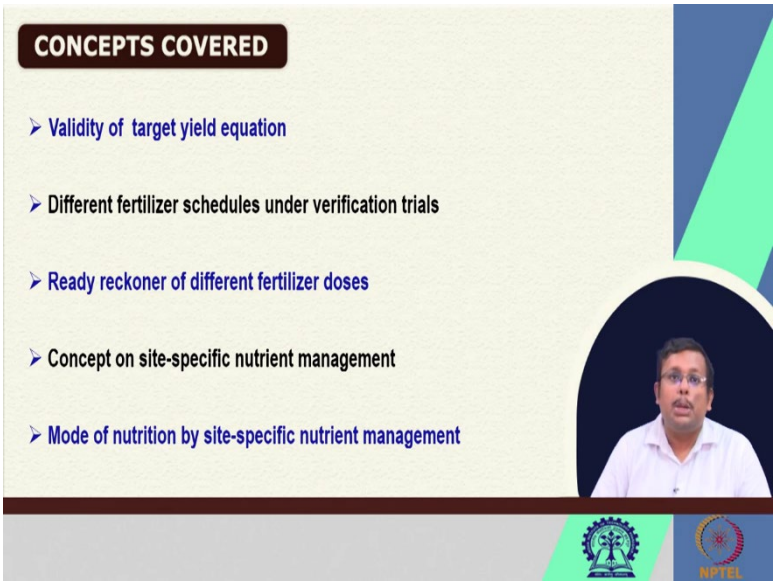
Soil Fertility and Fertilizers
Professor Somsubha Chakraborty
Agricultural and Food Engineering Department
Indian Institute of Technology, Kharagpur
Lecture 54
Fertilizer Recommendation Approaches and Integrated Plant Nutrient Management (Contd.)

Welcome friends, to this fourth lecture of week 11 of NPTEL Online Certification Course of Soil Fertility and Fertilizers. In this week, we are talking about fertilizer recommendation approaches and integrated plant nutrient management or INM. Now, in our previous couple of lectures in this week, we have discussed about the concepts of nutrient management and fertilizer recommendation.

We have discussed about potential yield, attainable yield, actual yield, we have also discussed about different types of nutrient recommendation and also interpretation and followed by nutrient recommendation methods, different types of soil fertility evolution methods, starting from deficiency symptoms, then plant tissue analysis, then microbial or biological methods, and also soil testing.

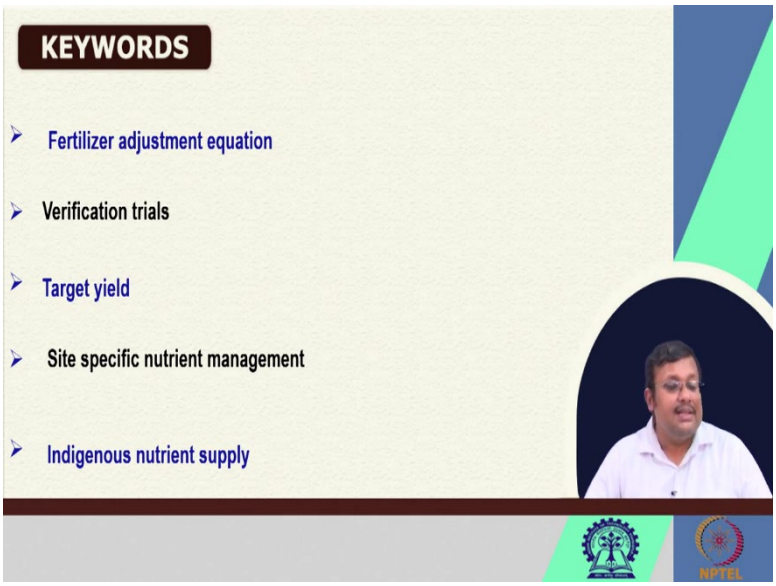
We have also described the Colwell's approach, then percent yield approach, then target yield concept, we have discussed and also, we have started discussing about the soil analysis crop correlation approach, using the target yield. We have seen that how we can calculate different components of this approach and then how we can input all those components to calculate the fertilizer requirement, setting up some target yield. So, this lecture will extend that soil analysis crop response approach, and also, we are going to see some case studies where this approach has shown some benefits over traditional methods.

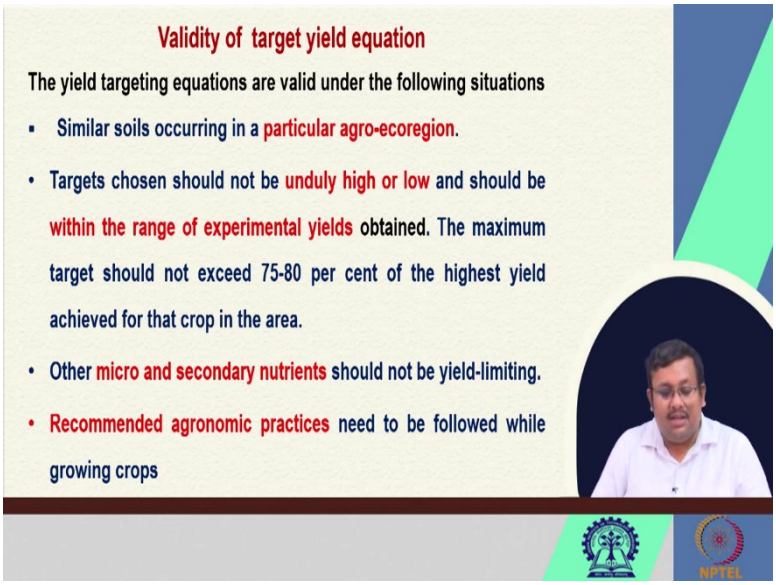
(Refer Slide Time: 2:45)



These are the concepts which we are going to cover in this lecture, first of all we are going to talk about validity of targeted equation, and then different fertilizer schedules under verification trials, then we are going to also discuss Ready Reckoner of different fertilizer doses, then concept of site-specific nutrient management, and mode of Nutrition by site specific nutrient management. So, these are the concepts which we are going to cover in this lecture.

(Refer Slide Time: 3:17)



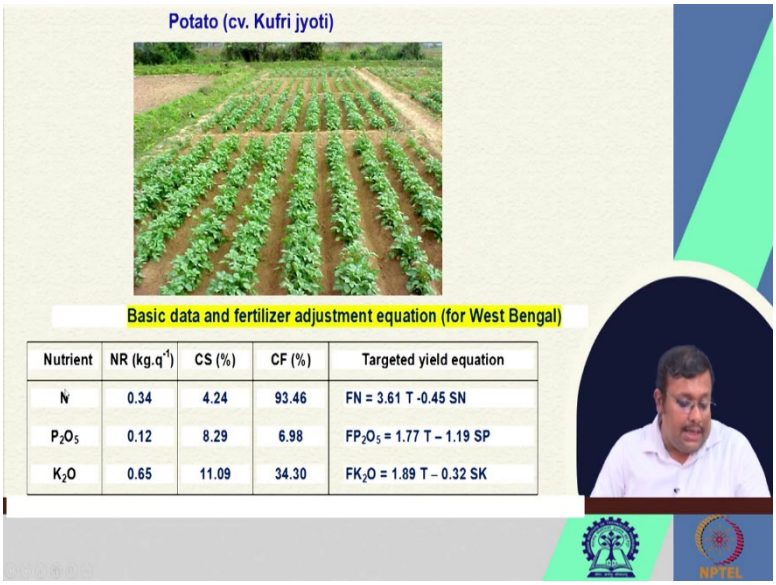


These are the keywords for this lecture. Fertilizer adjustment equation then verification trials then target yield, side switching nutrient management, and Indigenous nutrient supply, so these are some of the keywords of this lecture. Now, if we see the validity of target yield equation, the yield targeting equations are valid under some conditions or situation.

First of all, these are valid under similar soils occurring in a particular agro-ecoregion. This is the first criteria, secondly, targets chosen should not be unduly high or low and should be within the range of experimental yields obtained. The maximum target should not exceed 75 to 80 percent of the highest yield achieved for that crop in the area.

This is the second criteria, the third criteria is other micro and secondary nutrients should not be illumining, that means those micro and secondary nutrients should be present in optimum quantity in that soils. And recommended agro-ecoregion practices need to be followed while growing the crops. So, these are the four major assumptions, when we can apply or situations, where we can apply this target in equation.

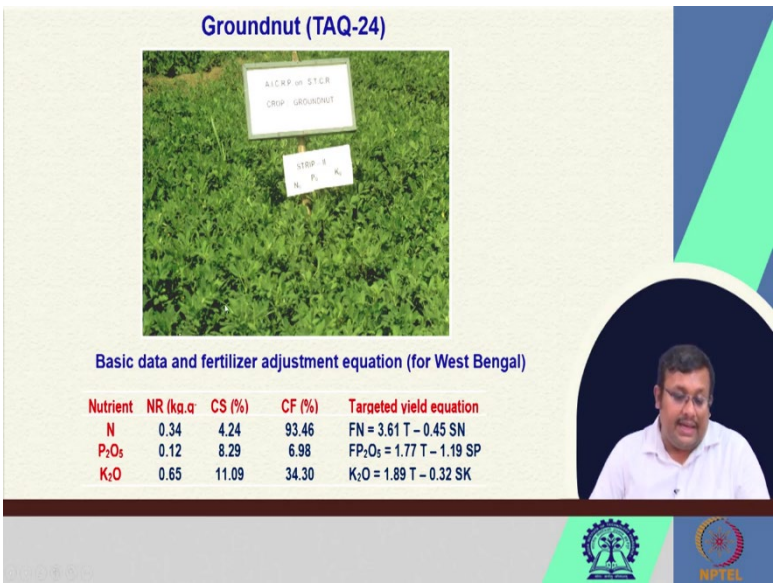
(Refer Slide Time: 5:01)

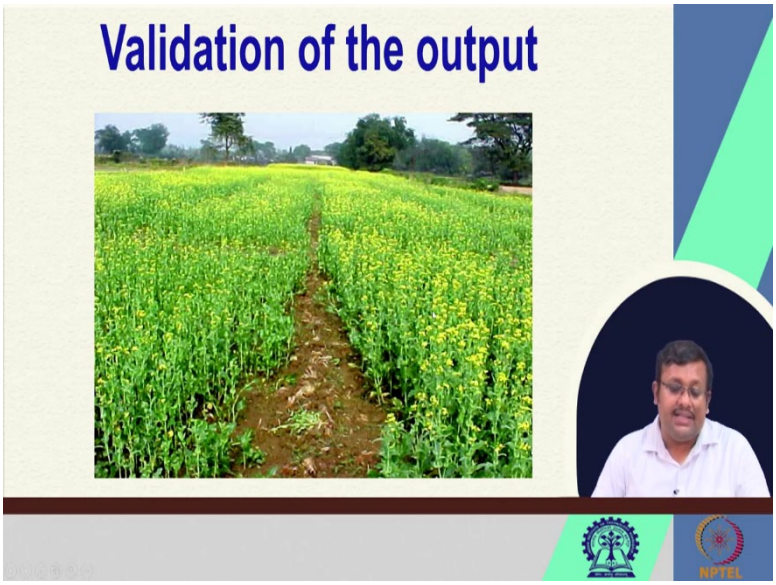


Now, this is the basic data and fertilizer adjustment equation for potato, for the variety Kufri Jyoti in West Bengal, state of India and we can see that N, P2 5, K2O requirement, nutrient and, so NR, CS, and CF for all these three nutrients are given, and we can see the targeted yield equation.

So, for fertilizer nitrogen we can see 3.61, T which is the targeted minus 0.45, SN means soil nitrogen, so once we calculate the soil available nitrogen, if we input this we can, and if we have a target yield, we can calculate the fertilizer nitrogen. Similarly, we can calculate the fertilizer P 25 as well as fertilizer K2. So, this is how we can calculate the fertilizer need for these three different nutrients.

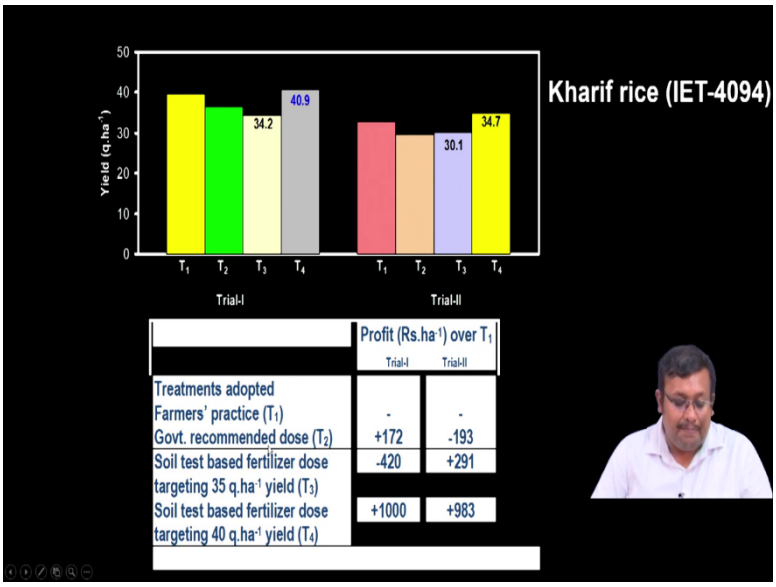
(Refer Slide Time: 6:14)





Similarly, for groundnut, we can see for variety TAQ-24, we can see here the NR, CS, CF for N, P25, and K 2, and also, we can see target yield equation for three different nutrients. Now, how to do the validation of the output? So for validation of the output we need some field trials also.

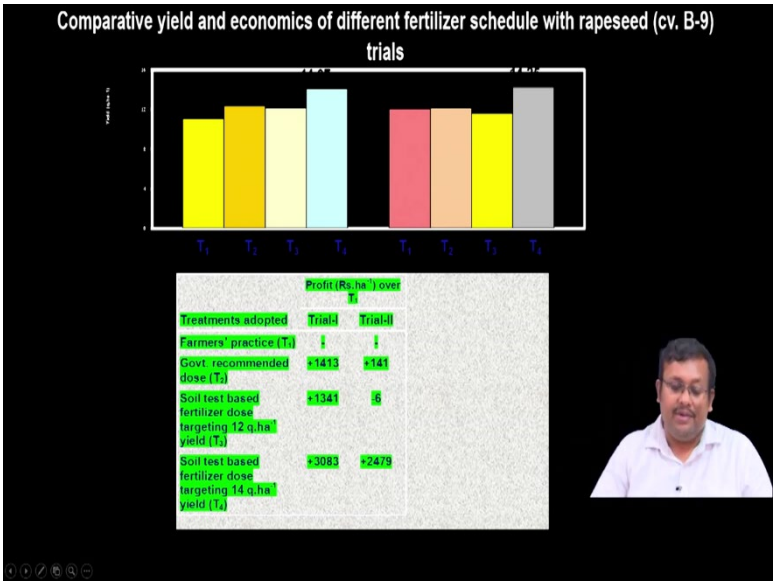
(Refer Slide Time: 6:50)



Now, let us see some results. One of the results we have seen that there are two trials, Trial 1 and Trial 2, and there are four different treatments. The first treatment is Farmers practice T1, T2 is the government recommended dose, T3 is the soil test based fertilizer dose targeting 35 quintal hectare per yield, and fourth one is soil test based fertilizer dose targeting 40 quintal hectare per hectare yield.

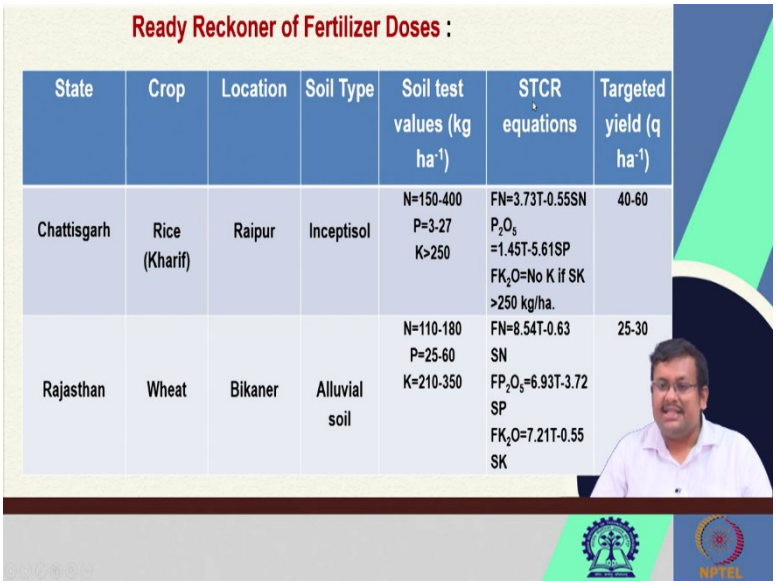
So, we can see that in case of government recommended dose, the profit of per hectare over T1 that is formal practice, we can see in case of Trial 1 using the government recommend dose, it is 172 rupees. However, there is a loss of 193 rupees for Trial 2 using the government recommended dose. When we are using T3, we are having a loss of 420, and in case of Trial 2, we are getting a profit of 291. In case of Trial 1 using T4, we are getting 1000 rupees of profit, and in case of Trial 2 we are getting a profit of 291. In case of Trial 1 using T4, the soil test, base fertilizer toast, using some target yield, like 40 quintal per hectare, then we are getting optimum profit per hectare.

(Refer Slide Time: 8:37)



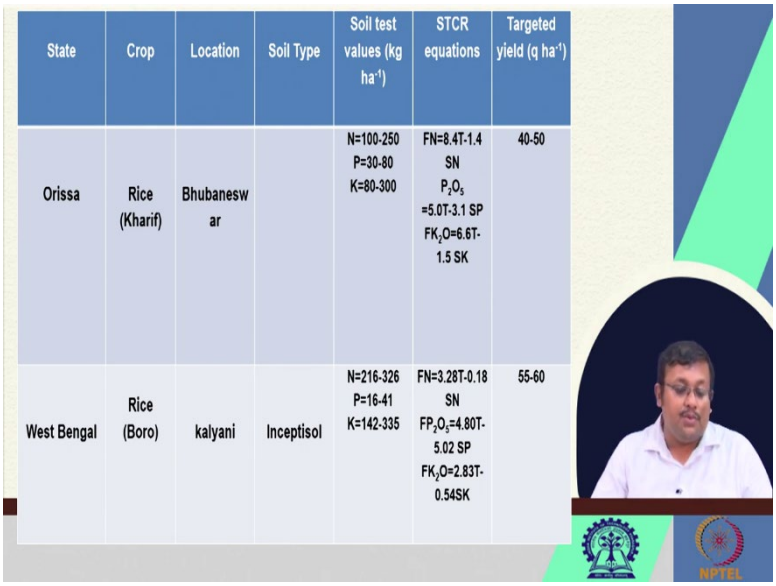
Similarly, for rapeseed also, there are two trials with four different treatments, and similarly you can see when we are using the government recommended tools, we are getting 1413 rupees per hectare in first trial, and in the second trial we are getting 141 rupees per hectare. In case of T 3, we are getting 1341, however, in case of Trial 1, we are getting 6 rupees per hectare loss. In case of soil test, based fertilizer dose targeting 14 quintals, T3 was 12 quintals, however when we are increasing it to 14 quintals, we are getting 3083 and 2479 rupees per hectare as profit.

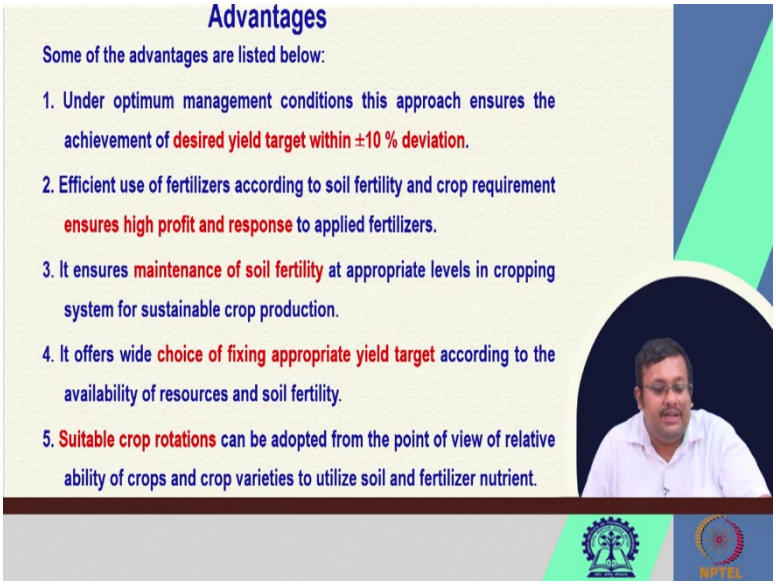
(Refer Slide Time: 9:28)



So, if you see the Ready Reckoner of fertilizer doses, you can see for different states and different crops, for different types of soil, we can have these STCR equation. Another name of the soil analysis fertility crop correlation is STCR or soil take test crop response equations for target yields, and we are getting this type of equations for all the states.

(Refer Slide Time: 9:56)

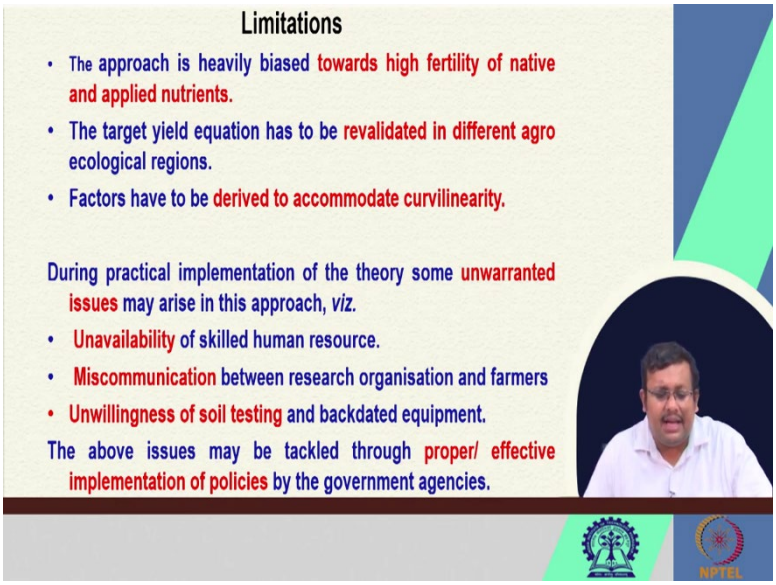




Similarly, for Orissa and West Bengal, you can get this type, so for all the states for different types of crops, we can get this type of equations. Now, let us see some of the advantages of this approach. The first advantage of this approach is under Optimum management condition. This approach ensures the achievement of desired yield target within plus minus 10 percent deviation. Secondly, efficient use of fertilizers are ensured according to soil fertility and crop requirement. And this as a whole ensures High profit and response to applied fertilizer, so this is the second advantage.

The third Advantage is 8, this using this approach, we can maintain the soil fertility at appropriate levels in cropping system for sustainable Crop Production. The fourth advantage of this method or this STCR approach is, it offers wide choice of fixing appropriate yield target according to the availability of resources and soil fertility. And fifth one is suitable crop rotations also can be adopted from the point of view of relative ability of crops and crop varieties to utilize soil and fertilize the nutrients, so these are five major advantages of this STCR approach or soil analysis crop correlation-based approach. Where we are fixing a target, and target yield, and for attaining that target end, we are using soil test values, I mean we are calculating the fertilizer requirements using the soil test values for different nutrients, okay.

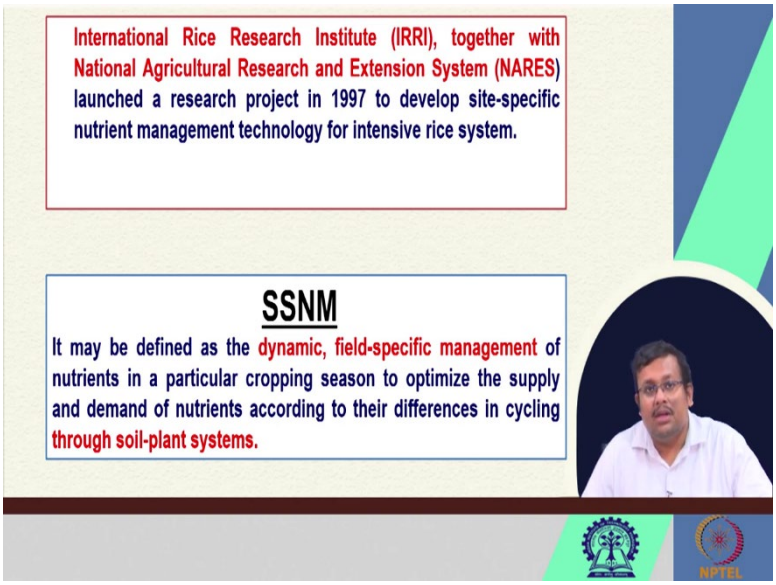
(Refer Slide Time: 11:50)



Now, apart from the advantages of this STCR approach, this STCR has some limitations also. First of all, this approach is heavily biased towards high fertility of native and applied nutrients. Secondly, the target yield equation has to be revalidated in different agro-ecoregion and factors have to be derived to accommodate curvilinearity. Now, during practical implementation of the theory, some unwarranted issues may arise in this approach. For example, unavailability of skilled human resource, then miscommunication between research organizations and farmers, and then unwillingness of soil testing and magnetic equipment.

So, these above issues may be tackled through proper or effective implementation of policies by the government agencies. So, these are some of the limitations and these should be properly addressed, so that these STCR approach can be utilized effectively.

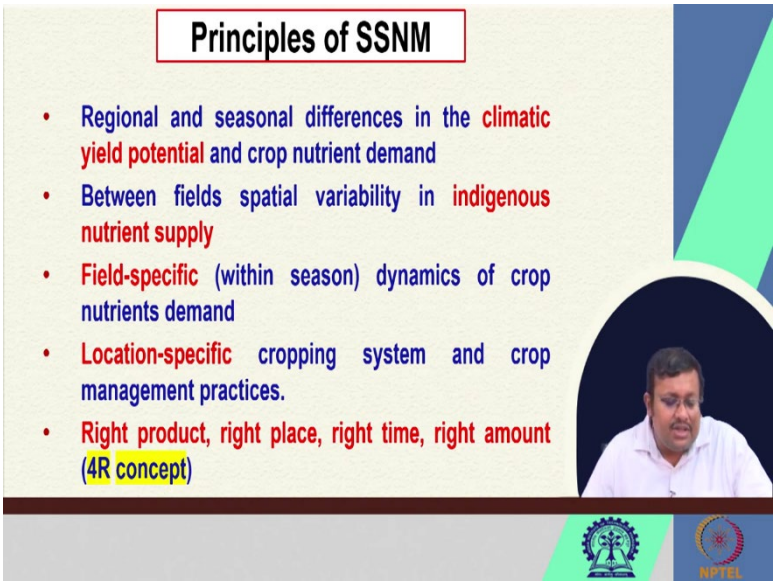
(Refer Slide Time: 13:04)



Now, let us discuss another important concept that is SSNM or site-specific nutrient management concept and approaches for nutrient management system. Now, International rights Research Institute or IRRI, together with national agricultural research and extension system launched a research project in 1997 to develop site specific nutrient management technology for intensive right system.

Now, what is SSNM? It may be defined as the dynamic field specific management of nutrients in a particular cropping season to optimize the supply and demand of nutrients according to their differences in cycling through soil plant systems. Again, as per the definition it is a dynamic field specific management of nutrients, to optimize the supply of the nutrients according to the crop demand.

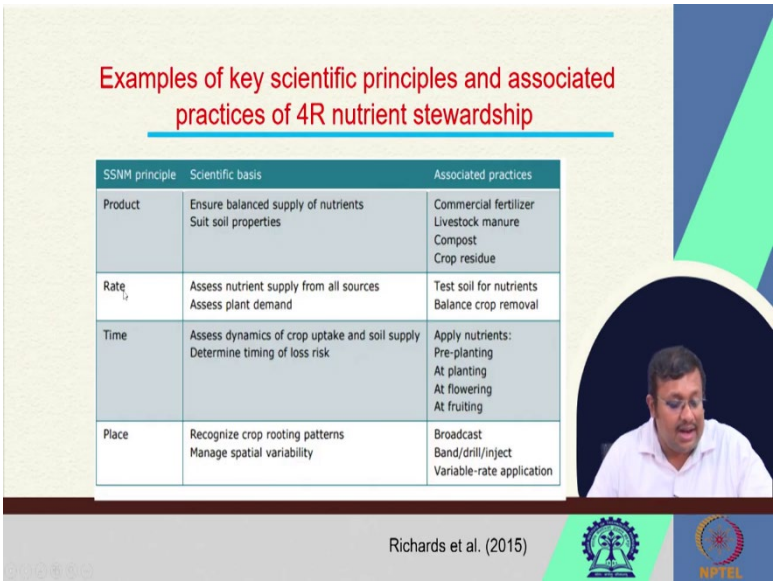
(Refer Slide Time: 14:16)



Now, what are the principles of SSNM? First of all, regional and seasonal differences in the climatic yield potential and crop nutrient demand, then between Fields special variabilities in indigenous nutrient Supply, then fields specific within season dynamics of crop nutrients demand, and full location specific cropping system and crop management practices, and the and the next one is the most important that is called 4R stewardship concept, that is a right product, right place, right time, and right amount.

You may see this 4R concept is a buzzword nowadays, and people are using this right product, right place, right time, and right amount concept or 4R concept, everywhere. Whereas, we are going for the site spacing nutrient management.

(Refer Slide Time: 15:22)



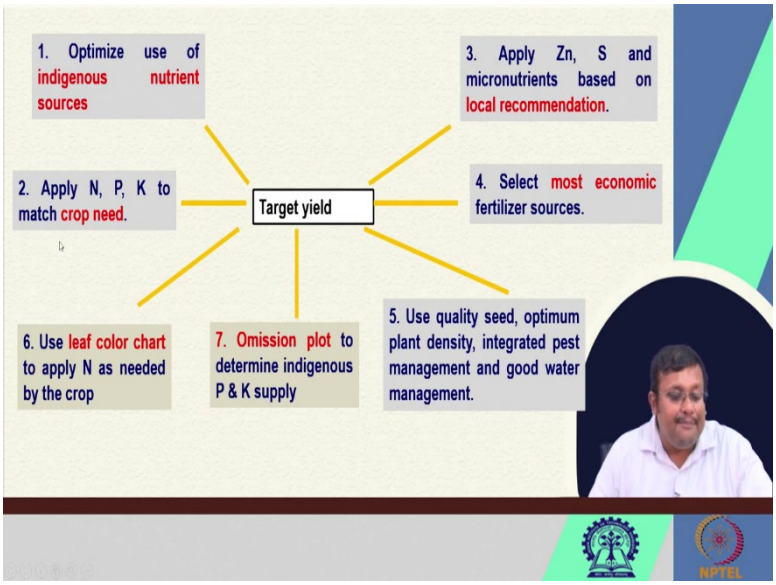
Now, some examples of key scientific principles and associated practices of 4R Newton stewardship. We have told that 4R means right product, right place, right time, and right amount, so right product, right rate, right time, and right place. So, right product means in, we have to ensure balance supply of nutrients which will suit soil properties. What are the associated practices? Commercial fertilizer, livestock manure, compost, crop residue, these are the associated practices.

What is right rate that is assessing nutrient Supply from all sources and assessing plant demand, so using these two scientific bases, we have to calculate the right rate. Just like in case of right product, we have considered the balance supply of nutrients and you know the soil properties. Similarly, for calculating the right rate, we have to calc we have to consider as you know nutrient Supply from all sources, and plant demand. What are the associated practices tests? You know we have to taste soil for nutrients and you have to balance crop removal.

Right time means you have to assess dynamics of crop uptake and soil supply and you have to determine timing of loss risk. You have to apply nutrients, pre-planting, at planting, at flowering, at fruiting, so these are the right times. And right place means you have to consider or recognize crop rooting pattern and you have to also manage the special variability, so you can select either broadcast or band or drill or inject or you can go with the variable rate application.

So, these are some scientific principle and associated practices of 4R Newton's stewardship. And these 4R Newton's stewardship is the backbone of site-specific nutrient management or SSNM.

(Refer Slide Time: 17:47)

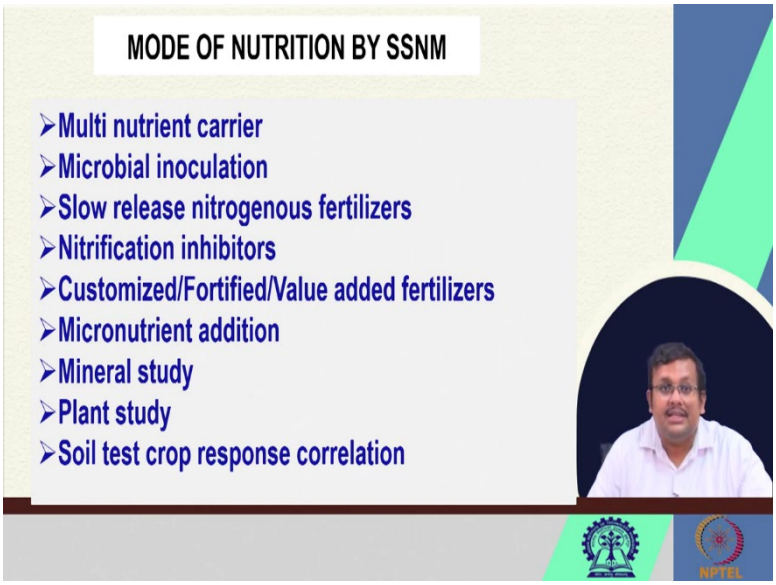


So, what we understand that site specific nutrient management can tackle typical problems of imbalanced nutrition and imbalance fertilization through soil testing. Now, in the site-specific nutrient management, we have to first fix a targeted, and then we have to optimize the use of indigenous nutrient resources. Then we have to apply N, P, K to match the crop need. In the third, we have to apply the zinc, sulphur, and micronutrient based on local recommendation.

Then we have to select most economic fertilizers resources or fertilizer sources. Then we have to use the leaf colour chart to apply nitrogen as needed by the crop, we can also use

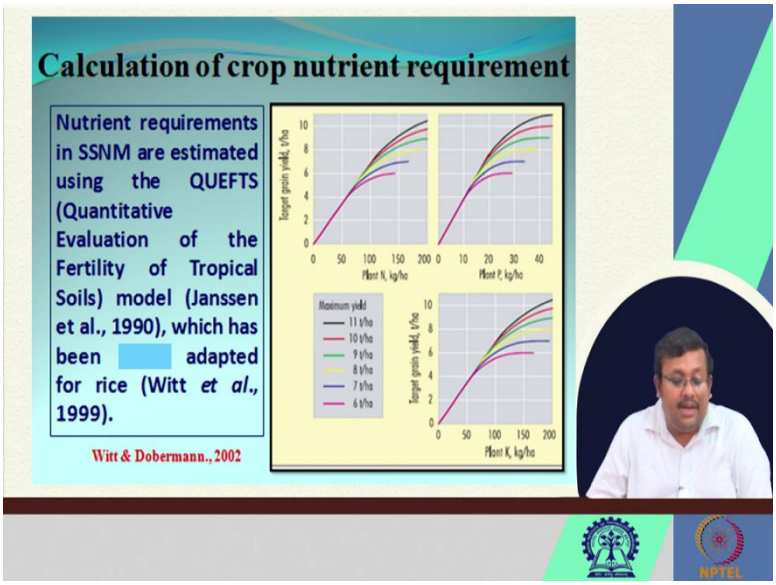
quantity seed, optimum plant density, integrated Pest Management, and good water management for SSNM. And also, finally, we can also use Omission plot technique to determine indigenous phosphorus and potassium Supply. So, these are some of the steps or some of the important components of site-specific nutrient management, after fixing a target field.

(Refer Slide Time: 19:16)



Now, what are the mode of nutrition by SSNM. You can use multi-nutrient carrier, you can use microbial inoculation, you can use slow-release nitrogenous fertilizer, you can use nitrification Inhibitors, you can use customized fortified or value-added fertilizers, you can use micronutrient addition, you can use mineral study, you can use plant study, you can use soil test crop response correlation. So, all of these we have already discussed. So, you can see that using all these methods, we can achieve the site-specific nutrient management. So, all these are integral components of site-specific nutrient management, okay.

(Refer Slide Time: 20:01)



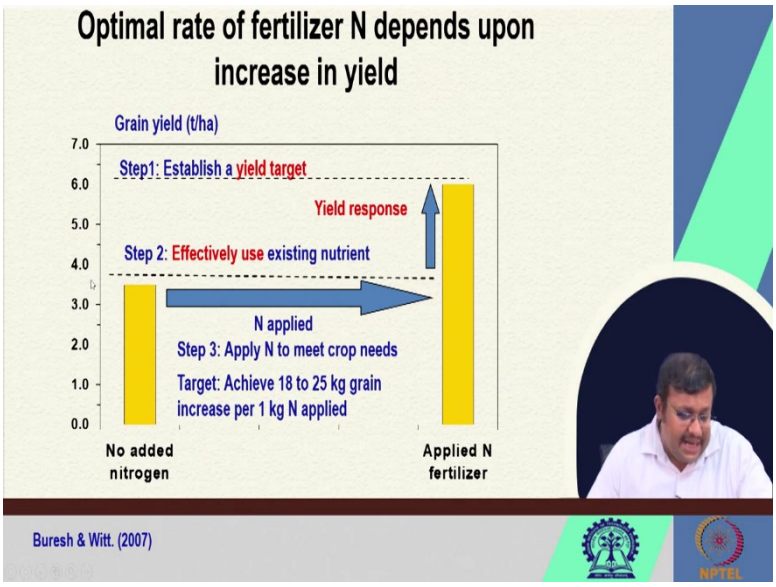
Now, let us see how to calculate the crop nutrient requirement in SSNM, so the nutrient requirements in SSNM are estimated using a model. This model name is quantitative evaluation of the fertility of the tropical soils or QUEFTS model. So, this QUEFTS model was developed by Janssen et al., in 1990, which has been adapted for Rice, by Witt et al. in 1999. So, this QUEFTS model is used for nutrient requirement in SSNM.

(Refer Slide Time: 20:39)

Now, we determine how much fertilizer nitrogen to apply? For example, so we have to estimate the total fertilizer nitrogen required for rice in a season and based on the expected yield response to nitrogen and efficiency fertilizer nitrogen use. So, fertilizer nitrogen

calculation can be done using in response to fertilizer nitrogen multiplied by nitrogen use efficiency. So, this is how we can calculate the fertilizer nitrogen requirement.

(Refer Slide Time: 21:06)

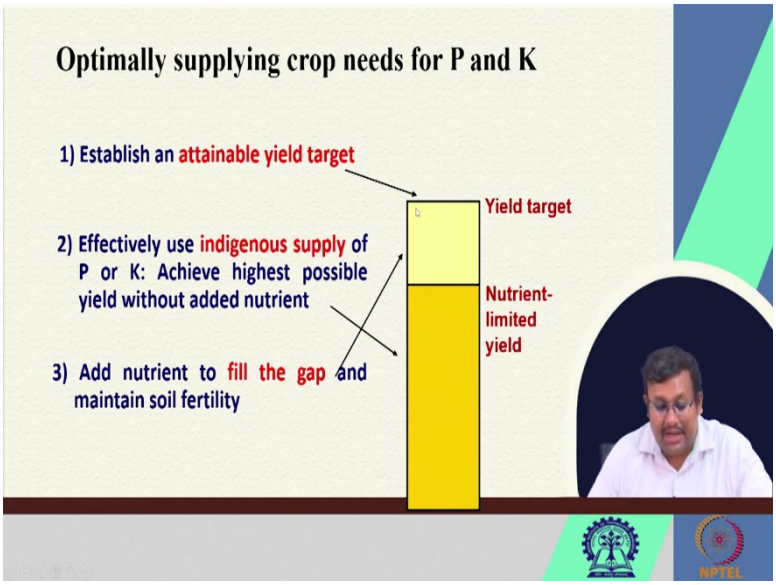


So, let us see an optimal rate of fertilizer nitrogen depends upon increase in yield, so here in this chart or in this graph we can see, in the x-axis we are seeing two extreme conditions where no added nitrogen and here you can see this body presents the applied nitrogen fertilizer and, in the y-axis, we can say grain yield. So, when there is a no added fertilizer and in case of applied nitrogen fertilizer, let us see the steps.

The step one is we have to establish a yield target, and second step is to effectively use the existing nutrient. So, when there is a no added nitrogen of course we are getting some yield, so this is the yield which we are getting through native supply of nitrogen from the soil. And then if we use the nitrogen, so we apply the nitrogen to meet the crop needs and target is to achieve 18 to 25 kg of grain increase per 1 kg of nitrogen applied, so you can see when we are applying the nitrogenous fertilizer, we are getting this yield response.

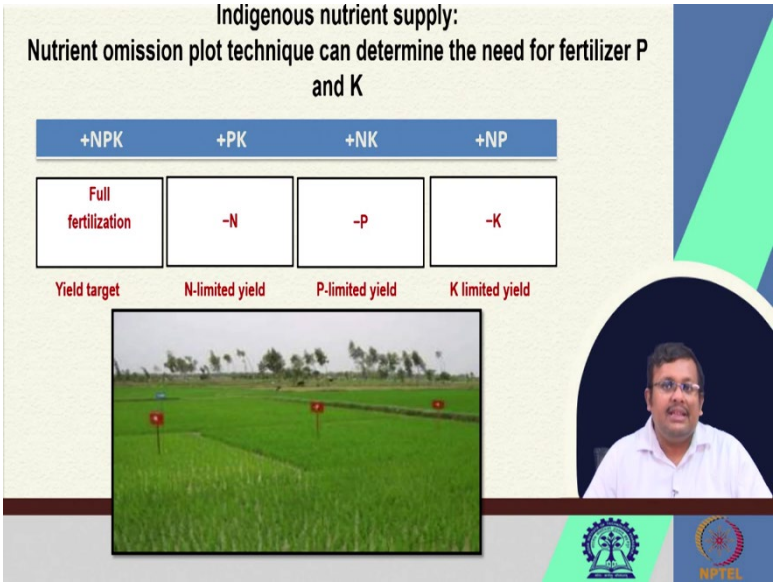
So, earlier we are getting this yield response where plants are growing using the native nitrogen, and when we are applying the nitrogen then we can see the yield response. So, the difference between the target yield, add the, if you know the yield of the using the existing nutrient, you can see the difference, so application of nitrogen is giving you the is yield response.

(Refer Slide Time: 22:57)



So, the steps are basically, first of all, you have to establish an attainable yield target, so here we are basically fixing an attenable yield target. And then, we have to effectively use indigenous supply of phosphorus and potassium to achieve highest possible yield without adding the nutrient, so here you can see this yellow bar is showing. And then we have to add nutrient to fill the Gap and maintain the soil fertility. So, here you can see this is the neutral limited yield and this is the additional yield which we are getting by adding the fertilizer nutrient. So, this is how you can optimally supply the crop needs for phosphorus and potassium.

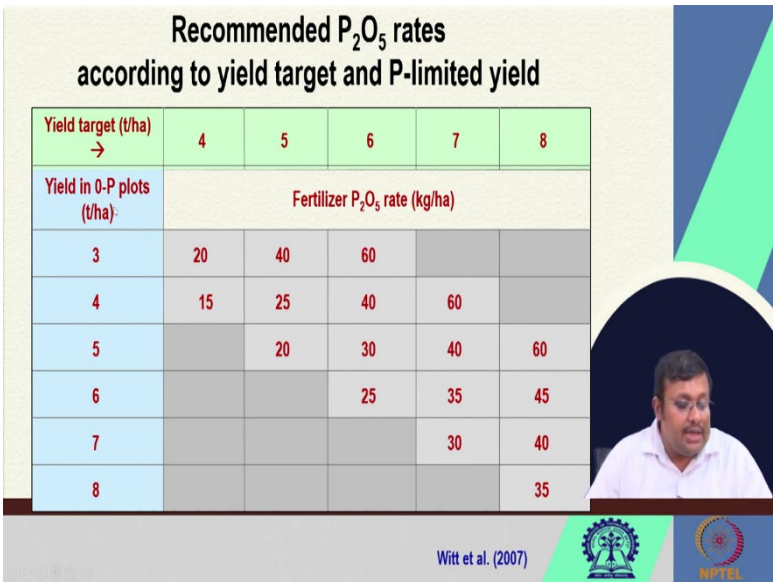
(Refer Slide Time: 23:46)



Now, for indigenous nutrient Supply, nutrient Omission plot techniques can be used to determine the need of fertilizer, phosphorus, and potassium. So, here you can see this is the scheme, so we have and yield target and we use the full fertilization of NPK, and then we are applying the full phosphorus potassium but we are not applying the nitrogen, so we will get the nitrogen limited yield. Similarly, we are also using the full NK but we are removing the phosphorus we are not giving the phosphorus fertilization, so we are giving, we are getting phosphorus limited yield.

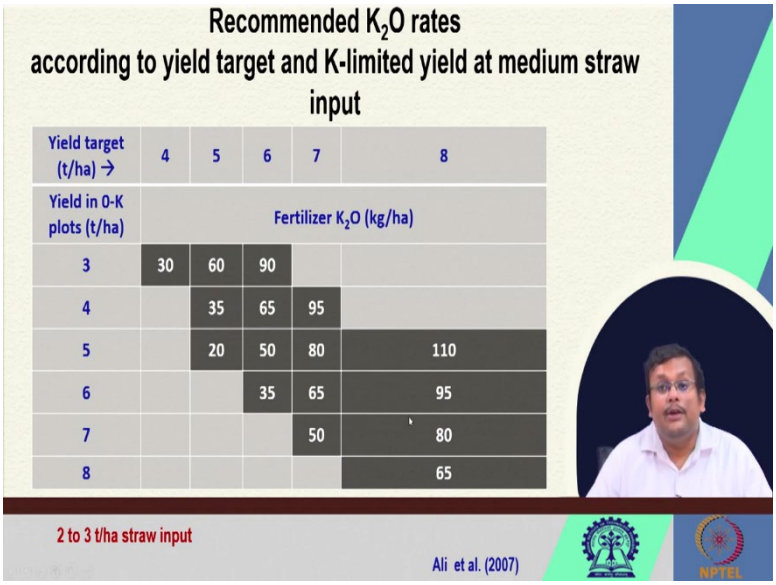
And then, we are not giving again potassium fertilizer and we are getting the nitrogen and phosphorus, we are giving only the nitrogen phosphorus fertilizers, we are getting the potassium limited yield. So, by seeing the differences, by comparing the differences, we can see the impact of different nutrients on the corrupt growth, so this is called Omission plot technique.

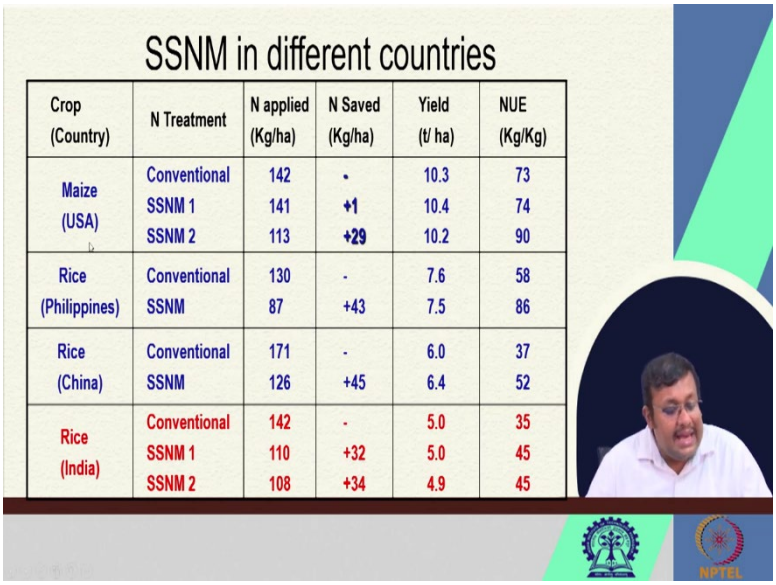
(Refer Slide Time: 24:48)



Now, if you see the recommended phosphorus pentoxide rates according to the yield target and P limited yield. So, yield in 0 P plot that means when we had wheat, we have not applied any first for us, so if these yields are from 3 ton per hectare, 4 ton per hectare, 5 6 7 8 tons per hectare, and if our target yield is 4 tons or 5 tons up to 8 tons per hectare, so we can see that recommended fertilizer P 25 rate in kg per hectare. So, wheat at all has showed this chart for recommending the fat P205 rates according to yield target and in case of phosphorus limited yield condition.

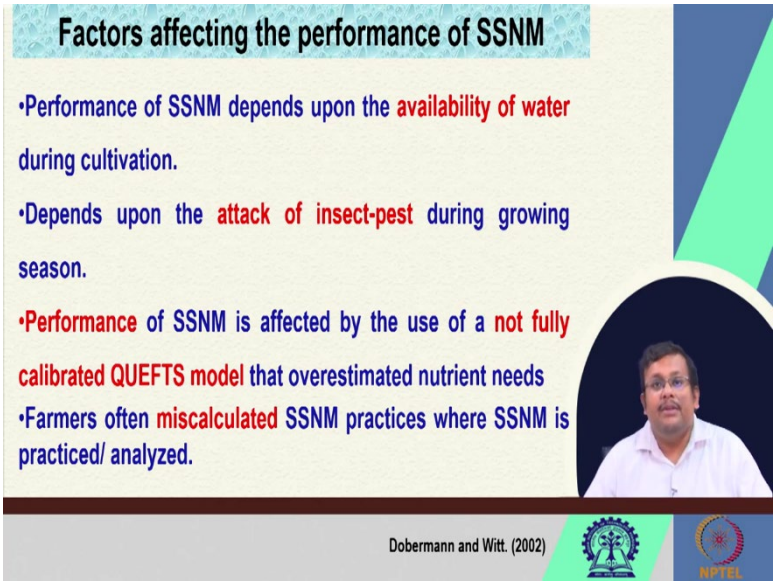
(Refer Slide Time: 25:40)





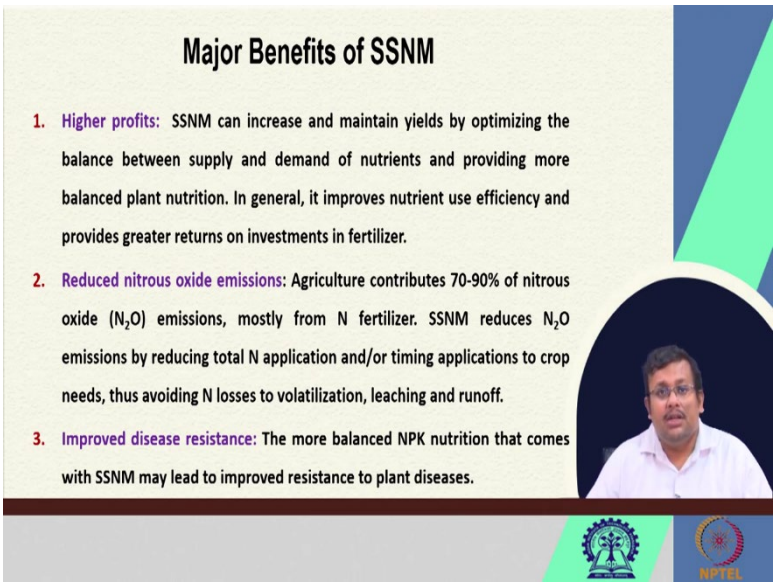
Similarly, for potassium limited yield condition also at medium straw inputs, we can see this is the recommended K2 rates. If we see the SSNM in different countries, we will see that in case of Maize, mainly SSNM is practiced in USA. So, conventional practices and different types of SSNM practice can save a nitrogen. In case of Philippines, SSNM is practiced in rice and we can see conventional and SSNM practice and we can see that there is saving of nitrogen. In case of China, SSNM is applied in rice and you can see there is saving of nitrogen. In case of India, we can also see that incident in practice can save nitrogen, as compared to the as compared to the conventional fertilization.

(Refer Slide Time: 26:40)



Now, what are the factors which affect the performance of SSNM? Performance of SSNM depends on upon the availability of water during the cultivation, and also it depends upon the attack of insect pests during growing season. Performance of SSNM is affected by the use of a not fully calibrated QUEFTS model that overestimated the nutrient yields. Next, and farmers often miscalculated SSNM practices, where SSNM is practiced or analysed, so these are some of the factors which can affect the performance of SSNM practice.

(Refer Slide Time: 27:18)



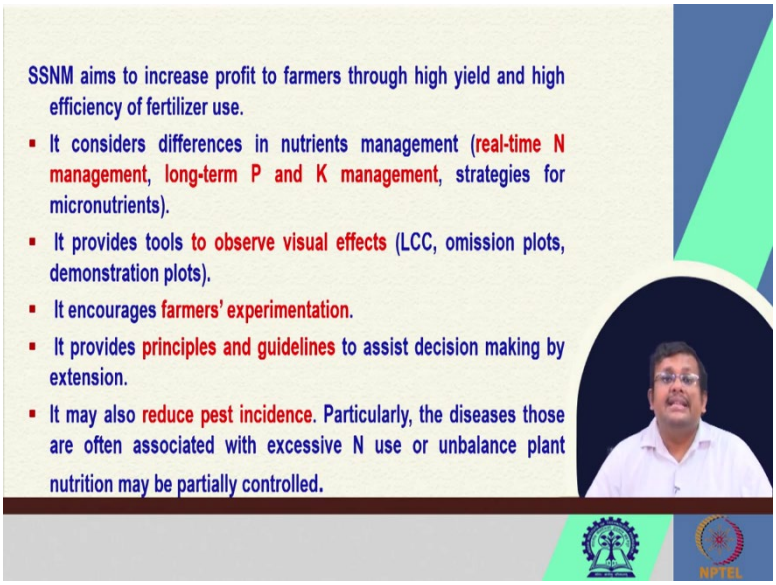
Now, what are the major benefits of SSNM? There are three major benefits, first major benefit is to get the higher profit, so SSNM can increase and maintain yields by optimizing the balance between supply and demand of nutrients and providing more balanced plan

nutrition. In general, it improves nutrient use efficiency and provides greater Returns on investment in fertilizer. This is the first benefit of SSNM.

The second is, reduce nitrous oxide emission. Now, agriculture you know that agriculture contributes 70 to 90 percent of nitrous oxide emission mostly from nitrogen fertilizer, and this nitrous oxide is known as a greenhouse gas. So, SSNM, when you practice a SSNM that reduces the nitrous oxide emission by reducing total nitrogen application and a timing of application to crop needs, because we have seen that we are you, in the SSNM and we see slow-release nitrogenous fertilizer is in component.

So, when we are using those different types of slow-release nitrogenous fertilizer, nitrogenous Inhibitors, then we can see that nitrous oxide emission is reduced, and avoiding and thus we can avoid the nitrogen losses to volatile digestion leaching and runoff. And the third important benefit is, improved disease resistance, so the more balanced NPK nutrition that comes with nitrogenous lead to improve resistant to plant diseases.

(Refer Slide Time: 28:50)

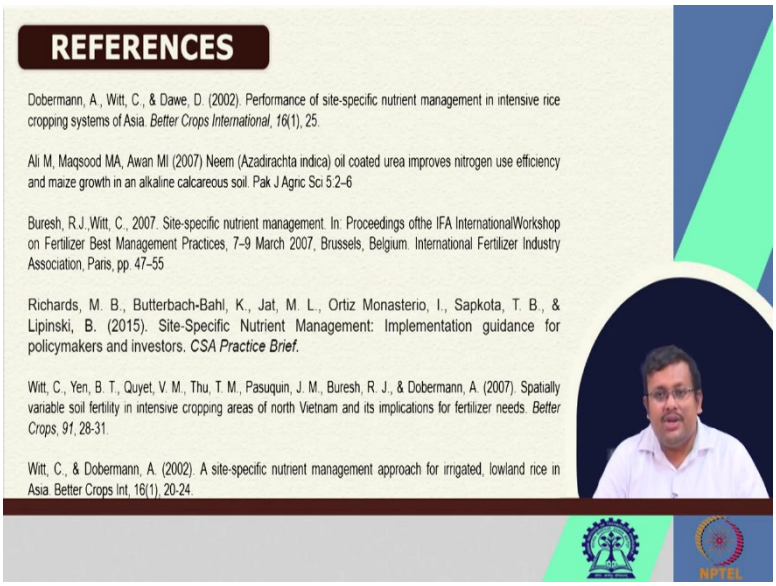


So summarily, we can see that SSNM aims to increase the profit to Farmers through high yield and high efficiency of fertilizer use. It considered differences in nutrient management, using real-time nitrogen management, long term phosphorus and potassium management, and strategies for micronutrients.

It also provides tools to observe visual effects, that is using LCC, Omission plots and demonstration plots. It encourages Farmer's experimentation; it provides principles and guidelines to asset decision making by extension. And it may also reduce space incidence,

particularly the disease those are often associated with excessive nitrogen use or unbalanced Plant Nutrition may be partially controlled. So, these are the benefits of SSNM.

(Refer Slide Time: 29:46)



So, guys, we have wrapped, we have completed this discussion regarding SSNM and different types of nutrient recommendation approaches. Let us wrap up this lecture and let us discuss more about the integrated nutrient management and different approaches of integrated linear nutrient management in our next lecture, with the with the help of some case studies. Thank you.