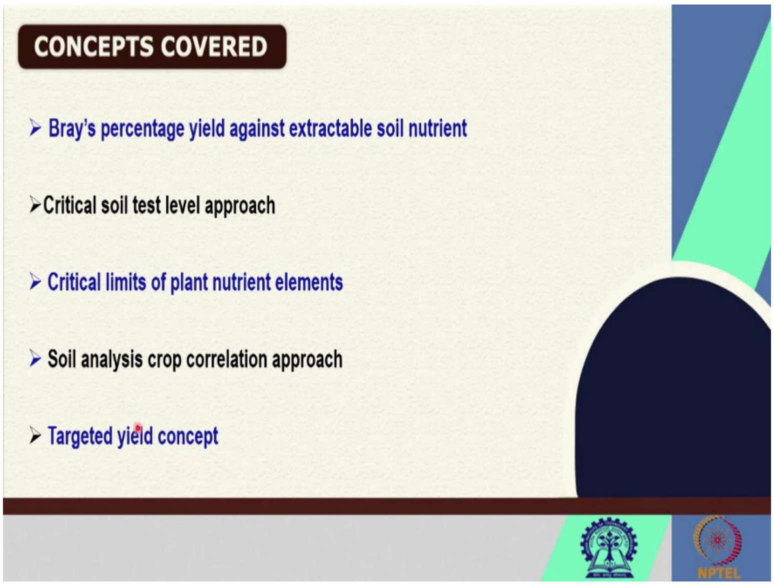
Soil Fertility and Fertilizers
Professor Somsubha Chakraborty
Agricultural and Food Engineering Department
Indian Institute of Technology, Kharagpur
Lecture 53
Fertilizer Recommendation Approaches and Integrated Plant Nutrient Management (Contd.)

Welcome friends, to this new lecture of week 11 of the NPTEL Online Certification Course of Soil Fertility and Fertilizers. And we are currently at lecture number 53, and in this week 11, we are discussing fertilizer recommendation approaches and integrated nutrient management. In the previous two lectures of this week, we have discussed the potential concept, the attainable yield concept, and actual concept, and also, we have discussed or summarized the salient features of different soil testing or soil fertility evaluation methods.

We have discussed the demerits of depending only on visual deficiency symptoms. We have discussed also the plant tissue testing salient points, how to do, what are the salient steps of plant tissue testing. And then, we have also discussed the biological test method for soil fertility evaluation. And finally, we have also discussed about the soil testing methods, we have summarized those methods which are commonly used for available macro and micronutrients and also for the soil conditions or soil like, whether our soil is saline, alkaline or acidic, we have discussed.

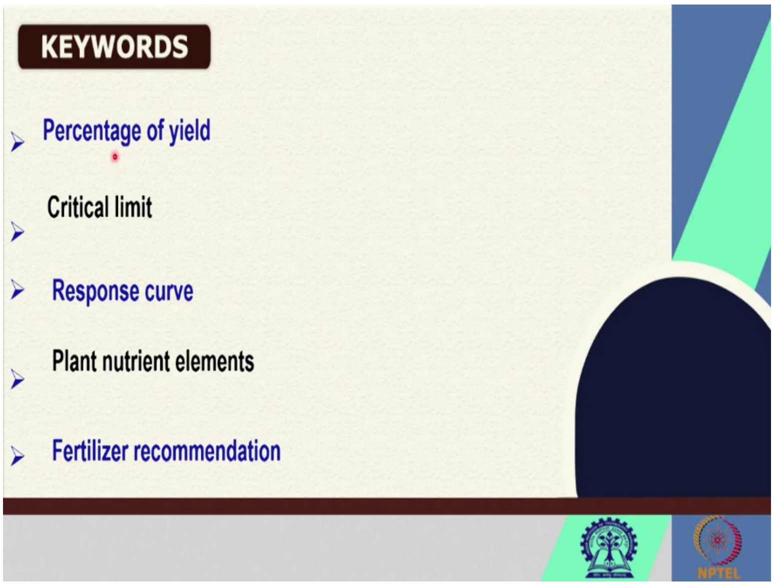
And then, we have discussed different types of methods for interpretation, so of soil test values. What are the ranges of the soil test values in the low, medium, and high category? And, so and then recommendation approaches, we have discussed. Now, we are going to continue from there when we get to see some of the interpretation and recommendation approaches. We are going to, also we are going to discuss the base percentage yield against extractable soil nutrient. We are going to discuss the critical soil test level approach. Then, critical limits of plant nutrient elements.

(Refer Slide Time: 2:30)



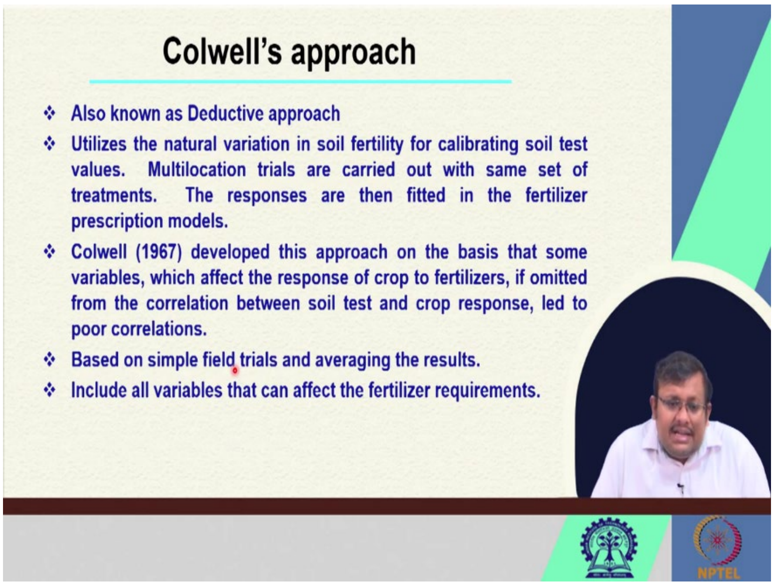
And then, soil analysis crop correlation approach, and finally we are going to discuss the targeted yield Concepts. So, these are the concepts which you are going to cover in this lecture.

(Refer Slide Time: 2:43)



These are some of the keywords like percentage of yield, critical limit, response curve, plant nutrient elements, and fertilizer recommendations, so these are some of the keywords for this lecture.

(Refer Slide Time: 2:56)

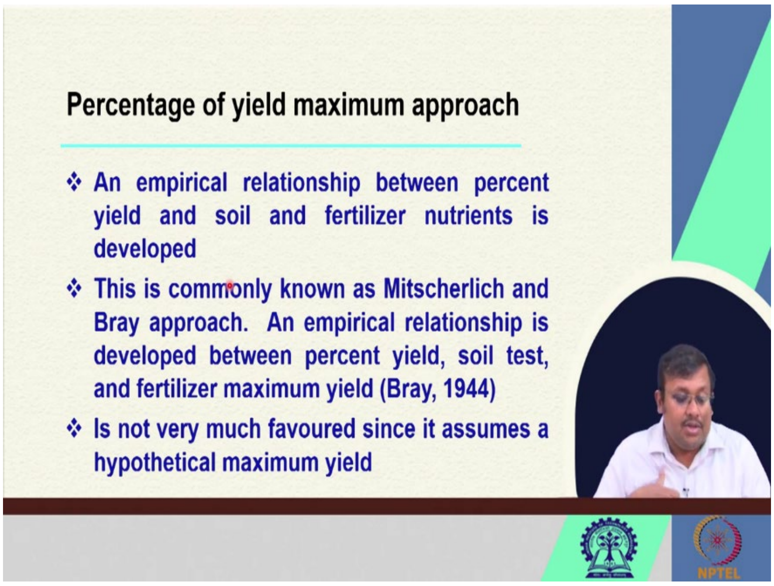


Now, while discussing the soil test interpretation and recommendation, we have also discussed the, we have discussed the generalized approach, we have discussed the soil test-based approach, now let us discuss the Colwell's approach. This approach is also known as deductive; it utilizes the natural variation in soil fertility for calibrating soil test values. In this approach, multiplication trials are carried out with the same set of treatments and the responses are then fitted in the fertilizer prescription models.

Why we call it as a Colwell's approach? Because Colwell's in 1950-67 developed this approach on the basis that some variables which affect the response of crop to fertilizer, if omitted from the correlation between soil test and crop response led to poor correlation. So, this is called Colwell's approach and we can see why this is also known as deductive approach. Because here we are deducing, we are deducting some of the variables which can affect the response of the crop to fertilizer which will ultimately impact the correlation between soil test and crop response.

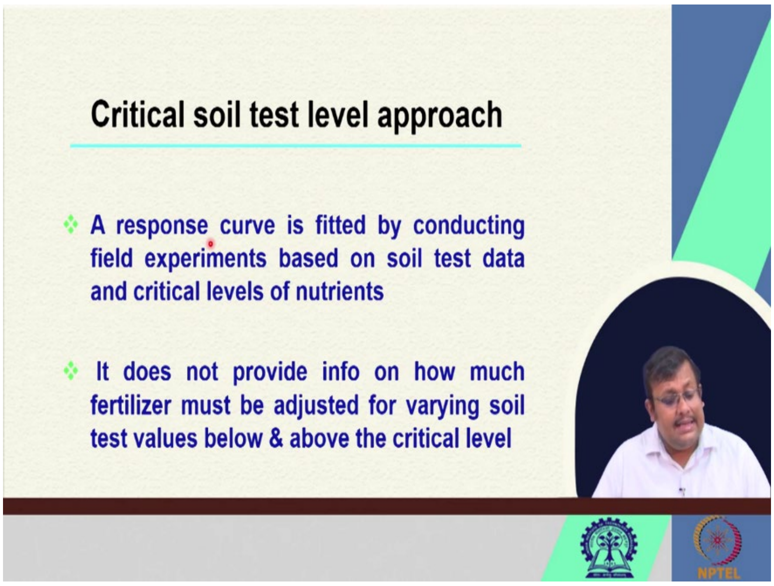
Remember, that this approach is based on simple field trials and averaging the results. And it can it includes all the variable that can affect the fertilizer requirements. So, these are some of the salient features of Colwell's approach.

(Refer Slide Time: 4:50)



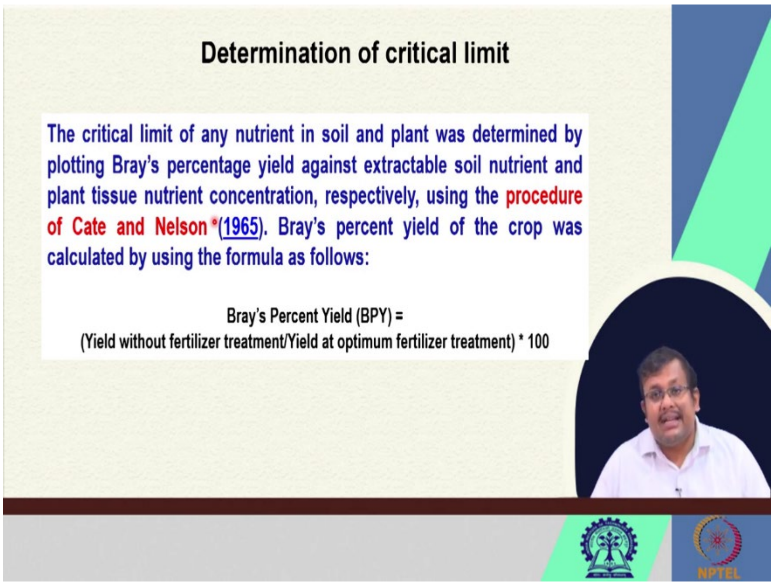
The next approach is percentage of yield maximum approach. So, basically an empirical relationship between percentile and soil and fertilizer nutrient is developed, and this is commonly known as Mitscherlich and Bray approach. An empirical relationship is developed between percentile, soil test, and fertilizer maximum yield. However, it is not very much favoured, since it assumes a hypothetical maximum yield. So, this is, these are some of the salient features of percent of yield maximum approach.

(Refer Slide Time: 5:31)



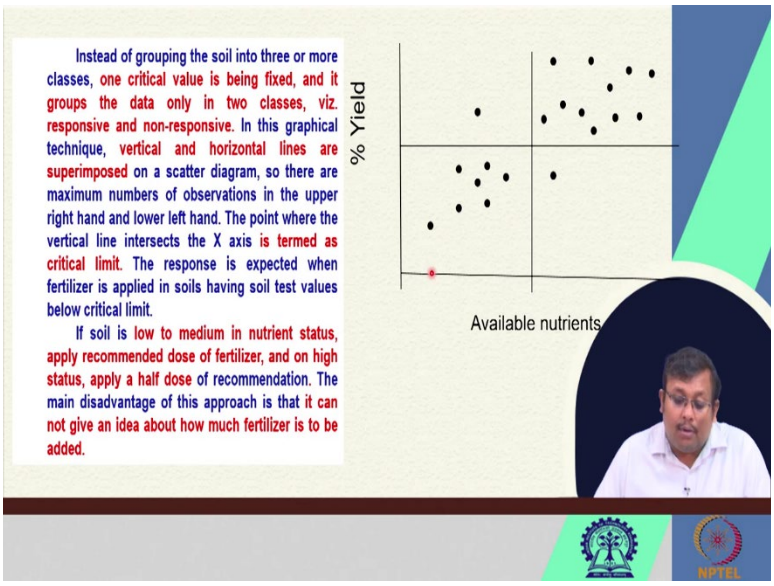
The next approach is critical soil test level approach. Here, in this approach a response curve is fitted by conducting field experiments based on soil test data and critical levels of nutrients. And it does not provide info on how much fertilizer must be adjusted for varying soil test value, below and above the critical level, so this is the major drawback of this critical soil test level approach. This is, again this approach basically fits a response curve, a plant yield or percentage of plant yield by conducting field experiment based on soil test data and critical levels of nutrients. However, the major drawback is it does not provide any info on how much fertilizer adjustment need to be done, used to be done, below and above the critical level.

(Refer Slide Time: 6:39)



Now, how to determine the critical limit? So, the critical limit of any nutrient in soil and plant was determined by plotting base percentage yield against extractable soil nutrient and plant tissue, nutrient concentration. Now, using the procedure of Cate and Nelson, so base percent yield, let us see base percent yield, how to calculate base percent yield. So, base percent yield of the crop was calculated by using the formula, where base percentage will be basically the multiplication of yield without fertilizer treatment, and then yield at Optimum fertilizer treatment multiplied by 100. So, yield without fertilizer treatment by yield at Optimum fertilizer treatment multiplied by 10, so this is how we calculate the base percentage yield.

(Refer Slide Time: 7:34)



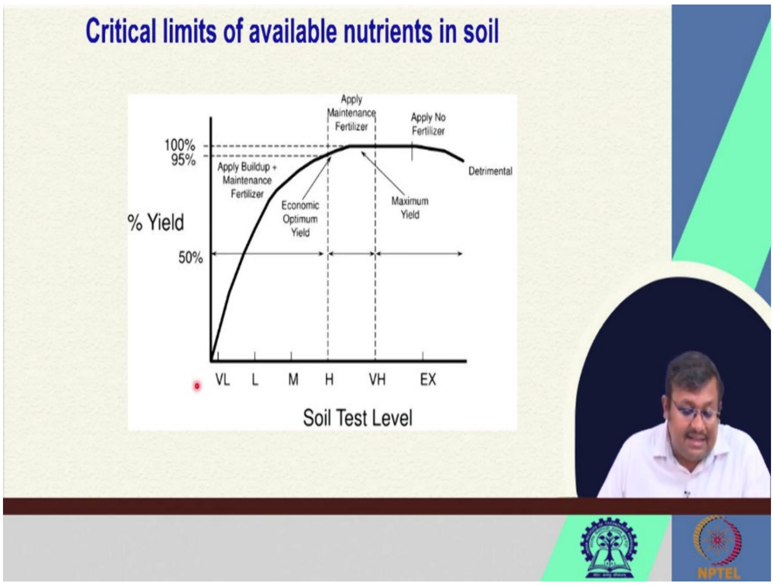
Now, instead of grouping the soil into, so now we are doing the soil test analysis, soil analysis for determining the available nutrients. And then, we are plotting the available nutrients in the x-axis and y-axis, we are putting the percentage yield. So, instead of grouping the soil into three or more classes, one critical value is been fixed. Now, in case of soil test-based approach, we remember that we have this low, medium, and high. However, here we are grouping them into two classes, that is vertical and horizontal and, that is responsive and non-responsive.

Now, in this graphical technique you can see vertical and horizontal lines are superimposed on a scattered diagram. So, this is basically scatter diagram between available nutrients and percentile. So, here this vertical and horizontal lines are superimposed, so that there are maximum numbers of observation in the upper right hand, and lower right hand. Now, the point where the vertical line insects, the x-axis is termed as the critical you know limit, so this is the critical limit.

So, the response is expected, when fertilizer is applied in soils, having soil test values below critically, so we can see that below this critical limit, if we apply the fertilizer, we will get crop response, so this is the definition of critical limit. Now, in this critical limit, we are basically dividing the data into responsive and non-responsive, so basically below the critical limit, the data become responsive, above the critical limit the data become non responsive, below it become responsive.

Now, if soil is low to medium in nutrient status, apply recommended dose of fertilizer, and on high status apply a half dose of recommendations. So, generally it is says that when the soil belongs to this medium and you know low to medium in nutrient status, generally it is recommended to apply a recommended dose of fertilizer, and on high status, when it is in high status a half dose of recommended, half of the recommended doses applied should be applied, and the main disadvantage of this approach is that it cannot give any idea about how much fertilizer is to be added. So, this is how this critical limit approach works.

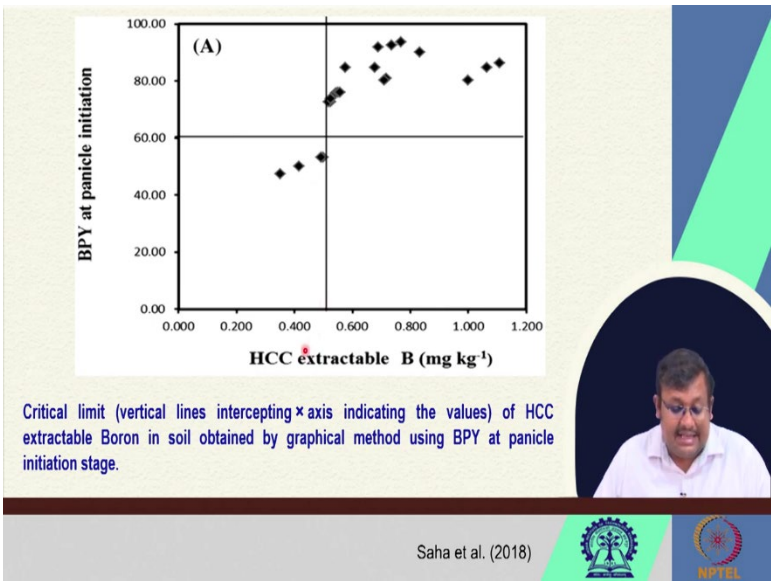
(Refer Slide Time: 10:27)

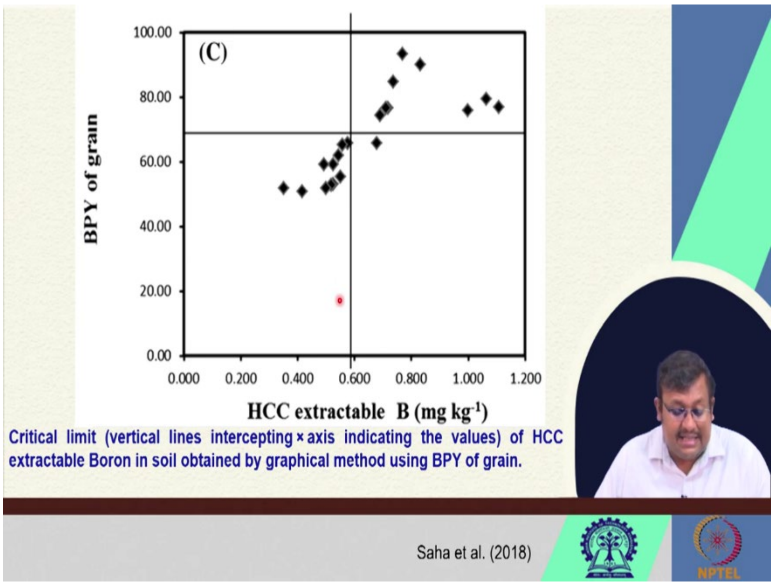


If we go ahead and see the actual grab between the soil test level and percentage yield, we can see this graph looks like this, and here you can see after this the graph, so the graph is increasing with increasing soil test level from very low, to low, to medium, to high, so you can see with the increase in soil test level, the percentage yield is increasing at higher rate, and then their rate of increase is slow down, is slowing down, and then they are reaching a plateau. And after certain higher level of soil concentration, which we call excessive amount, then we will see again that shows the detrimental effect.

So, if we draw a vertical line this will consider as the critical limit. And here, we can see this is the maximum yield and this is basically the economic Optimum yield, so this is a maximum yield where we can see per 100 percentile and economic Optimum value we are getting here when the yield may be 95 percent. So here, in this Zone from high to very high, it is suggested that we should apply the maintenance fertilizer, and beyond this very high, we should not apply any fertilizer. And below these you know in this Zone we should apply build up plus maintenance fertilizer, so this is how we should use the critical limits of available nutrients in the soil to identify the zone where we should apply the fertilizer the crop.

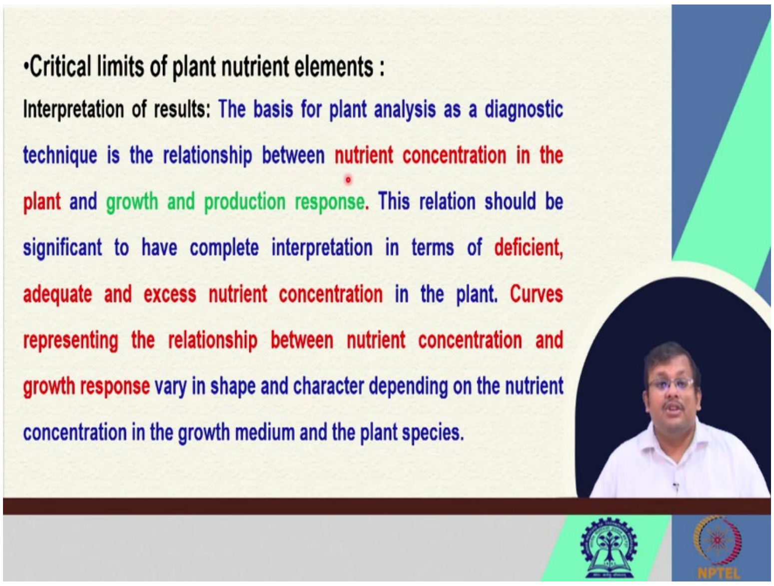
(Refer Slide Time: 12:28)





So, let us see some examples, here you can see that the base percentage yield at particle initiation stage of rise and here you can see hot calcium chloride extractable boron in PPM, so that shows this scatter plot, and if we can draw this vertical and horizontal line we can see this is a critical limit can be seen using this vertical line where, which is intercepting the x axis and, so we can clearly see that somewhere in between 0.4 to 0.6 PPM, the critical limit of boron is there. Then, if you see the critic, you know break percentage yield of grain, we can see that here the critical limit is basically around 0.6 PPM.

(Refer Slide Time: 13:36)



Now, interpretation of the results from the critical limit approach, the basis for you know, if we consider the interpretation of the particular limit approach, the basis for plant analysis as a diagnostic technique is the relationship between nutrient concentration in the plant and growth and production response, we know that. So, this relation should be significant to have complete interpretation in terms of deficient adequate and excess nutrient concentration in the plant.

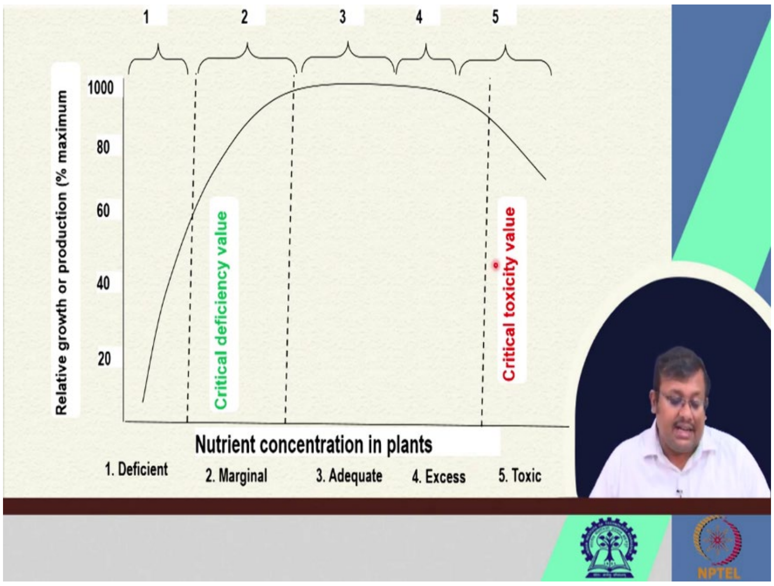
Now, carbs representing the relationship between nutrient concentration and growth response vary in shape and character depending on the nutrient concentration in the growth medium and data plant species, we see that in details in this chart.

(Refer Slide Time: 14:25)

So, when nutrients are in deficiency range plant growth and illness significantly reduced and foliar deficiency symptoms occur, we know that. Now, in this range application of nutrient results in sharp increase in the growth, so below the critical nutrient level if we apply the fertilizer, we will see the sharp increase in the growth.

Now, in marginal range growth or yield is reduced but plant does not show any deficiency symptom. Sometimes, the marginal range is also known as the transition zone, within the marginal or transition zone, the critical level or concentration lies. So, the critical level can be defined as the concentration at which growth or yield begins to decline significantly, we know that.

(Refer Slide Time: 15:09)

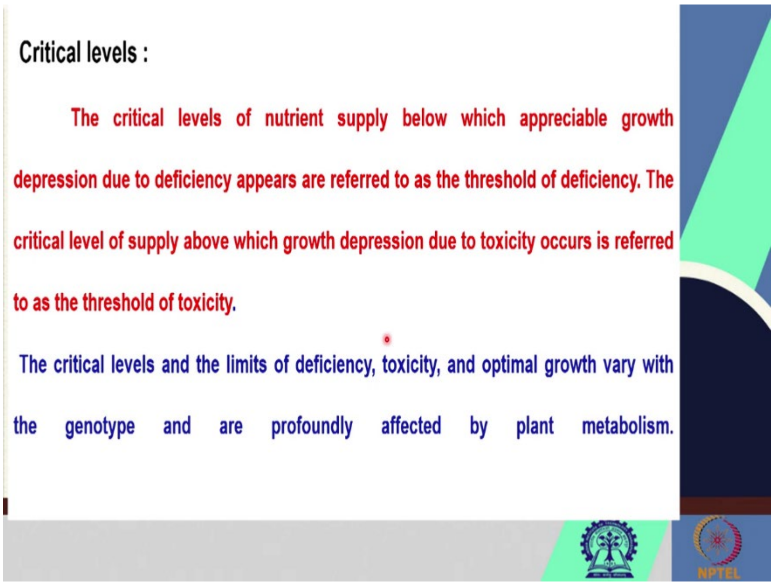


So, here you can see nutrient concentration in plants, so there are different zones, like deficiency Zone, marginal zones, adequate Zone, excess Zone, and toxic zones, we know that toxic zones, critical toxicity limit, and critical deficiency values are there. Based on this Zone, we can see in which category the nutrient concentration is there. So, if we go back and see these very low, so this is a deficiency Zone and this is a medium or marginal Zone, and then as we move in this x-axis, we can see the high vary in x-axis, Zone which can create a nutrient toxicity.

So similarly, here also we can see here deficiency Zone, then marginal Zone, then adequate Zone, axis Zone, and oxy zone, so if we go, if we see that this marginal range is also known as the transition zone, so within this marginal or transition zone, the critical level of concentration line.

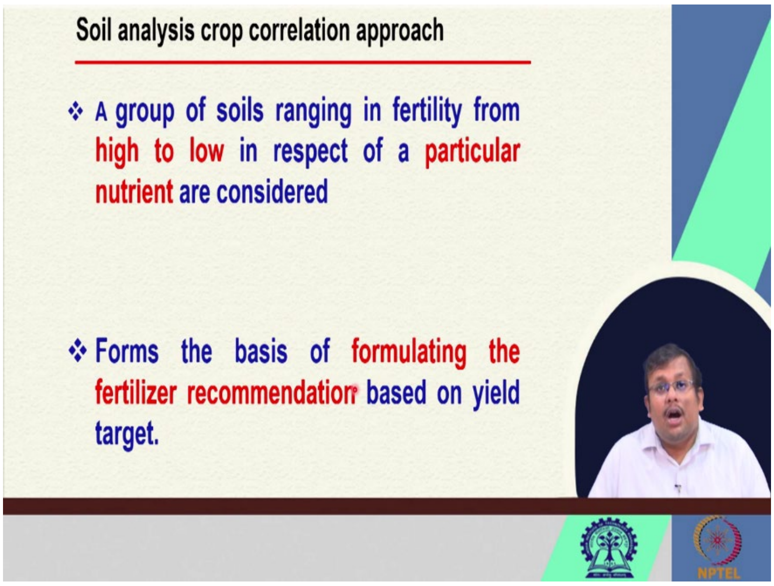
So, here we can see the critical concentration, we remember this is a critical concentration, and then the critical you know and below, and when we go further down in the in the x-axis, we can see the deficient Zone where severe deficiency of the crop growth can be seen.

(Refer Slide Time: 16:27)



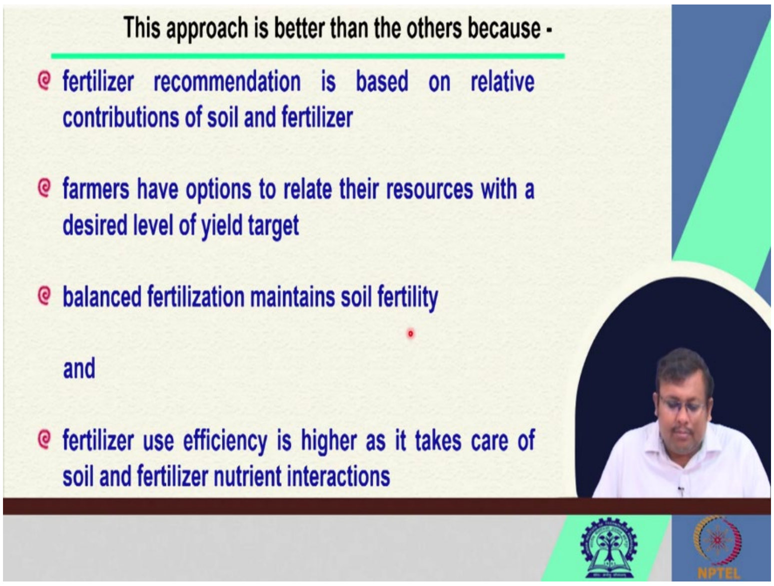
So, the critical level of nutrient Supply below which the appreciable growth depression due to deficiency appears are referred to as a threshold of deficiency. Now, we can see here this is the you know threshold of deficiency, so below that point we will see the deficiency of the crop. Now, the critical level of supply above which the growth depression due to toxicity occurs is referred as the threshold of toxicity. So, the critical levels and the limits of deficiency toxicity and Optimum growth vary with the genotype and are profoundly affected by plant metabolism.

(Refer Slide Time: 17:14)



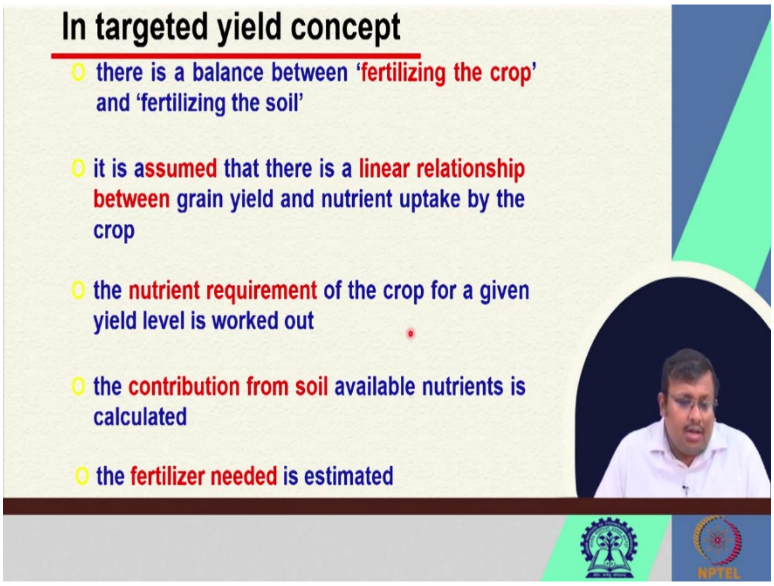
Now, if we see the another approach that is called soil analysis crop correlation approach. In This approach a group of soils ranging in fertility from high to low in respect of a particular nutrient are considered. Now, it forms and this approach forms the basis of formulating the fertilizer recommendation based on yield targets, so here we are considering the yield target for identification of the fertilizer recommendation.

(Refer Slide Time: 17:47)



Now, this approach is better than others, whatever we have discussed like Colwell's approach, then you know base percentage yield approach, then critical level approach, but this approach is basically this soil analysis crop correlation approach is basically superior than those, because fertility is the recommendation is based on a relative contribution of soil and fertilizer. And farmers have the options to relate their resources with a desired level of yield Target. It can offer the balance fertilization to maintain the soil fertility and fertilizer use efficiency is higher as it takes care of soil and fertilizer nutrient interactions.

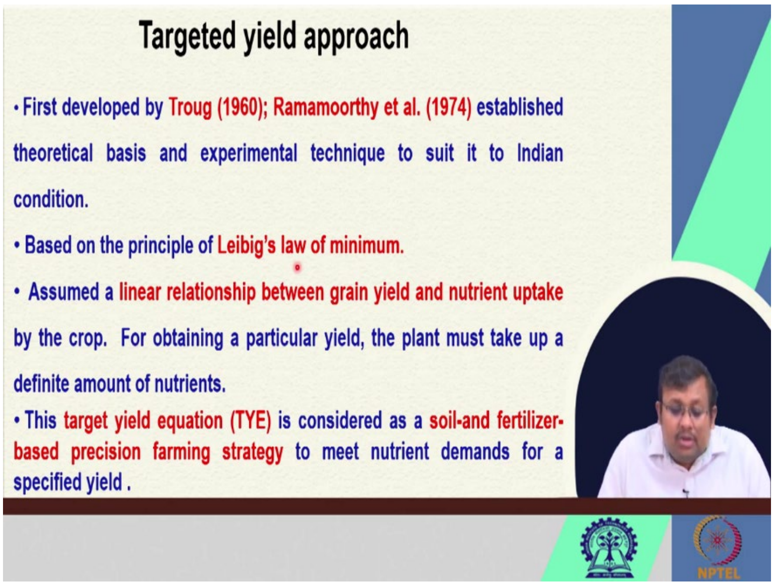
(Refer Slide Time: 18:34)



So, this is why this concept of soil test crop response is superior to other recommendation approach. Now, in the target yield concept, there is a balance between fertilizing the crop and fertilizing the soil, of course we have to maintain some balance. Now, it is assumed that there is a linear relationship between grain yield and nutrient uptick by the crop we know that.

There is a linear relationship between the growth of the plant and the nutrient uptake by the crop and grain yield. And the nutrient requirement of the crop for a given yield level is worked out, and the contribution from soil available nutrient is then calculated, and the fertilizer needed is estimated, so these are the step by step you know operation in this target yield concept.

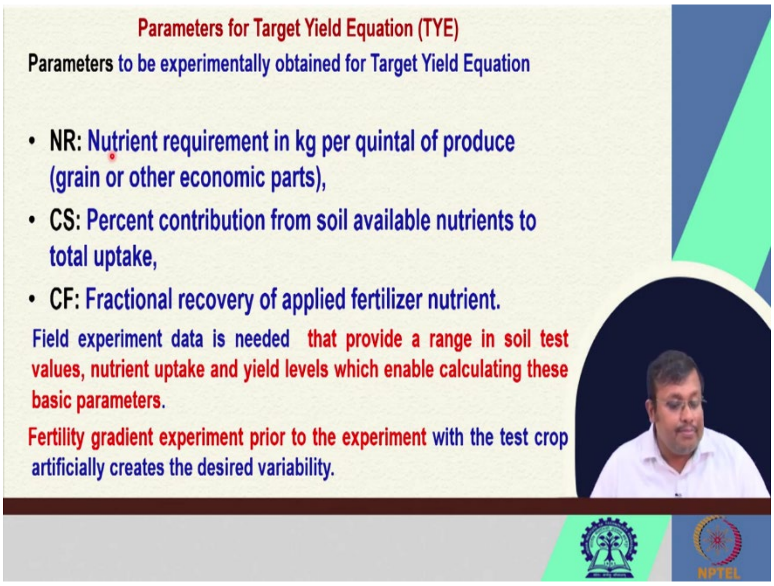
(Refer Slide Time: 19:29)



Now, this targeted approach was first developed by trug in 1960 and Ramamurthy at all in 1974, established the theoretical basis and experimental techniques to suit it into Indian condition. And this whole Target will concept or approach is based on principles of living's law of minimum, we have discussed this several time limit lock minimum, so I am not going to discuss them further, discuss it further. And here, in this targeting approach, we assume a linear relationship between Green Lane nutrient uptake by the crop, I have already told you.

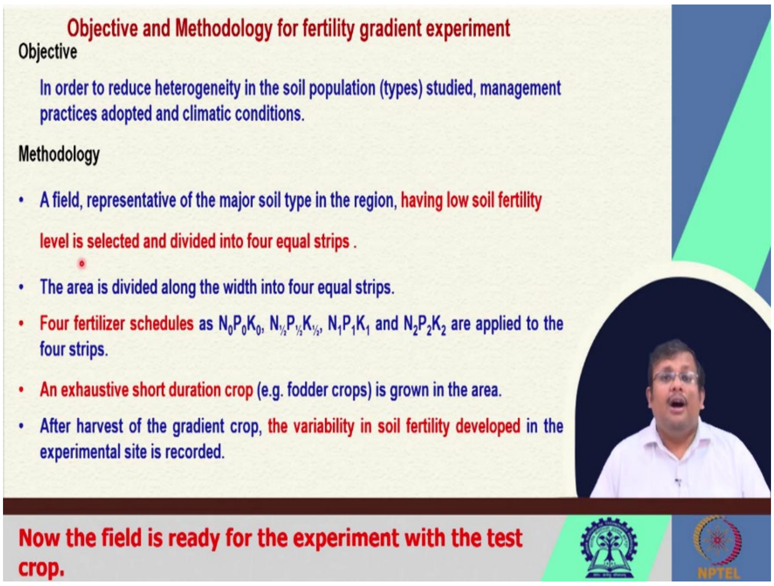
Now, for obtaining a particle particular yield, the plant must take up a definite amount of nutrient. Now, this target equation is considered as a soil and fertilizer-based Precision farming strategy to meet nutrient demands for specific yield.

(Refer Slide Time: 20:25)



Now, what are the parameters for this targeted equation? So first one is NR which is the nutrient requirement, in kg per quintal of produce, which may be either grain or other economic Parts, CS stands for the percent contribution from the soil available nutrients to Total uptake. And CF is fractional recovery of the applied fertilizer nutrient, so field experiment data is needed that provide a range in soil test values, nutrient uptake, and yield levels which enables calculating these basic parameters. And then, fertility gradient experiment also need to be done prior to the experiment with the test crop artificially creates the desired variability.

(Refer Slide Time: 21:13)

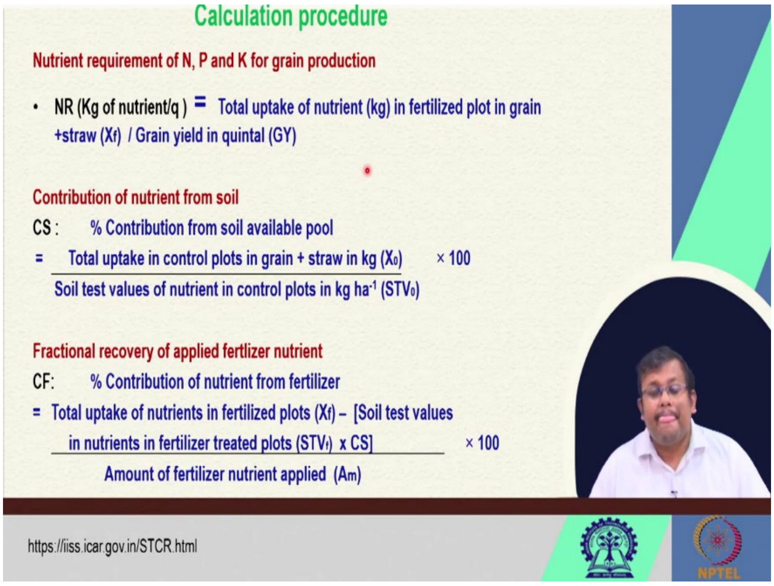


So, what are the objectives and methodology of fertility gradient experiments? So objective of fertility gradient experiment is to or to reduce the heterogeneity in soil population or type studied, management practices adopted, and climatic condition. What is the method here, a field representative of the major soil type of the region and having the low soil fertility level is basically selected and divided into four equal strips?

Now, the area is divided along the width into four equal strips, now the area is divided along the width selected and divided into four equal strips. Now, the area is divided along the width now four fertilizer schedules, such as N0, P0, K0, that means we do not apply any fertilizer, then half of N, half of P, half of K, so we can see that NPK half of recommended rows, and then full recommended dose of NPK and two I is the recommended dose of NPK are applied to the four strips. And then, an exhaustive short duration crop generally further crop is grown in the area and after harvest of the gradient crop, the variability in the soil fertility developed in the experimental site is recorded.

So, we first develop the strips of the land having the, first select this soil with the low fertility level and then divide into four equal strips, and then area is divided into along the width into four equal strips, and then we apply four fertilizer schedules, no fertilizer, half of the recommended dose, full recommended dose, and then double up the recommended use, and then an exhaustive short duration crop is grown in the area. And after harvest of the gradient crop the variability in the soil fertility developed in the experimental site is recorded. Now, the field is ready for the experiment with the test crop.

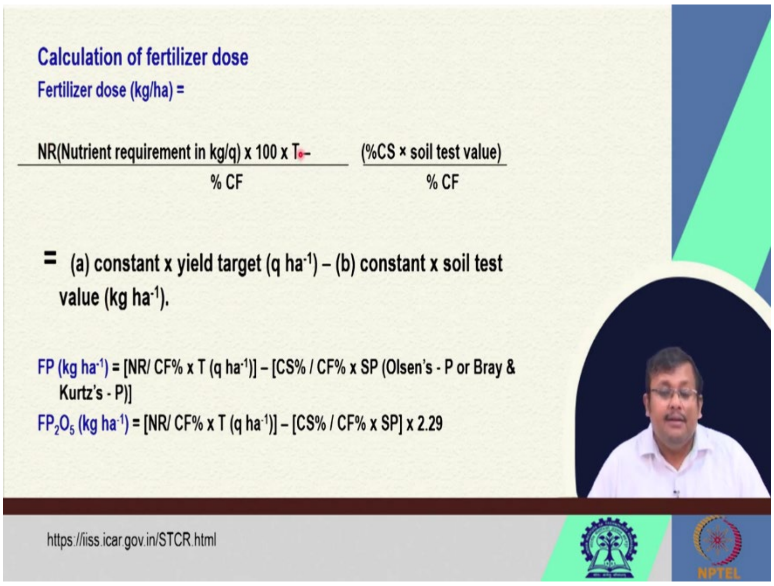
(Refer Slide Time: 23:06)



So, we can see here you know there are different strips, strip1, strip2, strip3 and strip4 for kharif rice, for this, so fertility gradient experiment. And then how to calculate, so the nutrient calculation of NPK for grain production, so we can see NR, nutrient requirement is basically we can see here, the nutrient requirement is calculated that kg of nutrient per quintal of economic produce, and this is calculated by total uptake of nutrient in fertilized plot in grain plus straw divided by grain yield in quintal, so this is how we calculate NR.

How to calculate the CS? CS is calculated by total uptake in control plots in grain plus straw in kg, divided by soil test values of nutrients in control plots in kg per hectare, multiplied by hundred, so this is how we calculate the CS. How to calculate the fractional recovery of the applied fertilizer nutrient or CF? Total uptake of the nutrients in fertilized plot minus soil test values in nutrients in fertilizer treated plot, multiplied by CS, that is contribution of nutrients from the soil, divided by amount of fertilizer nutrient applied, multiple by 100, so this is how we calculate the NR, CS, and CF.

(Refer Slide Time: 24:39)

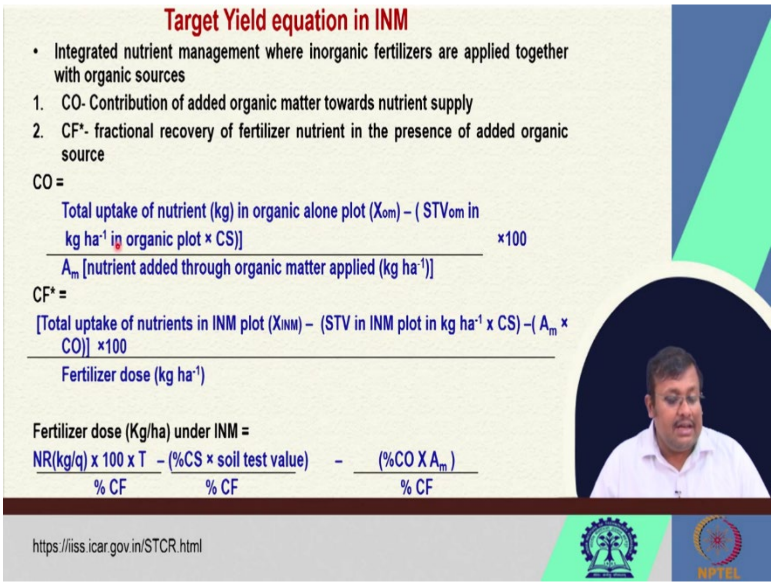


Now, how to calculate the fertilizer dose? So, to calculate the fertilizer dose NR has to be multiplied with 100, multiplied by T, so T is basically our Target yield, divided by percent of CF. So, CF we have already calculated, so once we calculate this NR, multiplied by 100, multiplied by T, by CF, minus CS into soil test value by CF, so this is how we calculate the fertilizer dose which is basically a constant, which we can be represented by a constant, multiplied by yield Target minus, another constant which is B multiplied by soil test values.

So, this fertilizer requirement can be calculated using an equation, linear equation, so here we can multiply a constant with the target yield minus another constant with the soil test value. For example, you can see here for fertilizer phosphorus, you can see this NR minus CF, multiplied by T, you can see here minus CS by CF multiplied by soil phosphorus, we can see minus P or Bray of you know and for you know, all sense P you know, soil phosphorus may be either all since phosphorus or Bray curves phosphorus and then once we calculate this fertilizer phosphorus, we just have to multiply it with the 2.25 to get the fertilizer P .25 in kg per hectare.

So, this is how we calculate the NR, CS, CF, and ultimately the fertilizer dose. And then we can convert one fertility you know nutrient to the available form of nutrients, just like here FP2, FP 25, we can calculate.

(Refer Slide Time: 26:38)

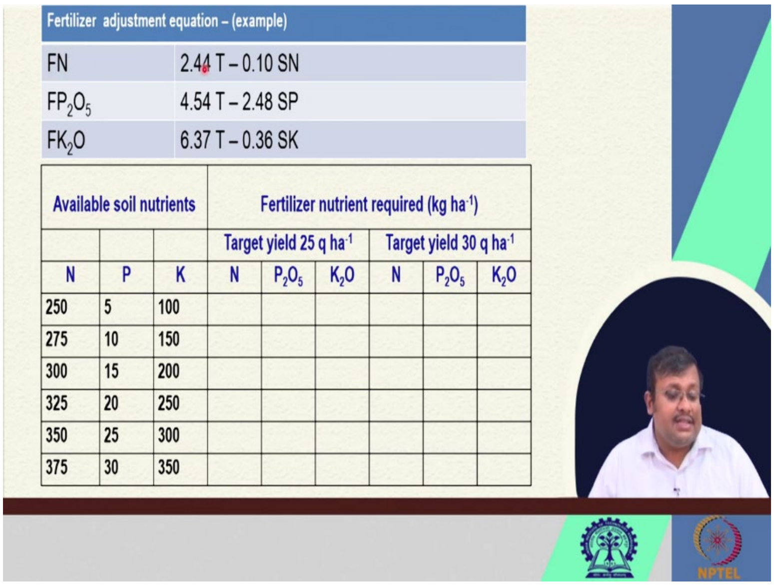


Now, targeted equation used in I and M on integrated nutrient management, we can see, so integrated nutrient management already you know that it is a new integrated you know nutrient management is concept, where inorganic fertilizers are applied together with Organic sources, so here CO is another parameter which is contribution of added organic matter towards nutrient Supply. And then CF is the fraction recovery fertilizer nutrient in the presence of added organic source.

So, how to calculate the CO, CO can be calculated by total uptake of nutrient in organic alone plot, where only organic application is there, no inorganic application is there, minus soil test value of organic matter in in organic plot my multiplied by CS, and then multiply by 100 by Am, which is nutrient added through organic matter applied. So, and then CF you can calculate by total uptake of nutrients in in plot minus soil test values in in plot in kg per hectare multiplied by CS, minus Am multiplied by CO into 100 by fertilizer dose, so this is how we calculate the CF star or fractional recovery of fertilizer nutrient in the presence of added organic source.

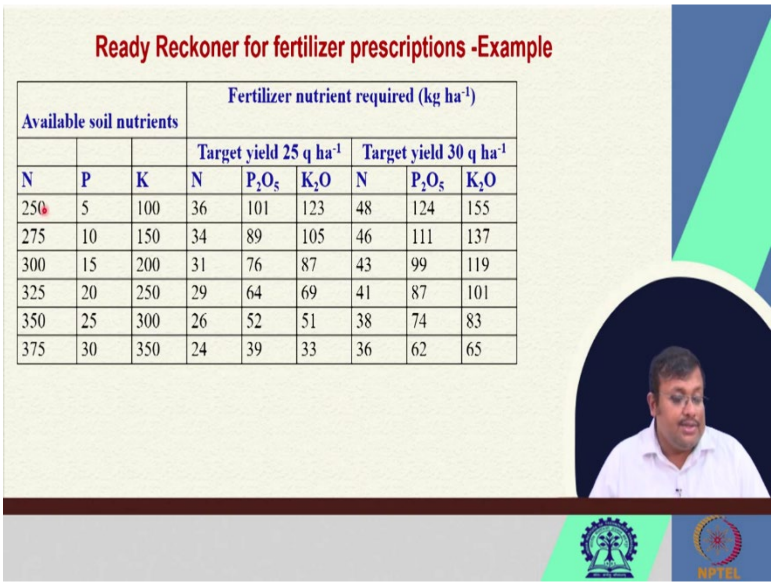
And then fertilizer dose under INM is calculated by using this formula, where NR is multiplied by 100, multiplied by Target yield by percent CF, minus CS multiplied by soil test value by percent CF, minus percent CO multiplied by Am by percent CF, so this is how we calculate the target, the fertilizer dose for specific target yield.

(Refer Slide Time: 28:30)



So, ultimately let us see some examples, here you can see some fertilizer nitrogen, here I told you that we can calculate using any linear equations, so you can see fertilizer nitrogen, fertilizer P 2Phi, fertilizer K2O can be calculated here, this is soil nitrogen, soil phosphate, soil potassium, and this is how you know, this is a table which we generally used to calculate the fertilizer nutrient requirement for a specific Target yield. Here, you can see available nutrients are given and then Target yield is given, for two different condition Target till 25 quintal per hectare, Target till 30 quintal per hectare and fertilizer neutral requirement are given.

(Refer Slide Time: 29:12)



Available soil nutrients			Fertilizer nutrient required (kg ha^{-1})					
			Target yield 25 q ha^{-1}			Target yield 30 q ha^{-1}		
N	P	K	N	P_2O_5	K_2O	N	P_2O_5	K_2O
250	5	100	36	101	123	48	124	155
275	10	150	34	89	105	46	111	137
300	15	200	31	76	87	43	99	119
325	20	250	29	64	69	41	87	101
350	25	300	26	52	51	38	74	83
375	30	350	24	39	33	36	62	65

So, here you can see Ready Reckoner for fertilizer prescription, so here you can see 250 and different doses, so if we have the target yield of 25 quintal per hectare, for example if we are having the nitrogen, available nitrogen is 275, and 10, and then 150, then if I have a target yield is 25 quintal per hectare, then we should select this 34, 89, 105, NP2, 5K2O per hectare. So similarly, these are Ready Reckoner for fertilizer prescriptions.

(Refer Slide Time: 29:50)

So, guys, let us wrap up this lecture, I hope that you have now have some good knowledges about this critical test level approach as well as Colwell's approach as well as this soil test crop response approach, how to calculate different parameters in the soil test crop response approach, what are the merits, how they are superior from other approaches, we have discussed. And then, I have showed you how to use the target yield to calculate the fertilizer nutrients and, then we can convert it to other forms, like for example fertilizer P to fertilizer P 25. So, let us wrap up this lecture, and these are the references which I use for this lecture. Let us meet in our next lecture to discuss further about soil fertility and the soil fertility recommendation. Thank you.