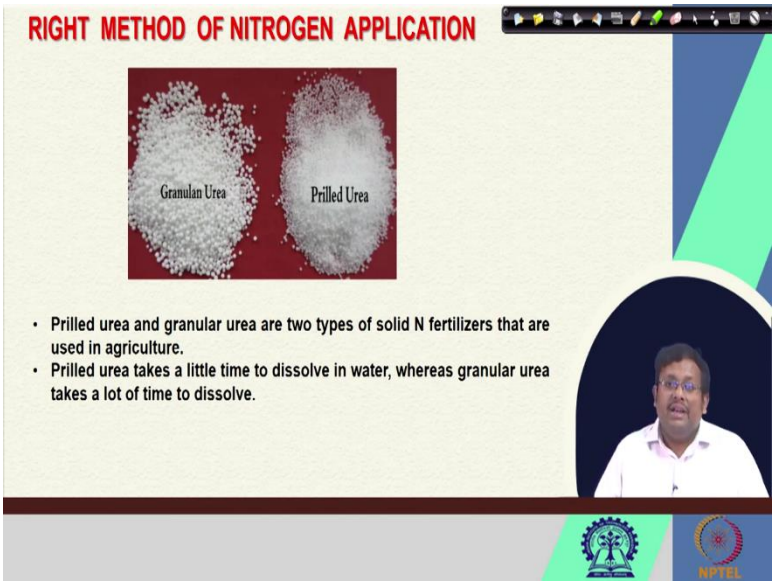

you will also frequently come across another term that is called prilled urea. Now, what is a difference between granular or urea granules and prilled urea. Now this prilled urea and granular both types of urea are these are the solid nitrogenous fertilizers that are used in agriculture. These are available in the market, but the difference between prilled urea and granular urea is prilled urea takes a little time to dissolve in water, whereas granular takes a lot of time to dissolve. So, from that point of view, granular urea or urea granules are better than prilled urea.

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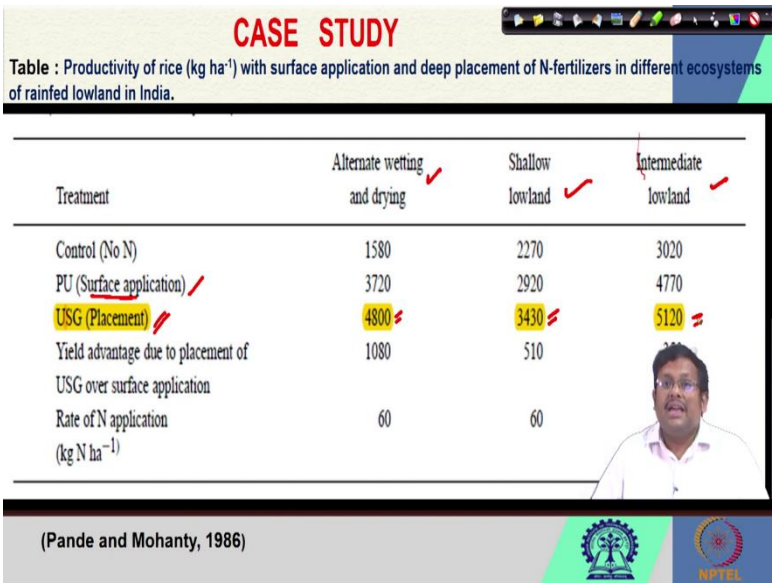

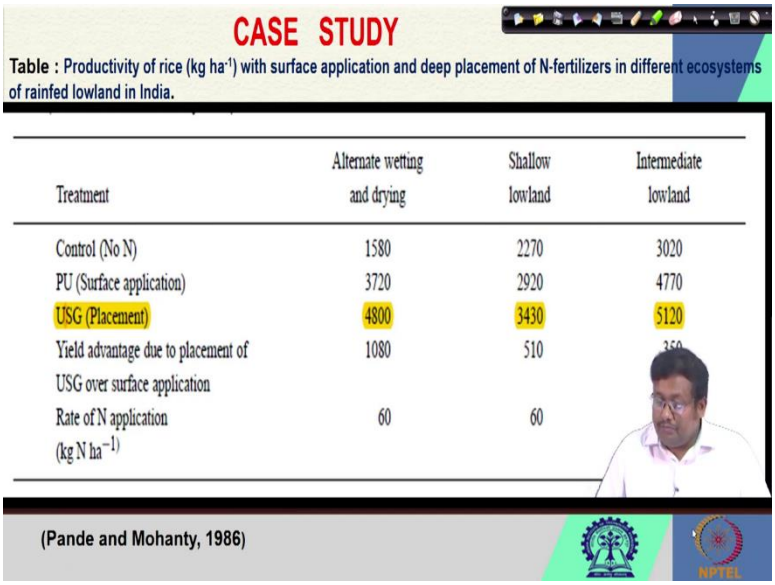

Now, there is a case study, which was published by Pande and Mohanty in the year 1986 and, that says the productivity of rice, which surface application and deep placement of nitrogenous fertilizer in different ecosystem of rainfed lowland, in India. So, if you can see that when there is prilled urea surface application of prilled urea, that and there are different types of method like alternate wetting and drying, then shallow lowland, or intermediate or intermediate lowland.

You can see in all these three conditions when you compare this prilled urea and urea super granules, you will see that rice productivity is always had when there is a deep placement of urea super granules as compared to the surface application of prilled urea. So, that shows the

benefit of using the urea super granules as compared to prilled urea. And this is because urea super granules takes time to dissolve, whereas the prilled urea can be easily dissolved.

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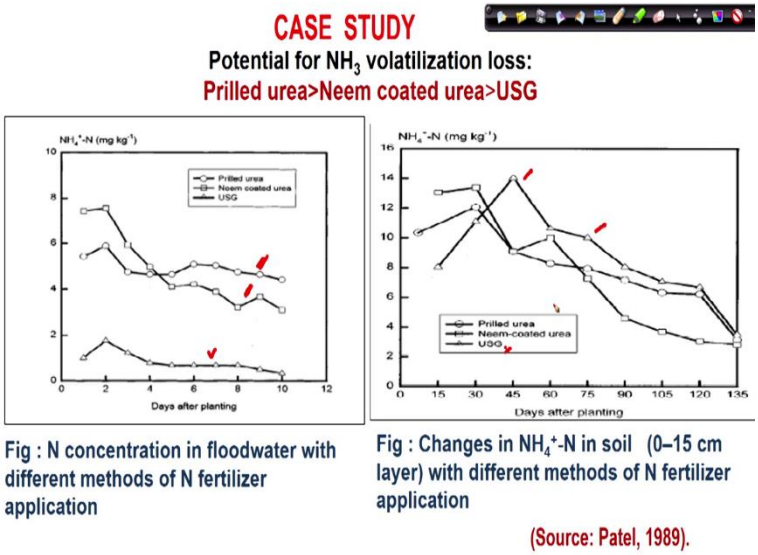

Fig : N concentration in floodwater with different methods of N fertilizer application

Fig : Changes in NH_4^+-N in soil (0–15 cm layer) with different methods of N fertilizer application

(Source: Patel, 1989).

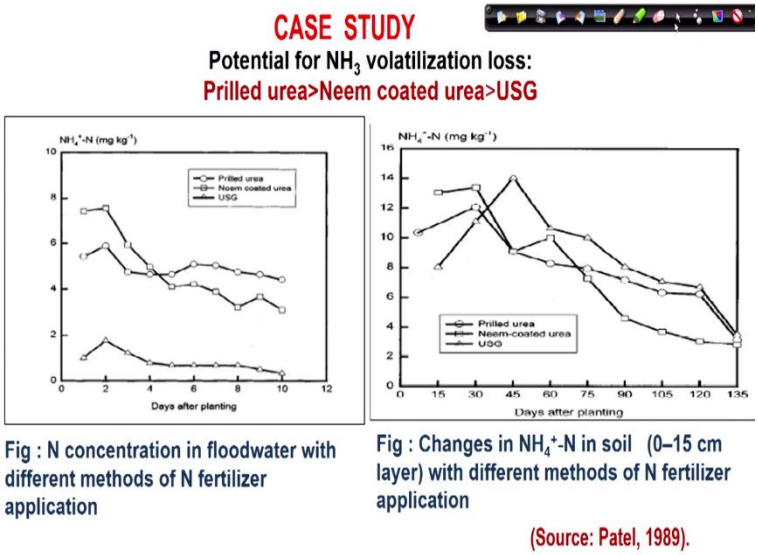

Fig : N concentration in floodwater with different methods of N fertilizer application

Fig : Changes in NH_4^+-N in soil (0–15 cm layer) with different methods of N fertilizer application

(Source: Patel, 1989).

Now also, it has been observed by Patel in 1989, that the potential ammonium volatilization loss is higher in case of prilled urea followed by neem coated urea, followed by USG or urea super granules. So, if you use the deep placement of urea super granules that can drastically reduce the ammonium volatilization loss.

So, if you see this, this graph, it is quite clear that after the days of planting the ammonium nitrogen concentration is, this nitrous concentration in floodwater is lowest in case of, urea granules. And also, whereas these nitrogen concentration in floodwater water is higher in

case of, these prilled urea as well as the neem coated urea. This is the neem coated urea and this is the prilled urea, so that shows the benefit of using the urea super granules.

Also, you can see here that changes in ammonium nitrogen in soil from 0 to 15-centimetre layer with different methods of nitrogen fertilizer application. So, you can see here when they applied the urea super granules, the urea super granules produces higher ammonium content in the soil as compared to the other two methods that is neeem coated urea and prilled urea. So, that shows the benefit of using the deep placement of, urea super granules for reducing the ammonium volatilization loss from soil.

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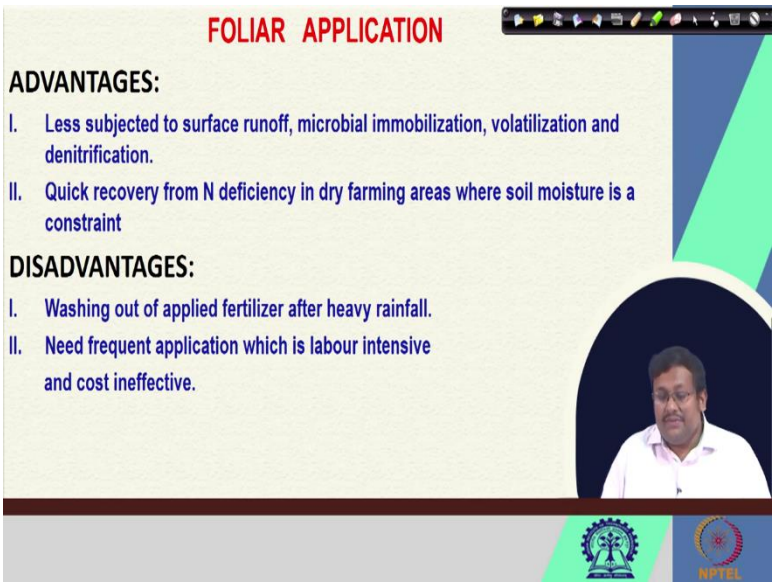

Another, useful method for nitrogenous fertilizer application is foliar application. Now, there are certain advantages as well as disadvantages of foliar application. First advantage is it is less subjected to surface runoff, microbial immobilization, volatilization, and denitrification. Of course, when you apply the fertilizer in bare soil, there are certain process through which it gets lost, for example, surface runoff, microbial immobilization, volatilization, and denitrification.

However, when you apply directly through foliar application, then these loss, the chances of nitrogen loss will be reduced. Secondly, quick recovery from nitrogen deficiency in dry farming areas where soil moisture is a constraint. So, soil moisture, when there is a constraint of soil moisture, foliar application can quickly recover the nitrogen deficiency symptom. At the same time, there are certain disadvantages, also what are those disadvantages, first of all, washing out of applied fertilizer after heavy rainfall.

So, when there is a heavy rainfall, the fertilizer gets easily washed away when there is a foliar application. Secondly, in case of foliar application, it requires frequent application, which is labour intensive and as also cost ineffective. So, these are some of the downside of foliar application of nitrogenous fertilizer.

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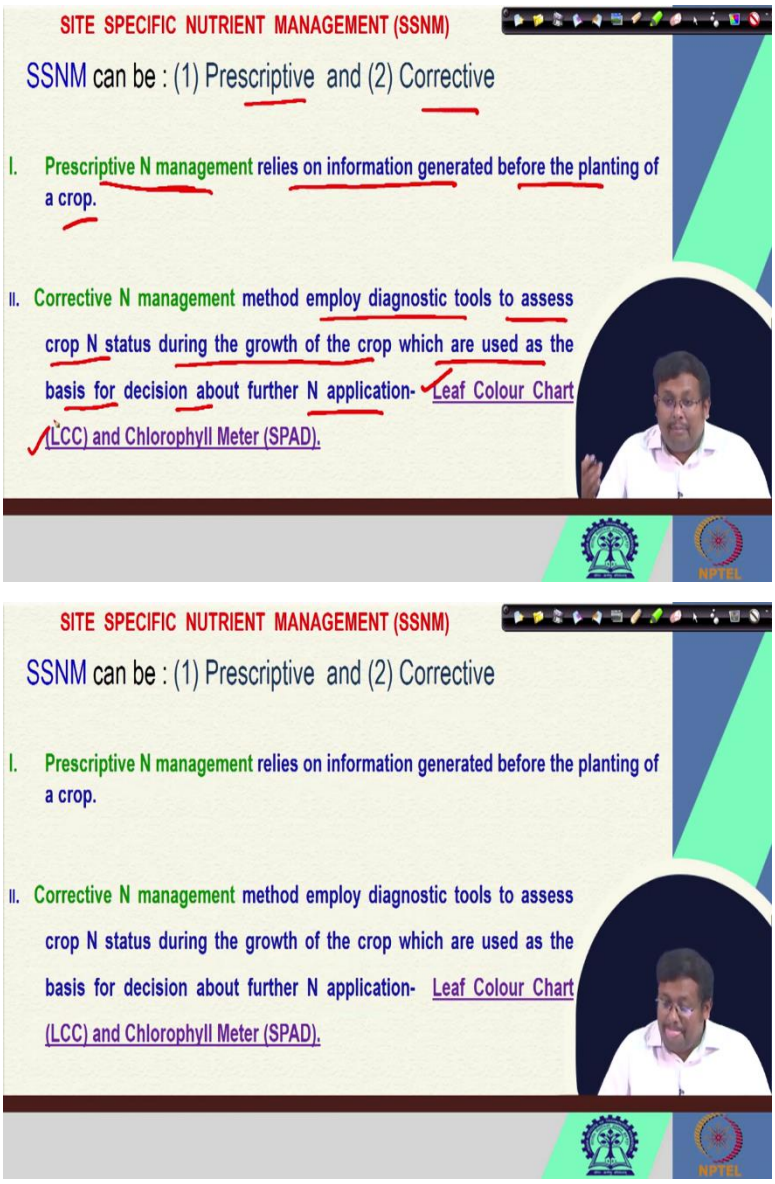

Now, another important term of increasing the nitrogen use efficiency is site specific nutrient management. Now site-specific nutrient management, can be of two types, one is prescriptive site specific management. Another one is corrective site specific management. Now, what is a difference? Now in case of prescriptive nitrogen, suppose we are considering the nitrogen management.

So, in case of prescriptive nitrogen management, this relies on information generated before the planting of the crop. So, before the planting of the crop, we rely on this type of prescription-based approach. However, there is a corrective nitrogen management, also this method employed diagnostic tools to assess crop nitrogen status during the growth of the crop, which are used as a basis for decision about further nitrogen application.

For example, in case of this corrective nitrogen measurement, we can use either leaf colour chart or SPAD meter for chlorophyll measurement. So, you can see the difference clearly between the prescriptive nitrogen management and another one is corrective nitrogen management. So, the site specific nutrient management can be achieved by both these ways for nitrogenous fertilizer or nitrogen uptake by the plant.

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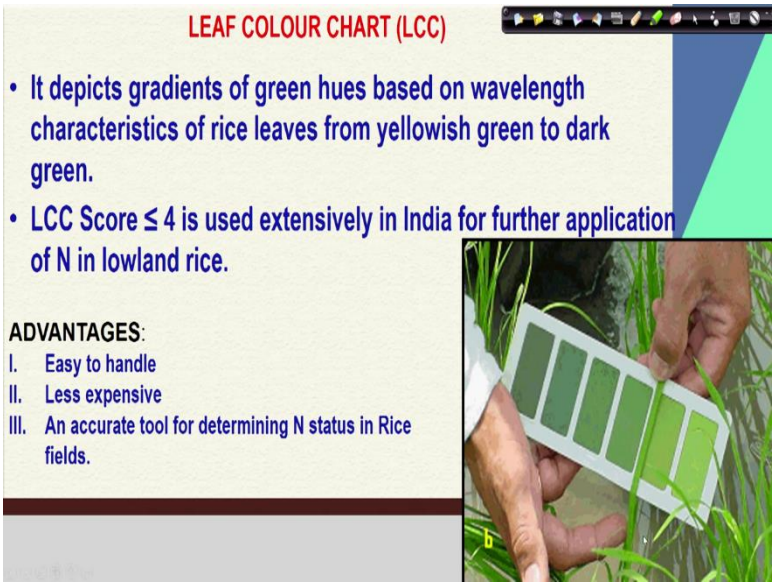

Now, let us consider what is leaf colour chart? Nw, this is a leaf coloured, as you can see in this picture. So, this leaf collected is very simple tool, and it depicts the gradients of green hues based on wave length characteristics of rice leaves from yellowish green to dark green. So, as the nitrogen, from nitrogen deficiency to nitrogen sufficiency, the shades vary from yellowish green to dark green.

So, by matching the colour of the leaves with these different shades in this leaf colour chart, we can determine qualitatively the deficiency or sufficiency of nitrogen in the plant. Now in India, generally for lowland rice, these LCC score less than equal to 4 is considered as a threshold for further application of nitrogenous fertilizers. Of course there are certain advantages of these approach.

First of all, it is very easy to handle. It is less expensive and is an accurate tool for determining the nitrogen status in rice field. So, this is the leaf colour chart-based approach, or, site specific nutrient management.

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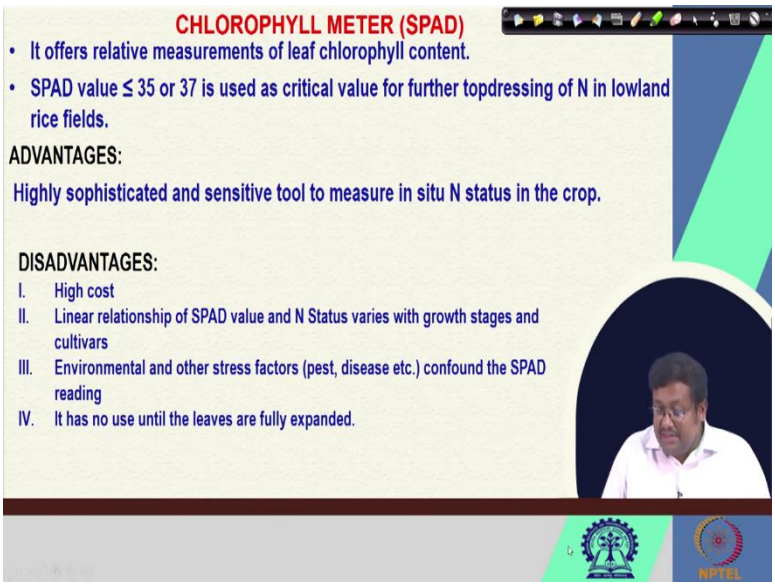

Now, if you go to the chlorophyll meter-based nutrient, management approach or SPAD meter based nitrogen management, it offers relative measurement of leaf chlorophyll content and SPAD values generally less than equal to 35 to 30 or 37 is used as a critical value for further top addressing of nitrogen in lowland rice field. What is the advantage of these chlorophyll meter?

This is a highly sophisticated and sensitive tool to measure nitrogen status in the crop. However, there are certain disadvantages also, first of all, is high-cost linear relationship between SPAD value and nitrogen status varies with growth stages and cultivars and environmental and other stress factors like pest, disease, et cetera, can confound the SPAD reading and finally it has no use until the leaves are fully expanded.

So, these are some the disadvantages of a this chlorophyll meter or SPAD meter. When you consider site specific nitrogen management.

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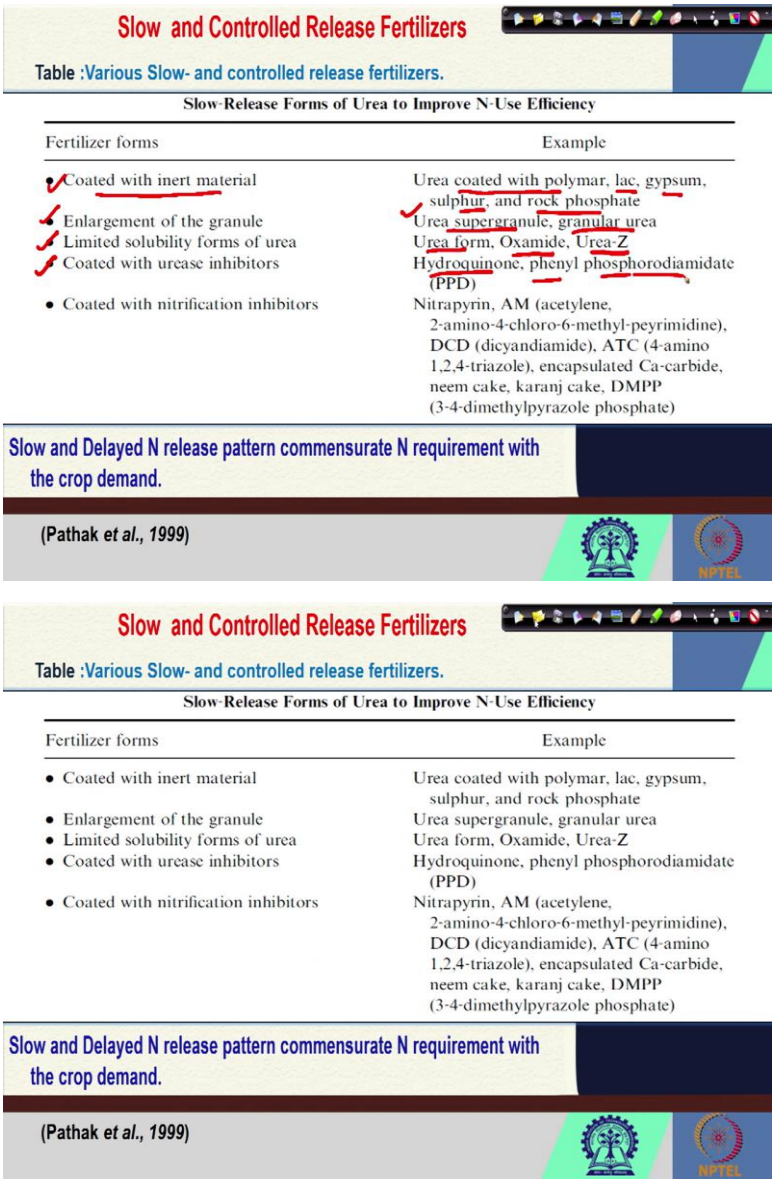

Slow and Controlled Release Fertilizers
Table :Various Slow- and controlled release fertilizers.
Slow-Release Forms of Urea to Improve N-Use Efficiency
Fertilizer forms
Example
Coated with inert material
Urea coated with polymar, lac, gypsum, sulphur, and rock phosphate
Enlargement of the granule
Urea supergranule, granular urea
Limited solubility forms of urea
Urea form, Oxamide, Urea-Z
Coated with urease inhibitors
Hydroquinone, phenyl phosphorodiamidate (PPD)
Coated with nitrification inhibitors
Nitrapyrin, AM (acetylene, 2-amino-4-chloro-6-methyl-peyrimidine), DCD (dicyandiamide), ATC (4-amino 1,2,4-triazole), encapsulated Ca-carbide, neem cake, karanj cake, DMPP (3-4-dimethylpyrazole phosphate)
Slow and Delayed N release pattern commensurate N requirement with the crop demand.
(Pathak et al., 1999)
NPTEL

Now, if you see the different barriers, slow and controlled release fertilizer which generally we use for improving the nitrogen use efficiency, we can have this list, first of all, the coated with inert material, sometime the fertilizer, suppose urea is coated with inert material. So, what are the examples urea coated with polymer, lac, gypsum, sulphur, and rock phosphate. The second approach is enlargement of the granules like urea super granule, which we have already discussed or granular urea.

Third one is limited solubility forms of urea, what are those urea form, oxamide, urea-z. So, these are the limited soluble forms of urea. The fourth approach is quoted with urease inhibitors. Now, that urease is required for hydrolysis of urea. Now, when there is an urease inhibitor, of course, the release of nitrogen will be inhibited. What are those? Hydroquinone, phenyl, phosphordiamidate or PPD.

So, these are some, urease inhibitors and also, there are some urea of fertilizers, which are quoted with nitrification inhibitors, so that the formation of nitrate get reduced. For example, nitrapyrin, AM, DCD, ATC. These are the scientific names in the parenthesis. So, you can see it is like DMPP. These are different types of nitrification inhibitors, which slows down the formation of nitrate in the soil. So, the slow and delayed nitrogen release pattern, by this, application of these fertilizers, commensurate nitrogen requirement, with the crop demand. So, this is how we can increase the nitrogen use efficiency and decrease the loss of nitrogen from the soil.

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Now, what are the advantages on disadvantages of nitrogen, nitrification inhibitors, which we have already discussed in our previous slide, there are certain nitrogen inhibitors. Now, nitrogen inhibitors generally slows down the conversion of ammonium to nitrate due to, by inhibiting the conversion. Now, of course, there are certain advantages for that, for example, higher availability of ammonium ion concentration in soil, which is less subjected to leeching and denitrification losses.

Secondly, inhibitor effect on methane oxidation and nitrous oxide emission. So, these are some of the greenhouse gases. So, the emission of these different types of greenhouse gases can be also reduced, by this nitrification inhibitor. However, there are certain disadvantages also like high cost, lack of availability in Indian market for these nitrification inhibitors.

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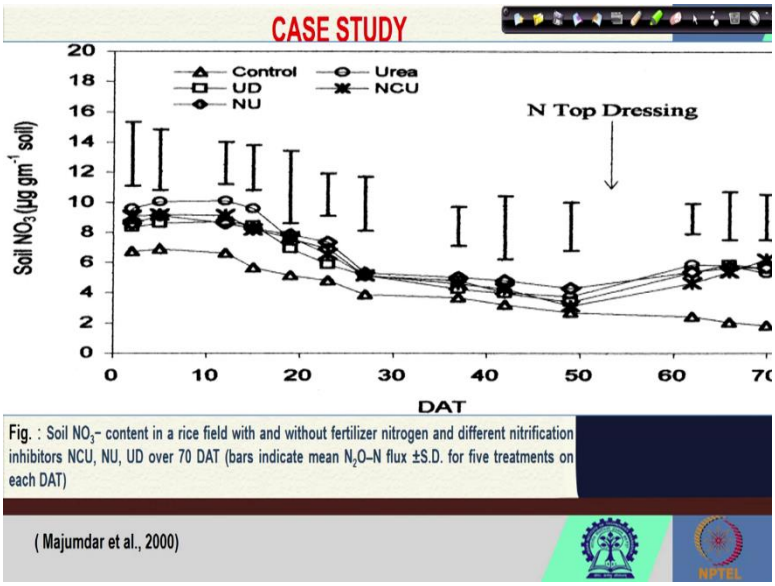

Now, there is a case study by Majumdar, in 2000 where we can see that soil nitrate in a rice field, then without fertilizer nitrogen, different nitrification inhibitors. So, we can clearly see that when urea is applied soil nitrate contain in the rice field is clearly higher in case in the initial days, and which is clearly less in case of different types of nitrification inhibitors. So, that shows the that proves the application of these nitrification inhibitors can reduce the formation of nitrate in the soil, thereby reducing their leeching loss and other types of loss.

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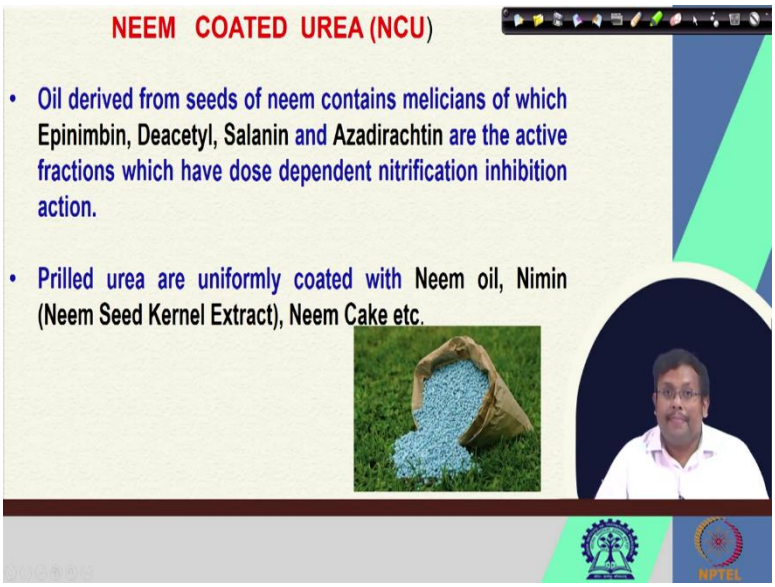

Now, we have discussed different types of coated fertilizer. Now, one of them is well, most famous is neem coated urea. now neem coated urea generally we remember that oil derived from the seeds of neem contains, different types of melicians of which, epinimbin then, deacetyl, and then salanin, and azadirachtin are the active fractions, which have dose dependent nitrification inhibition action. So, these are like epinimbin, deacetyl, salanin, azadirachtin.

These are these are the active faction which has the nitrification inhibition effect. Now prilled urea are uniformly coated with neem oil or nimin which is which is neem seed kernal extract, neem cake, et cetera, to produce these neem coated urea as you can see in this picture, these are neem coated urea.

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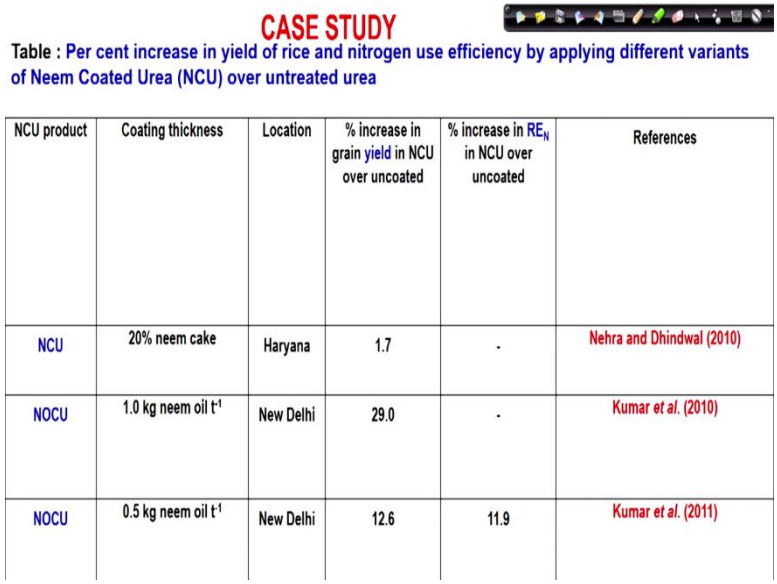

Now there is a case study and where percent increase in yield of rice and nitrogen and use efficiency by applying different variants of neem coated urea over untreated urea were compared, and you can see here by applying the 20 percent neem cake here. And then in there's a neem coated urea there is another variant of neem coated urea. So, applying these different variances of neem coated urea, you can see that there is a percent increase in grain yield in neem coated urea in this case, it is 1.7 percent.

It is 29 percent and 12.6 percent. Of course, there are different locations. So, also the apparent recovery efficiency of nitrogen in neem coated urea over uncoated urea, you can see, there is a percent increase, 11.9 percent increase in case of these NOC. So, that shows that when we apply different types of coated urea, that can increase the nitrogen use efficiency.

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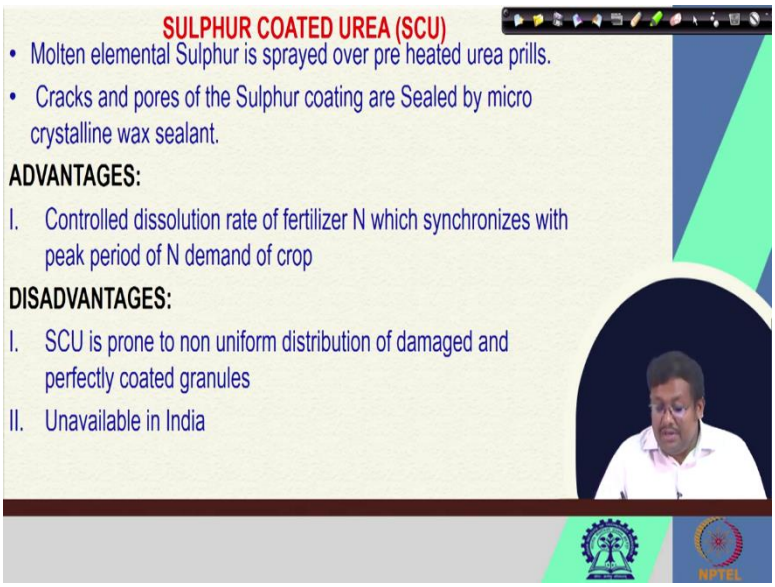

There is another coated that is called sulphur coated urea or SU where molten elemental sulphur is sprayed over preheated urea peels and cracks and pores of the sulphur coating are sealed by micro crystalline wax sealant. So, these are known as sulphur coated urea. What are the advantages? Advantage is controlled dissolution of fertilizer nitrogen, which synchronizes with peak period of nitrogen demand of crop.

Of course, there are two disadvantages, first of all, the sulphur treated urea is prone to non-uniform distribution of damage and perfectly coated granules, it unavailable in most of the part of India. So, these are some of the disadvantages of sulphur coated urea.

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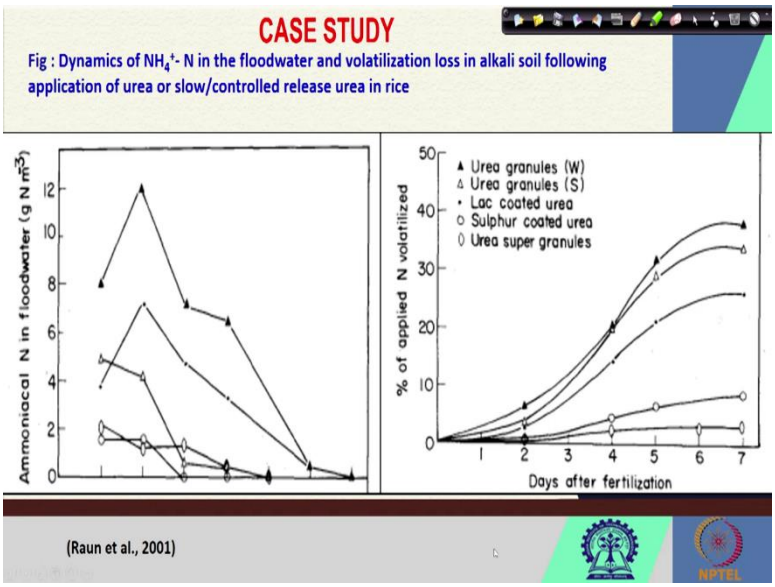

Now there is another case study by Ron et al in 2001, where we can see the dynamics of ammonium nitrogen in floodwater and volatilization, loss in alkali soil following application of urea at slow or controlled release urea in rice. So, you can see here in this graph, it is clearly seen that as the days after fertilization, the percentage of applied nitrogen volatilized is always higher when there is ureal granules. And when we use different coated urea, the volatilization loss of nitrogen is getting reduced from these urea granules to then then lac coated urea, then sulphur coated urea, and urea super granules. So, you can see here that how these, uncoated urea and different types of coated urea can change the nitrogen and volatilization situation in case of rice plant.

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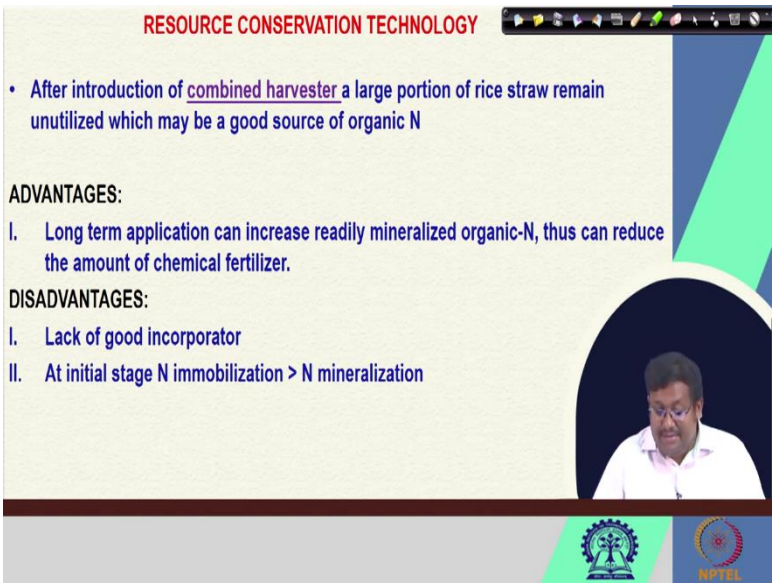

What are the research conservation technology? One of the most important research conservation technology which we are using nowadays is called the combined harvester. Now, after introduction of this technology, nowadays, it is very popular throughout India. And after an introduction of this technology a combined harvester, a large portion of rice straw remain unutilized and, that can be a good source of organic nitrogen in the soil.

If you consider the advantage of these research conservation technology for nitrogen management, long term application of this technology can increase readily mineralized organic nitrogen, thus can reduce the amount of chemical fertilizer when you incorporate this rice straw, in the soil that can reduce the requirement of nitrogen fertilizer and also there are some disadvantages also, for example, there is a lack of good incorporator and at initial stages of the nitrogen immobilization is higher than nitrogen mineralization.

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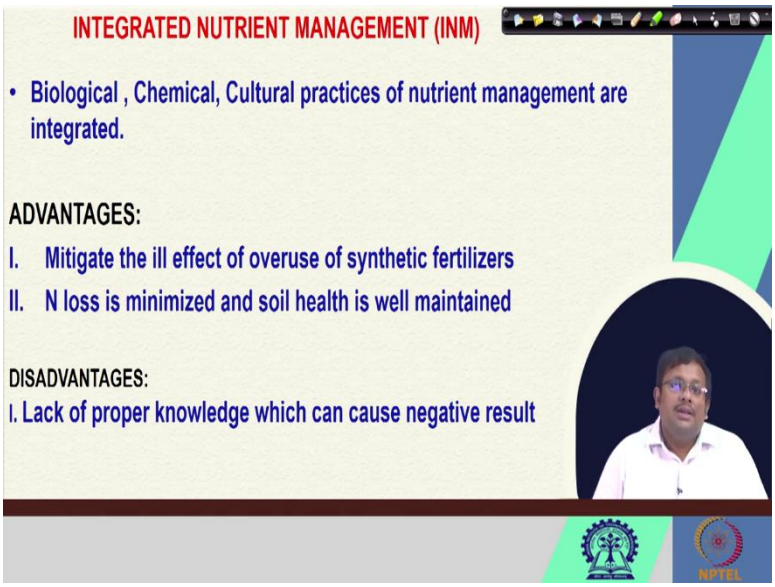

Another important term is integrated nutrient management or INM. Now INM is an integrated approach where we use both biological, chemical, and cultural practices of nutrient management. So, here not only we rely on synthetic fertilizer application, but at the same time, we modify our cultural practices. Also, we apply the biological sources of different nutrients like manure.

So, there are certain advantages of these integrated nutrient management. First of all, it mitigates the ill effect of overuse of synthetic fertilizer. Secondly, nitrogen loss is minimized and soil health is well maintained. However, it has one disadvantage, also lack of proper knowledge, which can cause negative result.

So, we have to properly understand what is integrated nutrient management, and we have to judiciously apply this concept so that the maximum benefit can be harvested. So, these integrated nutrient management is a very important concept for improving the nitrogen use efficiency. We are going to discuss this integrated nutrient management in our upcoming lectures in details, but at the, this time, we should remember that these INM is one of the most important concept for one of the most important concepts for, improving the nitrogen use efficiency.

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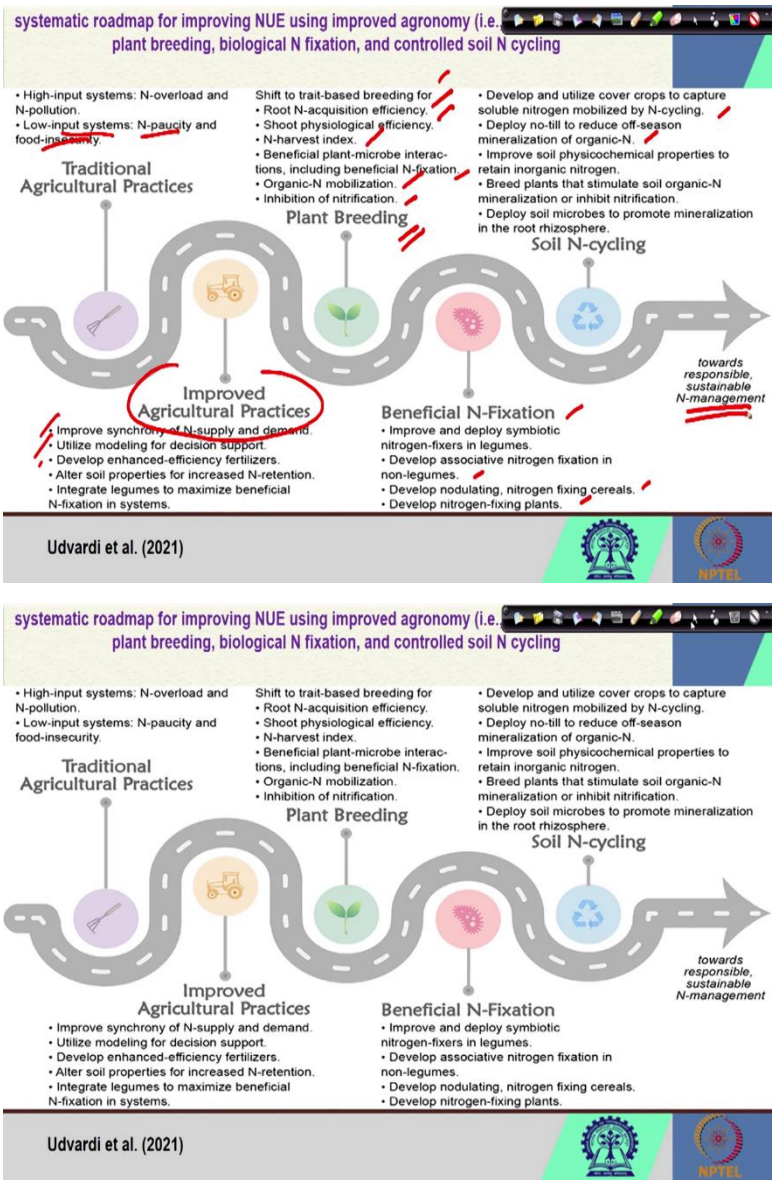

systematic roadmap for improving NUE using improved agronomy (i.e. plant breeding, biological N fixation, and controlled soil N cycling
• High-input systems: N-overload and N-pollution.
• Low-input systems: N-paucity and food-insecurity.
Traditional Agricultural Practices
Shift to trait-based breeding for
• Root N-acquisition efficiency.
• Shoot physiological efficiency.
• N-harvest index.
• Beneficial plant-microbe interactions, including beneficial N-fixation.
• Organic-N mobilization.
• Inhibition of nitrification.
Plant Breeding
• Develop and utilize cover crops to capture soluble nitrogen mobilized by N-cycling.
• Deploy no-till to reduce off-season mineralization of organic-N.
• Improve soil physicochemical properties to retain inorganic nitrogen.
• Breed plants that stimulate soil organic-N mineralization or inhibit nitrification.
• Deploy soil microbes to promote mineralization in the root rhizosphere.
Soil N-cycling
towards responsible, sustainable N-management
Improved Agricultural Practices
• Improve synchrony of N-supply and demand.
• Utilize modeling for decision support.
• Develop enhanced-efficiency fertiizers.
• Alter soil properties for increased N-retention.
• Integrate legumes to maximize beneficial N-fixation in systems.
Beneficial N-Fixation
• Improve and deploy symbiotic nitrogen-fixers in legumes.
• Develop associative nitrogen fixation in non-legumes.
• Develop nodulating, nitrogen fixing cereals.
• Develop nitrogen-fixing plants.
Udvardi et al. (2021)
NPTEL

This is a systematic roadmap for improving the nutrient, nitrogen use efficiency I can say nitrogen use efficiency using improved agronomy. So, traditional agricultural practices, is always depends on high input system where nitrogen and overload creates nitrogen pollution. And also there, if there is a low input system that can results in nitrogen paucity at food insecurity, so improved agricultural practices can improve the synchrony of nitrogen supply and demand.

It can utilize the modelling for decision support. It can develop enhance efficiency, fertilizer and so on and of course, plant breeding another important aspect for enhancing the nitrogen use efficiency shift to trade-based breeding for root nitrogen acquisition efficiency, shoot physiological efficiency, nitrogen harvest index, beneficial plan, microbe interaction, including beneficial nitrogen and fixation, organic nitrogen immobilization, inhibition of nitrification.

So, these are some of the important traits which the breeders should consider for developing the new breed of new plant variety so that that can enhance the nitrogen use efficiency. Beneficial nitrogen and fixation, which can improve of deploy symbiotic nitrogen fixers in legume and develop associative nitrogen fixation in non-legumes, develop nodulating nitrogen fixing cereals, and develop nitrogen and fixing plants, soil nitrogen, and cycling like develop and utilize cover crops to capture the soluble matters mobilizing by nitrogen cycling, deploy no-till to reduce the off-season mineralization of an organic nitrogen so on.

Then all these can result in sustainable nitrogen management. So, these are some of the ways through which we can enhance the nitrogen, use efficiency.

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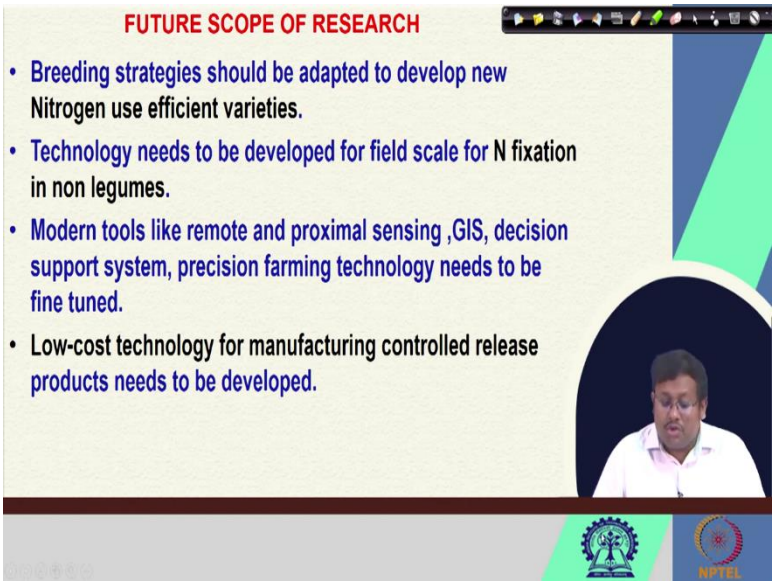

Now, future scope of research. What are the future scope of research? Breeding strategies should be adapted to develop new nitrogen use efficiency, efficient varieties. Technology needs to be developed for field scale for nitrogen fixing in non-legumes, fixation in non-legumes, modern tools like, remote and proximal sensing, GIS, decision support system, precision farming technology needs to be fine-tuned, and finally low-cost technology for

manufacturing-controlled release products needs to be developed. So, these are some of the, future scope of research.

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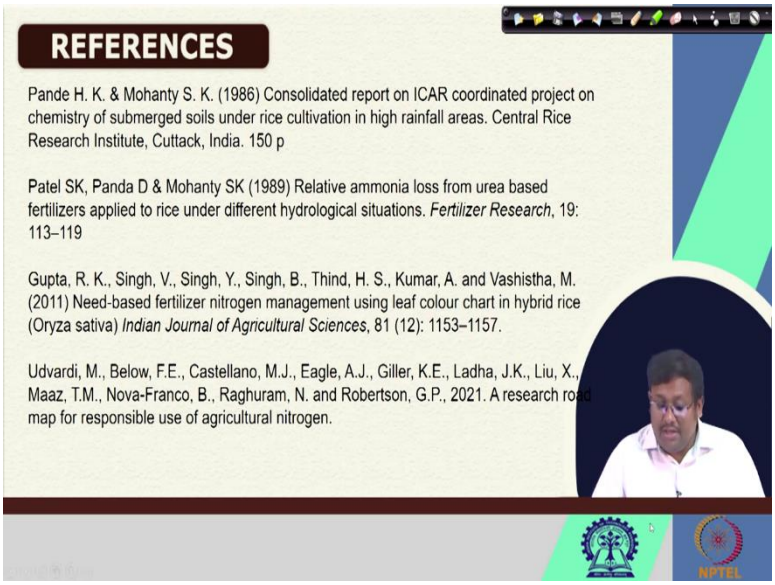

So, with this we wrap up, let us wrap up this week 2 of lectures, where we have discussed the importance of nitrogen for plant nutrition. These are some of the references which I used for this.

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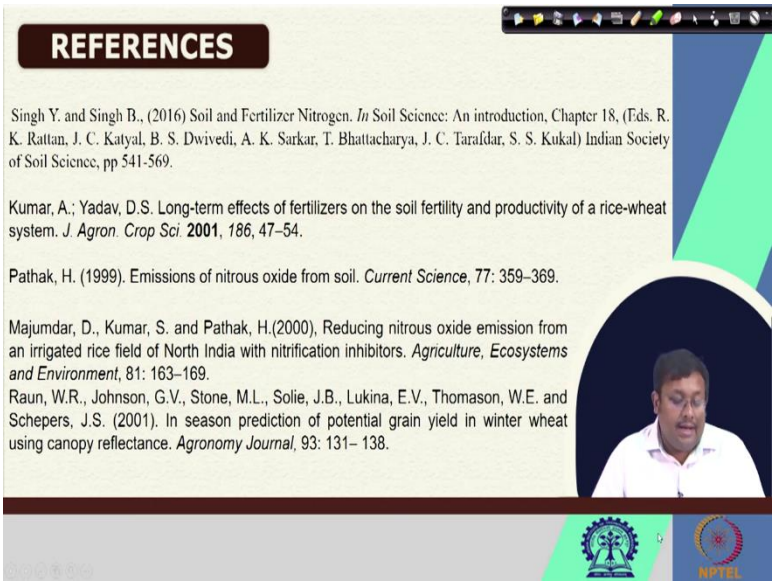

For this lecture.

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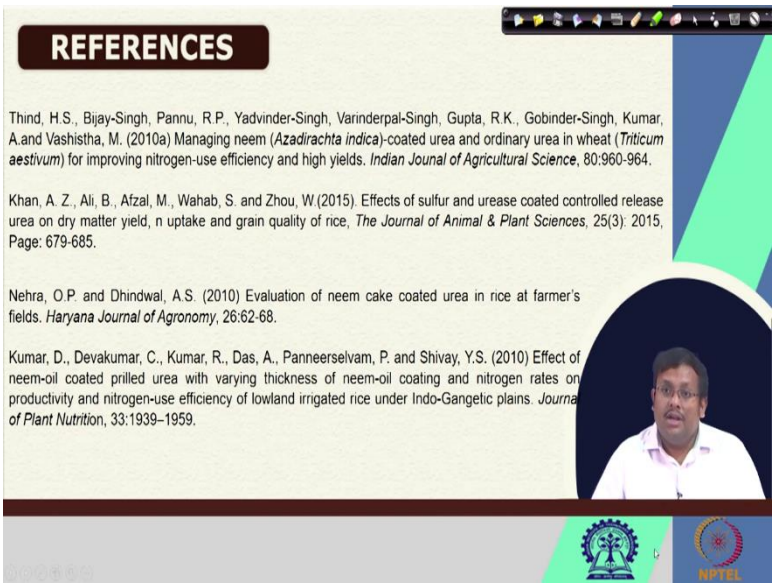

And, please feel free to go through these references to enrich yourself so that you can have more comprehensive knowledge of nitrogen nutrition of the plant.

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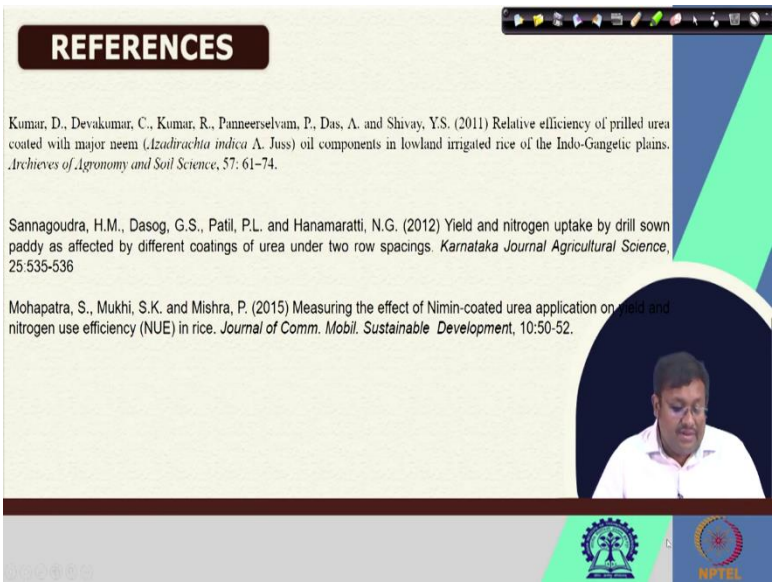

So, these are some of the references which we have used.

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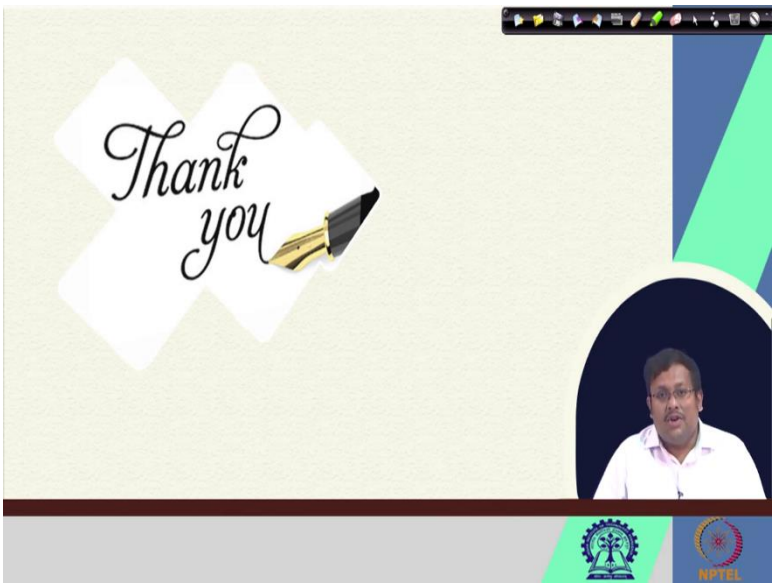

So, thank you and, let us meet in our week 3, where we will discuss the importance of phosphorus and potassium for plant nutrition. Thank you.