Soil Fertility and Fertilizers
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Lecture 55
Fertilizer Recommendation Approaches and Integrated Plant Nutrient Management (Contd.)

Welcome friends, to this fifth lecture of week 11 of NPTEL Online Certification Course of Soil Fertility and Fertilizers. In our previous lectures of this week, we have discussed about different yield concept. We have also discussed about different types of nutrient recommendation practices, starting from the generalized practice as well as soil test-based recommendation, and then STCR approach.

We have discussed in details about the benefits and some issues regarding the STCR approach, we have seen some Ready Reckoner for application of different fertilizer, for different crops in different locations. And we have also discussed in details about site specific nutrient management. Now, in this lecture we are going to discuss the integrated nutrient management in details.

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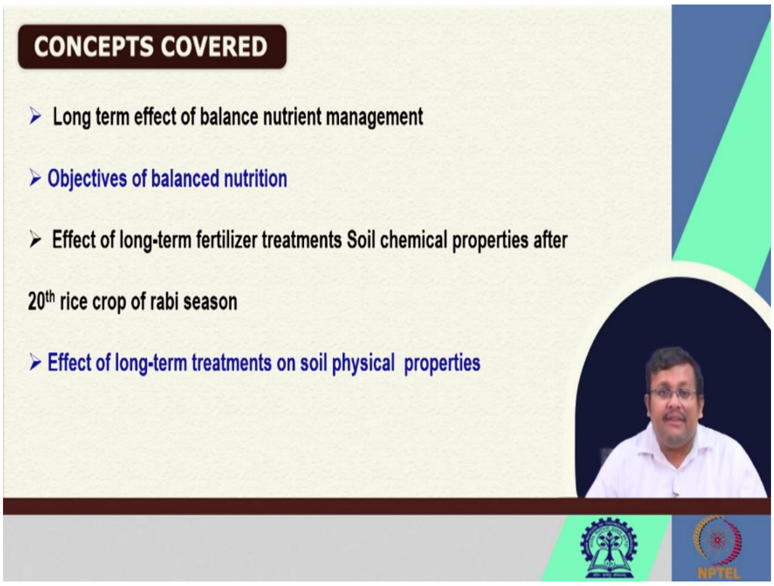

And then, we are going to also discuss about the objectives of balanced nutrition and effect of different long term fertilizer treatments on soil chemical properties, soil physical properties. And then, effect of long-term treatment on soil physical properties also. So, these are the concepts which we are going to discuss in this lecture.

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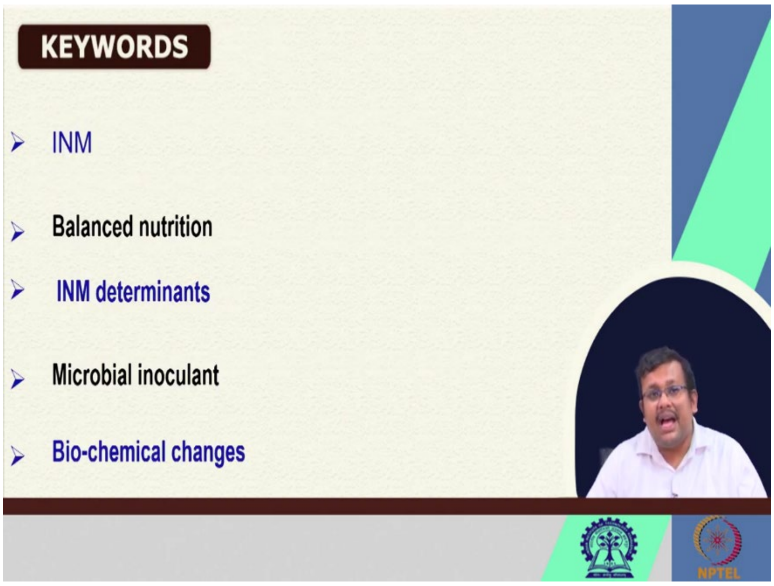

And these are some of the keywords like INM, balance nutrition, INM determinants, microbial inoculant, biochemical changes, so these are some of the keywords for this lecture.

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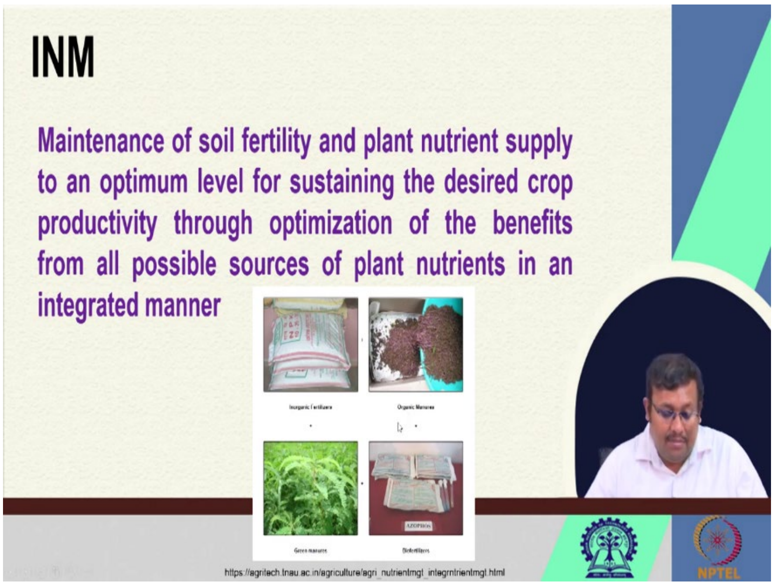

Now, we have already discussed about INM previously, but let us summarize those things again, so that we can connect the benefits of INM which we have seen in different case studies. You know that INM basically defines as the maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible optimize of all possible sources of plant nutrients in an integrated manner.

So, as per the definition, INM maintains the soil fertility and plant nutrient supply in optimum level, through application of different forms of plant nutrients, from different, not only different forms from different sources of the plant nutrients. For example, here you can see inorganic fertilizers is a component of INM, organic manure is a component of INM, then green manure is a component of INM and bio fat laser is another component of INM.

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Now, the concept of INM says that, it using INM you can regulate nutrient supply for optimum crop growth and higher productivity. You can improve and maintain the soil fertility. And you can ensure zero adverse impact on agro-ecoregion quality by balanced fertilization of organic manures, inorganic fertilizers, and bio inoculants.

So, these are the major concepts or major, I would say the assumptions of in implementing the INM. First of all, you have to regulate the nutrient supply for optimum crop growth and higher productivity, then you have to improve and maintain the soil fertility and finally at the same time you have to ensure that there is no detrimental impact on the ecosystem by ensuring a balanced fertilization of consisting of different sources of the nutrients like bio fertilizers, like organic manure, like inorganic fertilizers.

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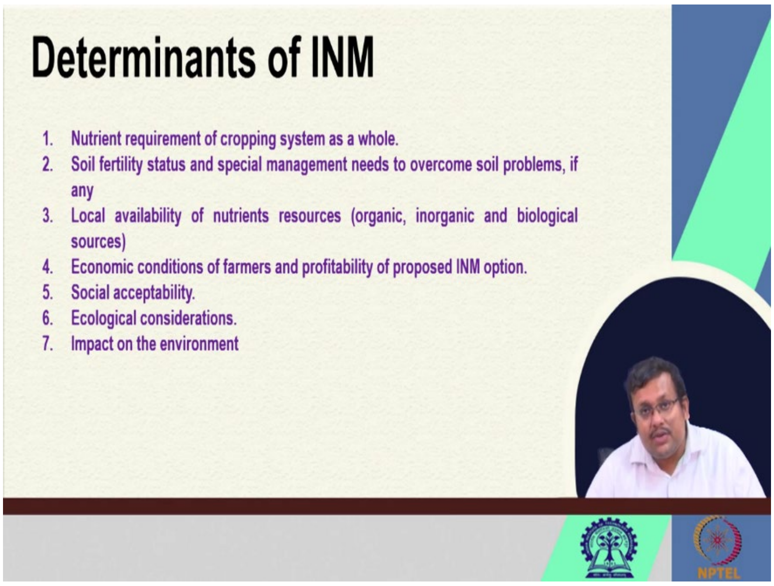

Now, what are the determinants of INM? first of all nutrient requirement of cropping system as a whole is the major determinant, then soil fertility status and special management needs to overcome the soil problems. If any third is local availability of nutrient resources like organic inorganic and biological sources, fourth one is economic condition of farmers and profitability a proposed INM option. Fifth one is social acceptability, sixth one is ecological consideration and seventh one is impact on the environment, so these are some of the important determinants of the INM.

Again, the nutrient requirement of cropping system as a whole should be considered for integrated nutrient management, then soil fertility status, and if the soil is having any unfavourable condition like acidity, alkalinity, if any, that has to be also taken care of. And then, local availability of the nutrient resources not only formulating the balanced nutrition, but formulating the balanced nutrition using the locally available resources is the major thrust.

Then economic condition of the farmers and profitability of proposed INM option, this is very important unless there is profit from the proposed solution that will not attract a large number of farmers. Then society, you know social acceptability is an important issue, then ecological considerations and of course finally impact on the environments these are the major determinants of INM.

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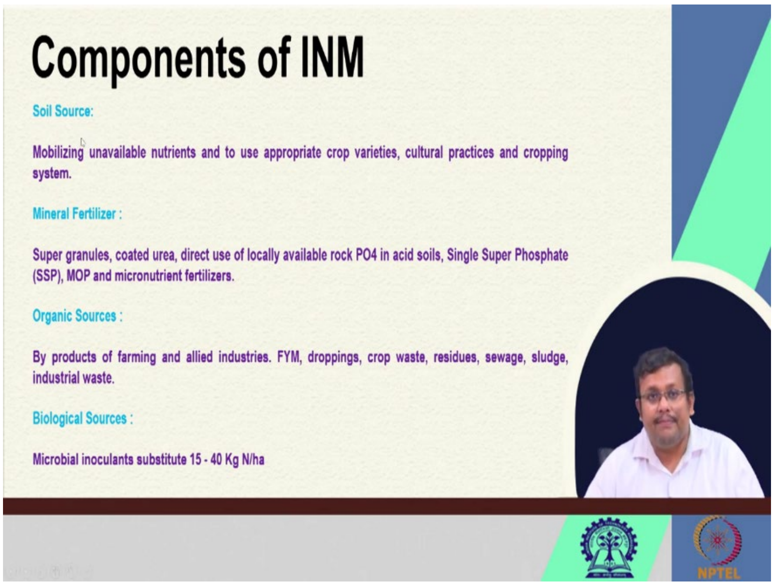

Now, what are the components of INM? If you see the components of the INM, first of all is soil resource. Basically, in using the soil source, we have to mobilize unavailable nutrients and to use appropriate crop varieties, and then cultural practices and cropping system. For example, we can integrate the pulse crop in the cropping system just to supply the nitrogen, then the mineral fertilizer like super granules, coated urea, direct use of locally available rock phosphate in acid soils, then single super phosphate, muriate of potash, and micronutrient fertilizers.

Then organic sources like by-products of farming and allied industries, then fermion yield manure, droppings, crop waste, residues, sewage, sludge, industrial waste, all these are different types of organic sources. And bio biological resources or bio fertilizers like microbial inoculants, which can substitute for 15 to 40 kg of nitrogen per hectare. So, you can see not only the soil source where we are managing the soil available nutrients and also, we are managing the cultural practices, we are we are also integrating the mineral fertilizer organic sources and biological sources or bio fertilizers, so these are important components of INM.

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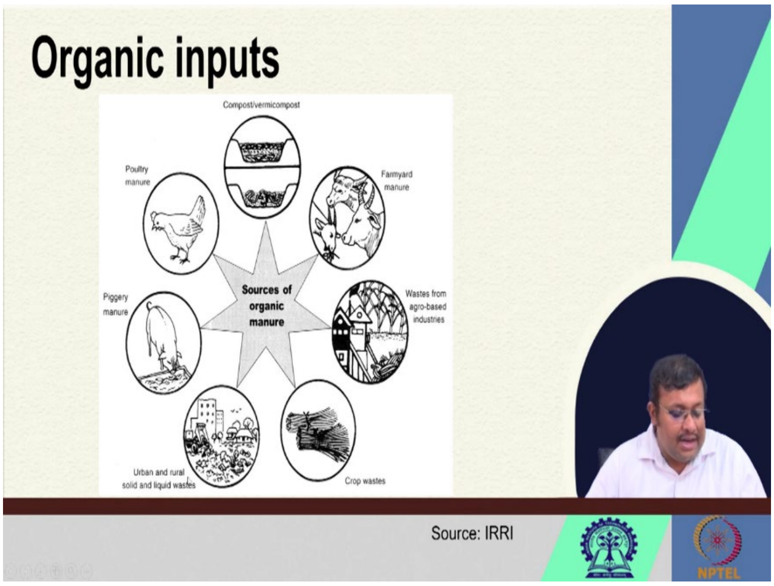

So, if you see the organic inputs compost and vermicompost, then fermion manure, then waste from agro based industries, then crop waste, urban and rural solid and liquid waste, piggery manure, and poultry manure, all these are different types of organic inputs or source of organic manure in the integrated nutrient management concept.

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Now, government India has started schemes like balanced and integrated use of fertilizer with the aim of promoting the use of organic manures and biofertilizers. Now, the scheme is also designed to encourage the processing and production of compost from urban waste and biofertilizers.

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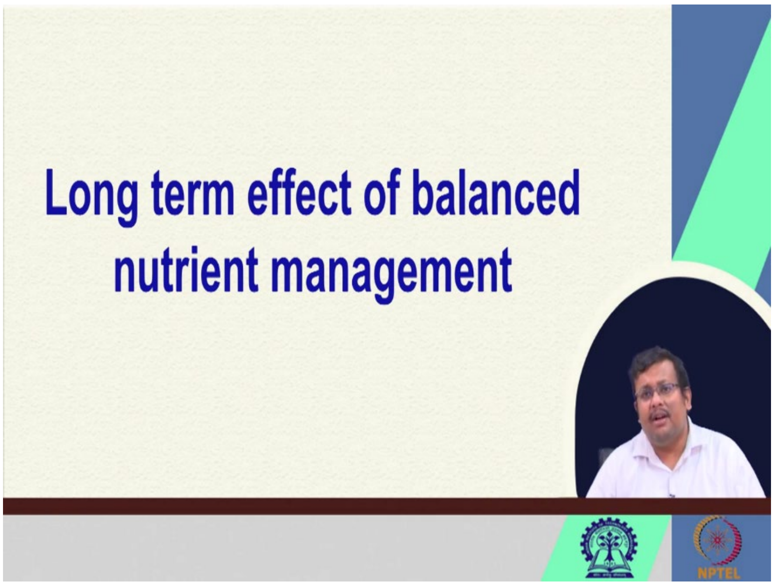

Now, we have seen some basic info about INM, let us see some long-term effect of balanced nutrient management. So, we know that the impact of balanced fertilization on soil health can improve the soil health, that also can improve the plant health and intern that again help the human health. So, these are the different steps of improvement or the different steps of harnessing the benefits from balanced fertilization, which can help to augment the soil health, and then in turn it also improves the plant health and human health.

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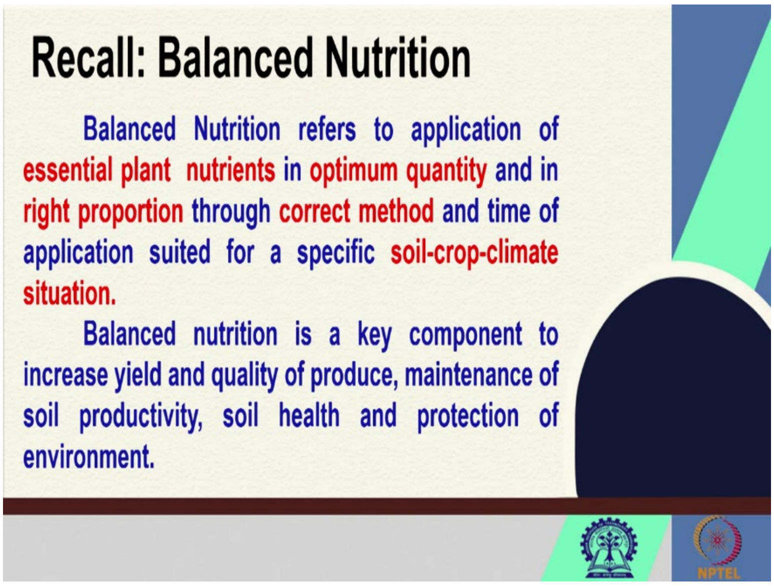

Now, if you recall the balanced nutrition, balance nutrition refers to application of essential plant nutrients in optimum quantity, and in right proportion to correct method and time of application suited for a specific crop, soil crop climate situation. Remember that 4R nutrient stewardship? So this balanced nutrition is a key component to increase the yield and quality of produce, maintenance of soil productivity, soil health, and protection of environment.

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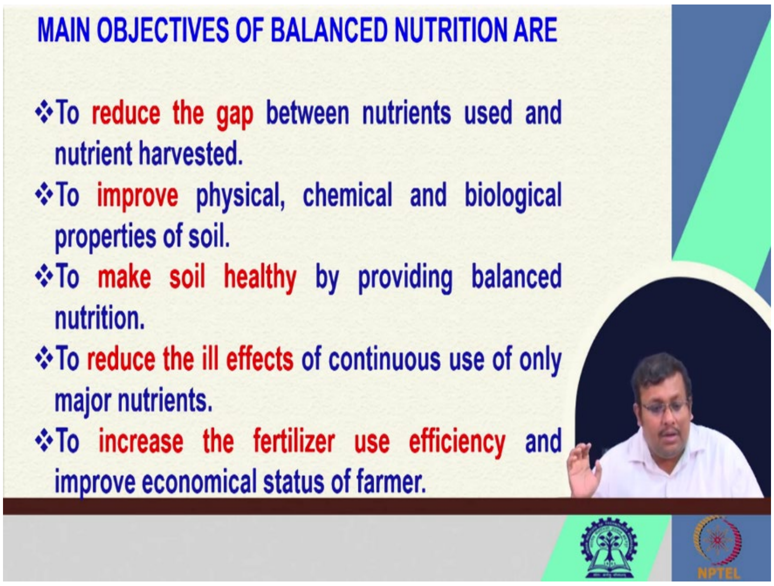

Then, let us see the major objectives of balance nutrition. First of all, to reduce the gap between nutrient used and nutrient harvested, if we maintain the, if we can reduce the gap between nutrient used and nutrient harvested, then we can save the nutrient and this can be only achieved through balanced nutrition. Secondly, we can also improve the physical chemical and biological properties of the soil. Thirdly, we can make our soil healthy by providing balanced nutrition. Fourth, we can reduce the yield effects of the continuous use of major nutrients, so if we use the continuously some major nutrients only some major nutrients without adding the additional sources of nutrients, then that can reduce the native soil fertility, and finally to increase the fertilizer use efficiency and improve economic status of the farmer, so these are the major objectives of balanced nutrition.

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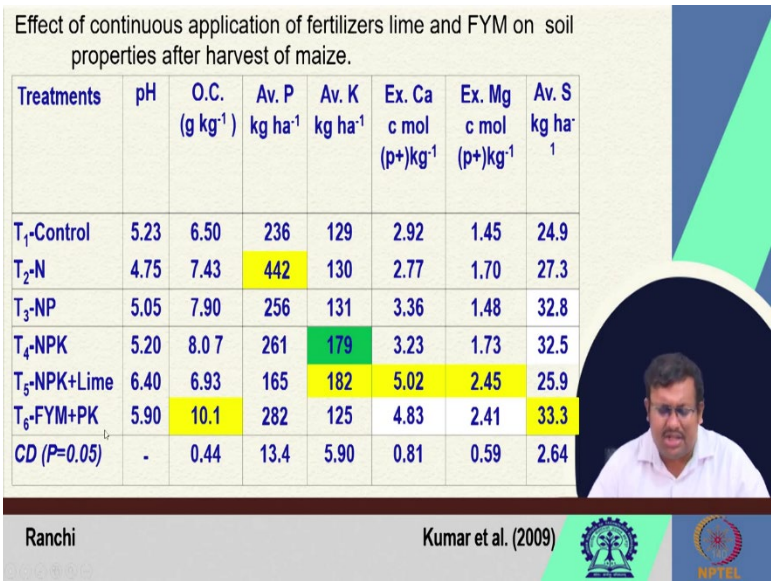

Treatments	pH	O.C. ($g\ kg^{-1}$)	Av. P $kg\ ha^{-1}$	Av. K $kg\ ha^{-1}$	Ex. Ca c mol $(p+)kg^{-1}$	Ex. Mg c mol $(p+)kg^{-1}$	Av. S $kg\ ha^{-1}$
T_1-Control	5.23	6.50	236	129	2.92	1.45	24.9
T_2-N	4.75	7.43	442	130	2.77	1.70	27.3
T_3-NP	5.05	7.90	256	131	3.36	1.48	32.8
T_4-NPK	5.20	8.0 7	261	179	3.23	1.73	32.5
T_5-NPK+Lime	6.40	6.93	165	182	5.02	2.45	25.9
T_6-FYM+PK	5.90	10.1	282	125	4.83	2.41	33.3
CD (P=0.05)	-	0.44	13.4	5.90	0.81	0.59	2.64

Now, if we see the effect of continuous application of fertilizer lime and if I am on soil properties after harvest of mix, this is a case study published by Kumar et al., in 2009, we can see there are different treatment, and we can see when there is a T2, which is nitrogen based treatment, where available phosphate was highest, and when we apply, they applied the tree five T5, that is NPK plus lime, they got the highest available potassium, and then highest exchangeable calcium, and then highest exchangeable magnesium, highest exchangeable magnesium, and when they have used the FYM in combination with phosphorous and potassium, they got the highest organic carbon, and also they got the highest available sulphur.

So, this shows the continuous application of fertilizer lime and FYM, so here you can see, when you are applying not only the fertilizer but also lime as an amendment, that how they can improve the soil chemical properties. And also, here you can see we are applying the FYM plus phosphorous and potassium, so this combination of nutrients or integrated nutrient, they can improve the soil chemical properties.

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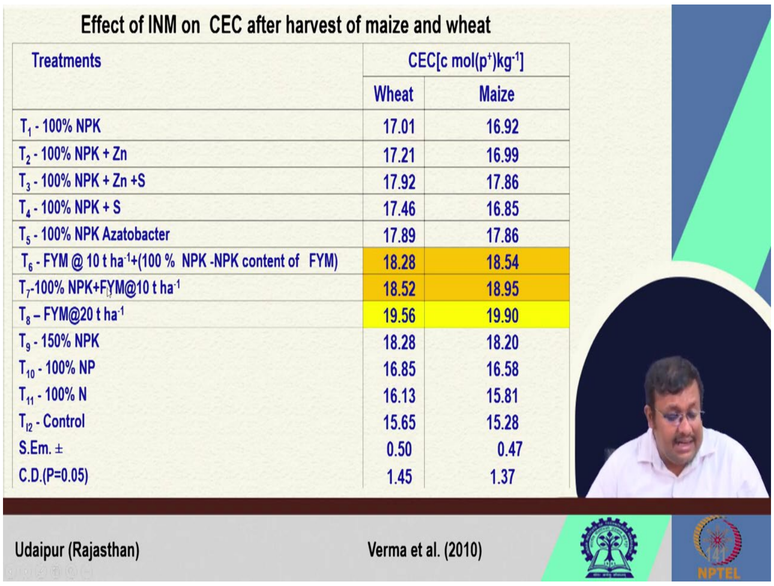

Treatments	CEC[c mol(p⁺)kg⁻¹]	
	Wheat	Maize
T_1 - 100% NPK	17.01	16.92
T_2 - 100% NPK + Zn	17.21	16.99
T_3 - 100% NPK + Zn +S	17.92	17.86
T_4 - 100% NPK + S	17.46	16.85
T_5 - 100% NPK Azatobacter	17.89	17.86
T_6 - FYM @ 10 t ha^{-1}+(100 % NPK -NPK content of FYM)	18.28	18.54
T_7-100% NPK+FYM@10 t ha^{-1}	18.52	18.95
T_8 – FYM@20 t ha^{-1}	19.56	19.90
T_9 - 150% NPK	18.28	18.20
T_{10} - 100% NP	16.85	16.58
T_{11} - 100% N	16.13	15.81
T_{12} - Control	15.65	15.28
S.Em. ±	0.50	0.47
C.D.(P=0.05)	1.45	1.37

Similarly, you can see here, this is an effect of INM on CEC after harvest of maize and wheat. You can see when they are applying FYM at 10 ton per hectare, plus 100 percent of NPK, then for wheat they are getting the high CEC, that is 18.28 centimole P plus per kg, and for maize also they are getting high CEC.

When they are applying 100 percent NPK plus FYM at 10 ton per hectare, then you know the earlier in T 6 of course 100 percent NPK minus NPK content of FYM was applied, however in T 7, 100 percent in NPK plus FYM, you know here you can see it at 10 percent per hectare, they are also getting higher a high CEC for both the crops, and in case of T8 when you are applying the FYM at 20 ton per hectare, there we are also getting the high wheat and maize yield.

Maize, you know CEC, in case of wheat and maize, after their harvest, so that shows that how INM can improve the soil fertility properties. CEC is an important soil fertility property, indicator of the soil fertility status, so you can see with the application of FYM, how these CEC can be improved.

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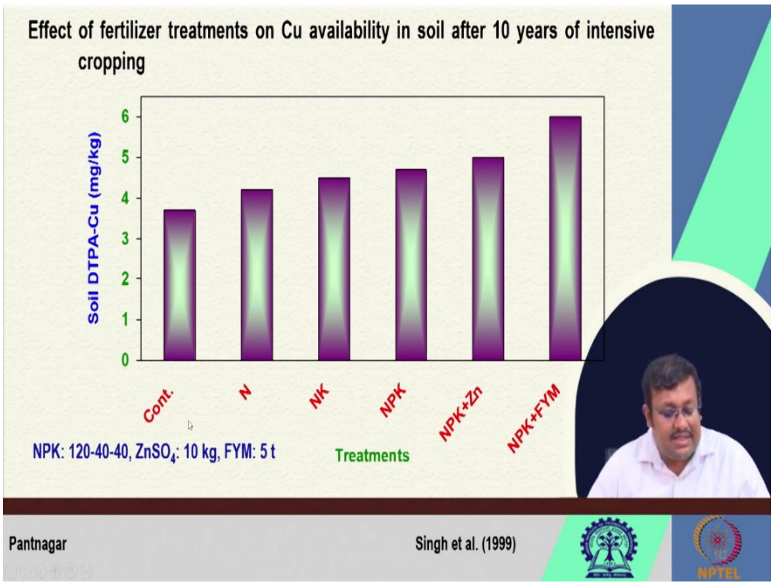

Also, if we can see the effect of fertilizer treatments on copper availability in soil after 10 years of intensive cropping, you can see that when we are adding these NPK plus FYM, that is showing the highest yield followed by NPK plus zinc, and then NPK, NK, N and, so on, so NPK here the recommended dose was 120-40-40, and then zinc sulphate was applied at 10 kg per hectare, and FYM was applied as 510 per hectare.

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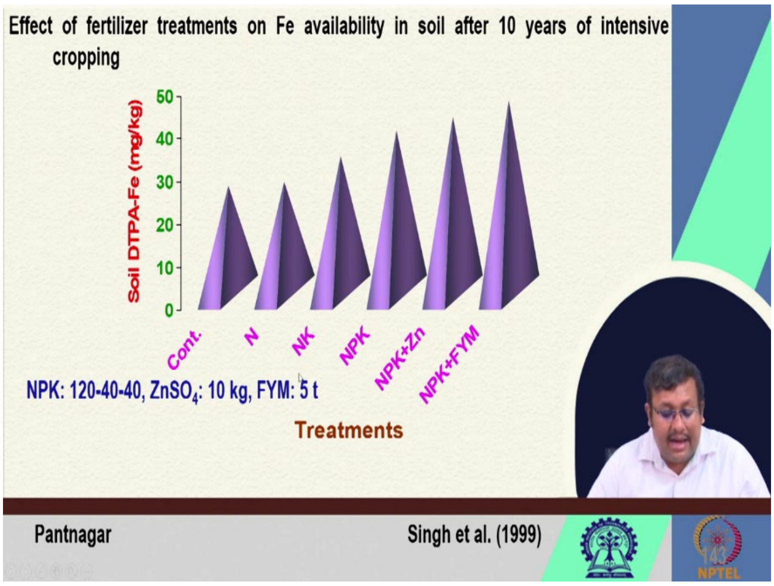

Now, you are you can also see the effect of fertilizer treatments on INM availability in soil after 10 years of intensive cropping, published by seeing it all in 1999, when in Pantnagar, we can see that when we are applying the NPK plus FYM combination that is showing the highest soil DTPA extracted Fe, so that means the micronutrient content is also in increasing, when we are getting the, when we are applying the fertilizer, inorganic fertilizer in combination with organic resources. So, this is an another example of improvement of soil fertility status for long term trial, using, in case of intensive cropping, using balanced fertilizer or integrated nutrient management, okay.

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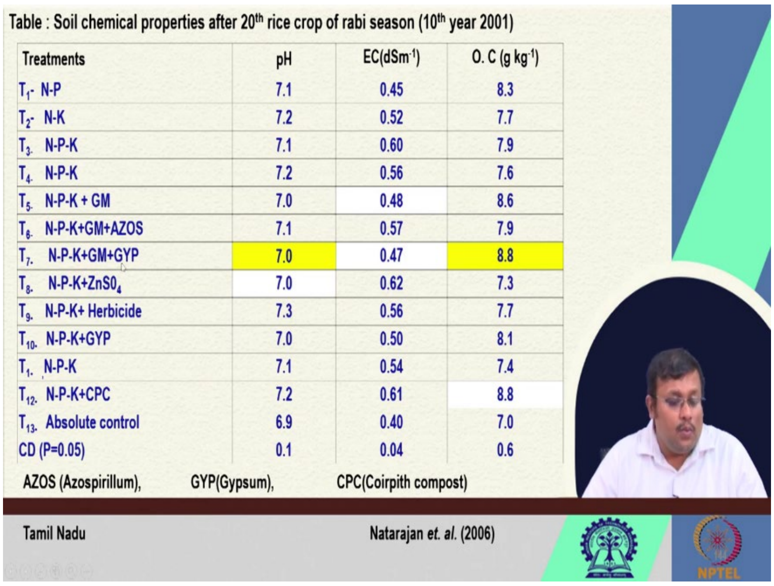

Treatments	pH	EC(dSm-1)	O. C (g kg-1)
T_1- N-P	7.1	0.45	8.3
T_2- N-K	7.2	0.52	7.7
T_3. N-P-K	7.1	0.60	7.9
T_4. N-P-K	7.2	0.56	7.6
T_5. N-P-K + GM	7.0	0.48	8.6
T_6. N-P-K+GM+AZOS	7.1	0.57	7.9
T_7. N-P-K+GM+GYP	7.0	0.47	8.8
T_8. N-P-K+ZnSO4	7.0	0.62	7.3
T_9. N-P-K+ Herbicide	7.3	0.56	7.7
T_{10}. N-P-K+GYP	7.0	0.50	8.1
T_1. N-P-K	7.1	0.54	7.4
T_{12}. N-P-K+CPC	7.2	0.61	8.8
T_{13}. Absolute control	6.9	0.40	7.0
CD (P=0.05)	0.1	0.04	0.6

Now, again if you see the soil chemical properties of the twentieth rice crop of rabi season, we can see then when we are applying the NPK plus green manure plus gypsum, the Natarajan et al., 2006, they have got the optimum pH as well as the highest organic carbon content. They got the organic carbon content of using this combination of inorganic fertilizer, then green manure and soil amendment like gypsum.

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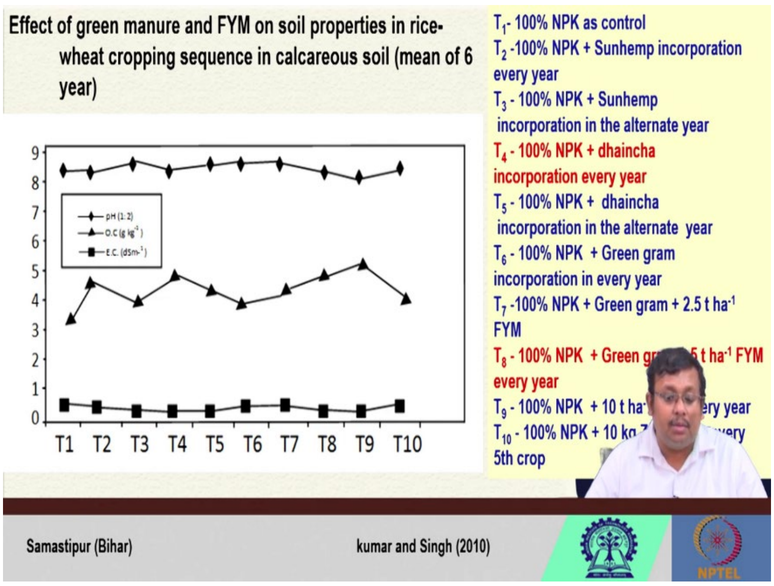

Also, in this graph we can see the effect of green manure and FYM on soil properties in rice with cropping sequence in calculus soil, which is a mean of six years, so you can see that this is the pH trend this shows the organic carbon train and this is the electrical conductivity trend, We can see that T 1 is 100 percent NPK control, and T 2 is 100 percent NPK plus Sunhemp incorporation every year, T 3 is 100 percent NPK plus Sunhemp incorporation in the alternate year, T4 is the 100 percent NPK plus doing chain corporation every year, so you can see that when we are applying this T 4, it is improving the soil organic carbon.

Similarly, for T8 you can also see that the high when there is an application of 100 percent NPK plus green gram plus 5 ton of FYM every year, we are also getting higher organic carbon and lower pH. So, I mean somewhat lower pH than the T 7, so this is showing the temporal you know treatment wise changes of soil properties in a rice sweet cropping sequence by application of different combination of nutrients.

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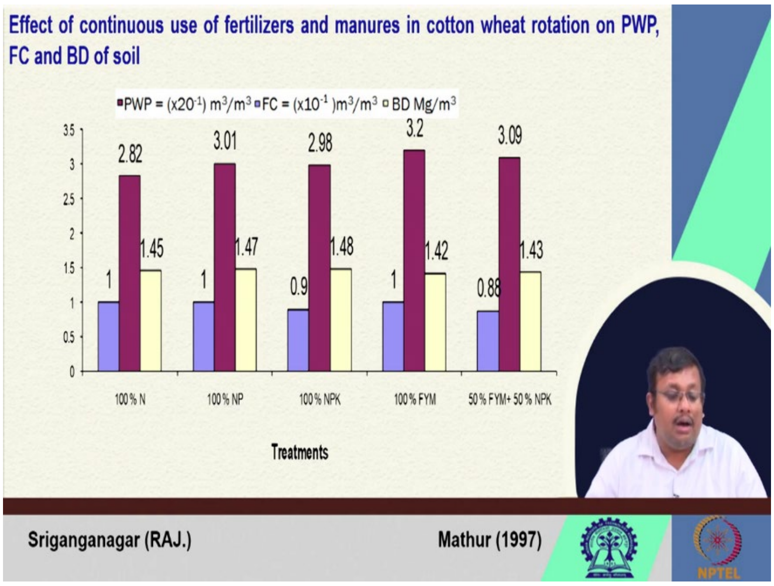

Then, we can see the effect of continuous use of fertilizers and manures in cotton wheat rotation on permanent wilting point and then fill capacity or burn density of soil, so we can see here published by Mathur et al., in nineteen, method in 1997, so here you can see when there is a 100 percent nitrogen, whatever we are getting, we when we are applying 15 percent FYM plus 15 percent NPK, we are getting more you know PWP we can see here, the PWP is highest in case of 100 percent FYM followed by the 50 percent FYM plus 50 percent NPK, followed by 100 percent NP.

So, and also the field capacity is you know generally is same for 100 percent nitrogen, 100 percent NP, and then 100 percent FYM. The lowest we can be found in case of 50 percent

FYM plus 50 percent NPK. However, bulk density is also similar almost, however, comparatively when we are seeing the FYM, 100 percent FYM, and when there is an FYM plus 50 percent NPK, 50 percent FYM plus 50 percent NPK, we can see the lower levels of bulk density which is favourable soil physical condition.

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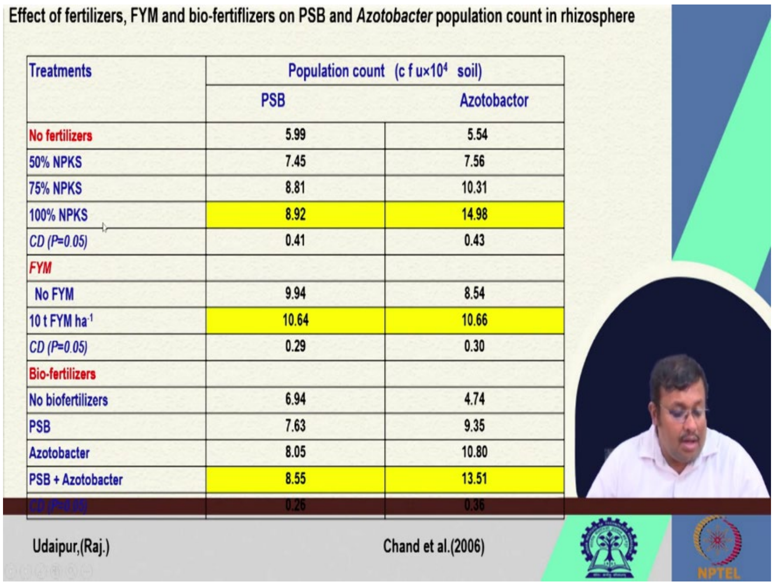

Effect of fertilizers, FYM and bio-fertiflizers on PSB and *Azotobacter* population count in rhizosphere

Treatments	Population count (c f u×10⁴ soil)	
	PSB	Azotobacter
No fertilizers	5.99	5.54
50% NPKS	7.45	7.56
75% NPKS	8.81	10.31
100% NPKS	8.92	14.98
CD (P=0.05)	0.41	0.43
FYM		
No FYM	9.94	8.54
10 t FYM ha⁻¹	10.64	10.66
CD (P=0.05)	0.29	0.30
Bio-fertilizers		
No biofertilizers	6.94	4.74
PSB	7.63	9.35
Azotobacter	8.05	10.80
PSB + Azotobacter	8.55	13.51
CD (P=0.05)	0.26	0.36

We can also see the effect of fertilizers, FYM and biofertilizers on phosphorus solubilizing bacteria, and azotobacter population count in rhizosphere, when we can see that you know in different conditions, we are getting the higher amount of PSB and 100 percent of nitrogen phosphorus potassium and sulphur, you can see that we are getting the highest PSB content and or colony forming unit, and then for also Azotobacter column is also.

When we are applying the FYM, that is 10-ton FYM per hectare, we are getting more than the NPK application that is 10.64 and 10 you know here in case of PSB, we are getting 10.64, however, in case of Azotobacter, there is somewhat reduction. In case of bio fertilizers application, we can see that PSB plus isotope vector can show higher you know population count and also Azotobacter can show the higher population count as compared to no bio fertilizer, PSB and Azotobacter, so the combination always shows here the better results.

Similarly, here also when there is a no FYM and 10-ton FYM, 10-ton FYM is already producing better results. Similarly, here also you can see when we are applying the NPKS in combination we are getting the higher you know population count for both PSB and Azotobacter.

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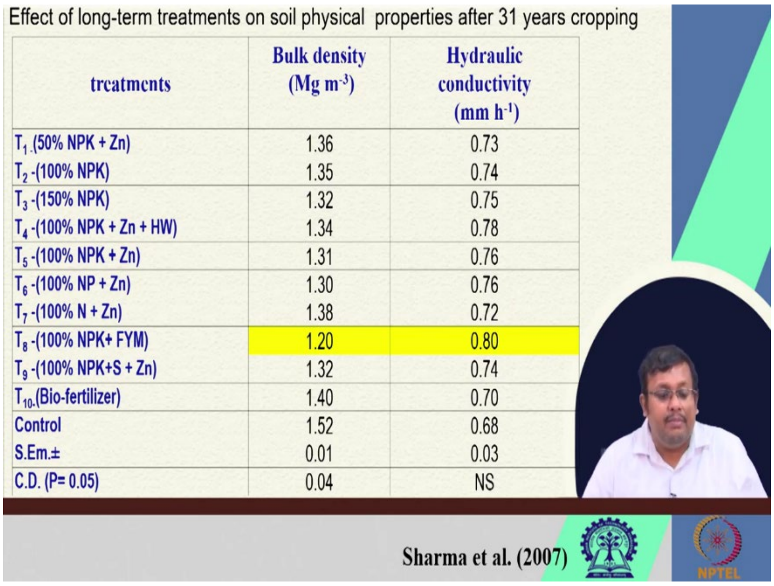

Then you can see the effect of long-term treatments on soil physical properties after 30 years, 31 years of cropping. So, here you can see when 100 percent NPK plus FYM was applied, bulk density was reduced and, so bulk density is lowest in this condition, and also hydraulic conductivity is highest, that is point 80 millimetre per hour.

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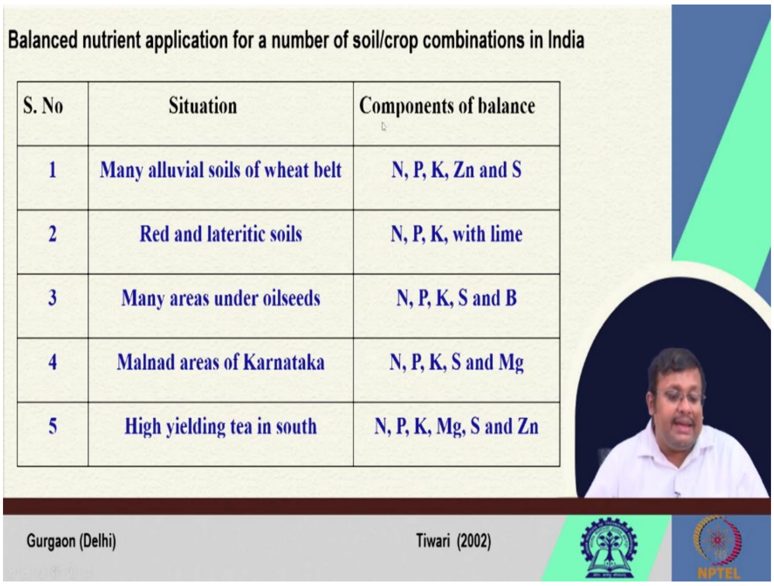

So, balance nutrition nutrient application for a number of soil crop combination of India, if you want to see that, there are different situation like many alluvial soils in wheat belt, there are different components of balance like NPK, zinc, and sulphur, in case of red and electrolytic soils NPK with lime, and then many areas under oil seed NPKS and boron. In case of Malnad areas of Karnataka N, P, K, sulphur and magnesium, and high link tea in south we can see NPK magnesium, sulphur, and zinc.

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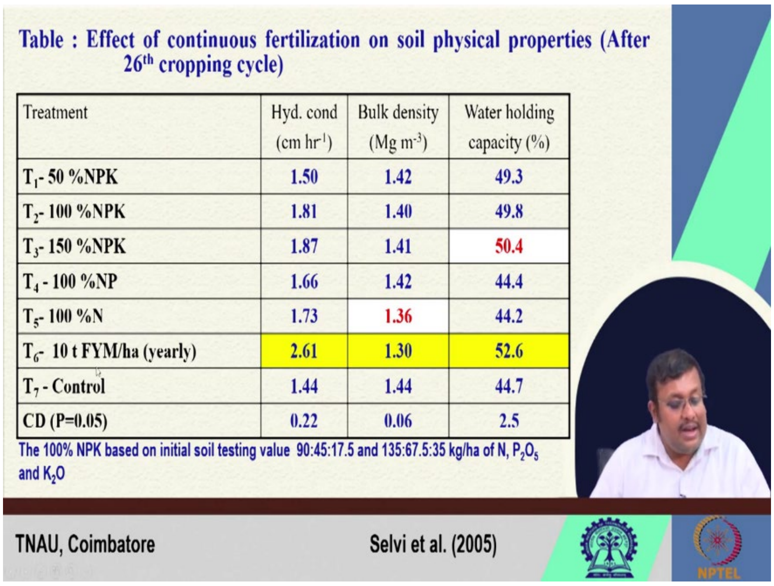

Table : Effect of continuous fertilization on soil physical properties (After 26th cropping cycle)

Treatment	Hyd. cond ($cm\ hr^{-1}$)	Bulk density ($Mg\ m^{-3}$)	Water holding capacity (%)
T_1- 50 %NPK	1.50	1.42	49.3
T_2- 100 %NPK	1.81	1.40	49.8
T_3- 150 %NPK	1.87	1.41	50.4
T_4 - 100 %NP	1.66	1.42	44.4
T_5- 100 %N	1.73	1.36	44.2
T_6- 10 t FYM/ha (yearly)	2.61	1.30	52.6
T_7 - Control	1.44	1.44	44.7
CD (P=0.05)	0.22	0.06	2.5

The 100% NPK based on initial soil testing value 90:45:17.5 and 135:67.5:35 kg/ha of N, P_2O_5 and K_2O

TNAU, Coimbatore Selvi et al. (2005)

We can also see effect of continuous fertilization on soil physical properties, so when we are applying this 10-ton FYM per hectare then you can see that hydraulic conductivity is increasing, then bulk density is decreasing, and also water holding capacity is increasing, so that shows the effect of you know addition of different types of organic amendment or organic component in the soil on the soil physical properties.

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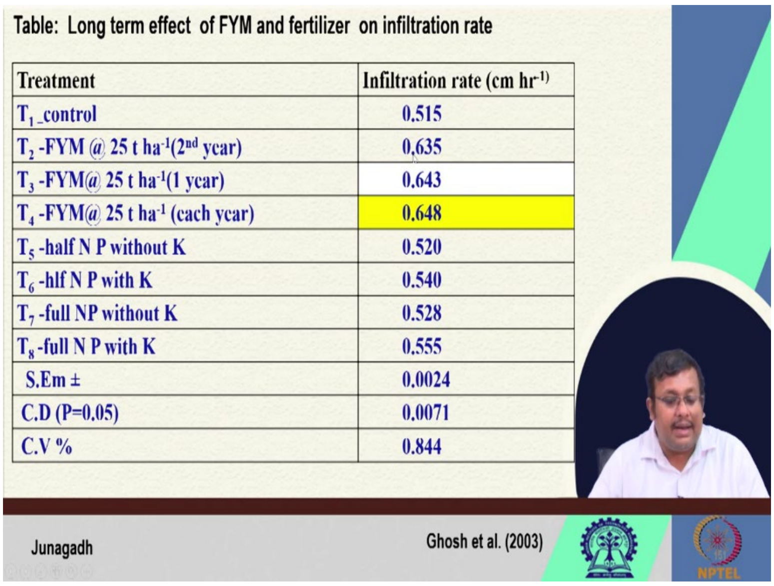

Table: Long term effect of FYM and fertilizer on infiltration rate

Treatment	Infiltration rate ($cm\ hr^{-1}$)
T_1_control	0.515
T_2-FYM @ 25 t ha^{-1}(2^{nd} year)	0.635
T_3-FYM@ 25 t ha^{-1}(1 year)	0.643
T_4-FYM@ 25 t ha^{-1} (each year)	0.648
T_5-half N P without K	0.520
T_6-hlf N P with K	0.540
T_7-full NP without K	0.528
T_8-full N P with K	0.555
S.Em ±	0.0024
C.D (P=0.05)	0.0071
C.V %	0.844

Junagadh Ghosh et al. (2003)

We can also see long term effect of FYM and fertilizer on infiltration rate, if you can see here when we are applying the FYM at 25 ton per hectare, it is in case of control it is 0 point 515, in case of FYM 25 ton per hectare, 0.65 and then that in the second year, in the first year you can see 0.434, and then in each year if we apply then you will get that 0 point 484, 4648, 0 point 648. So, this is how you can see the effect of FYM and fertilizer on infiltration rate.

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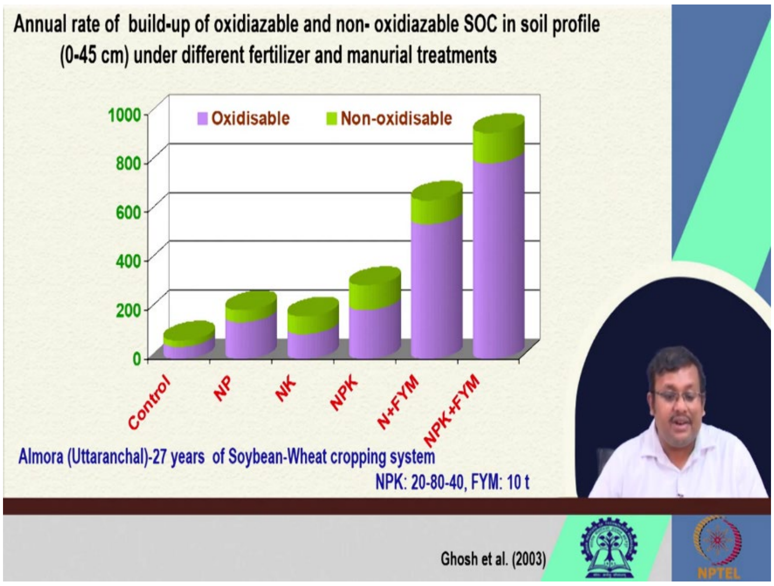

Annual rate of build-up of oxidizable and non-oxidizable soc in soil profile under different fertilizer and manure treatment, you can see there is a control and when we are applying the combination of NPK and plus FYM, we can see both oxidizable and non-oxidizable organic carbon the cumulatively it is increasing.

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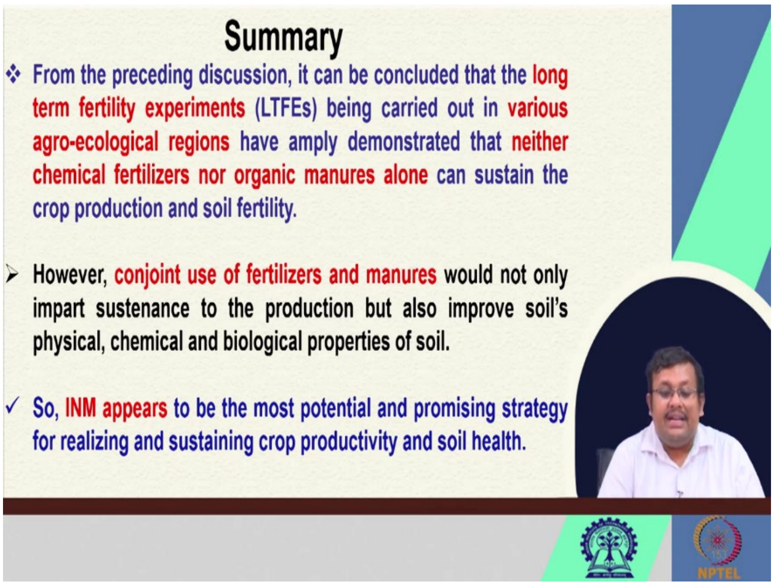

So, as a summary, we can see that you know the long-term fertility experiments being carried out in various agroecological regions have amply demonstrated that neither chemical fertilizer nor organic manure alone can sustain the crop production in soil fertility. However, conjoint use of fertilizer manures would not only impart sustenance to the production but also improve soils physical chemical and biological properties. So, INM appears to be the most potential and promising strategy for realizing and sustaining crop productivity and soil health.

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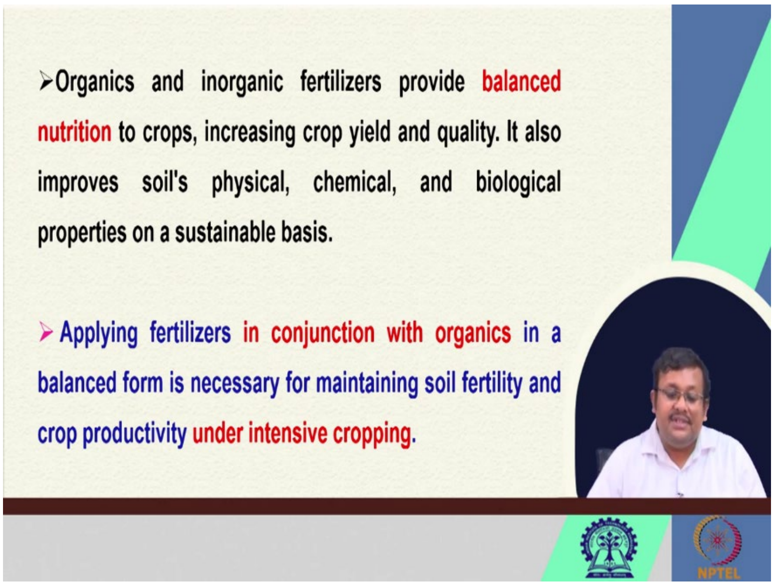

We also know that organic and inorganic fertilizers provide balanced nutrition to crop increasing crop yield and quality, and it also improves soil physical chemical and biological properties on a sustainable basis, applying fertilizer in conjunction with organics in is in a balanced form is necessary for maintaining the soil fertility and crop productivity under intensive cropping.

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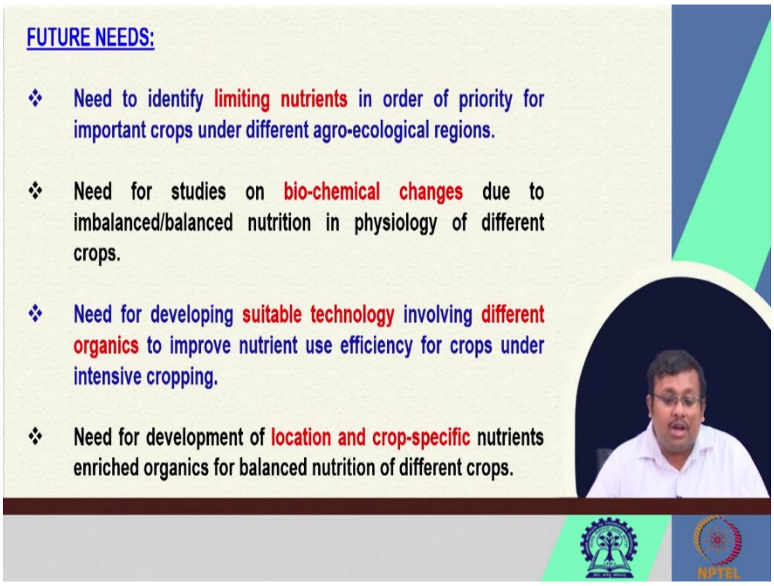

What are the future needs? So we need to identify the limiting nutrients in order of priority for important crops under different agroecological regions, there is a need for studies on biochemical changes due to imbalance or balanced nutrition in physiology of different crop. There is a need for developing suitable technology involving different organics to improve nutrient use efficiency for crops under intensive cropping, and also there is a need for development of location and crop specific nutrients enrich organics for balanced nutrition of different crops. So, this is these are the future needs.

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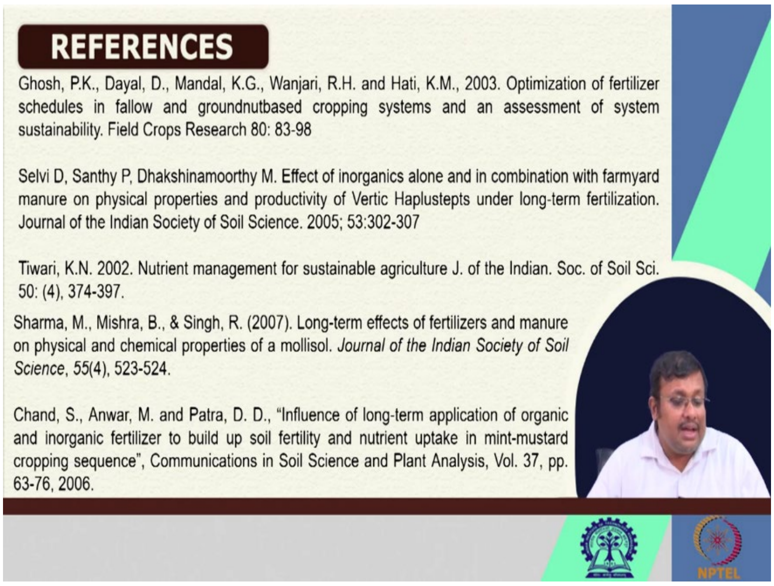

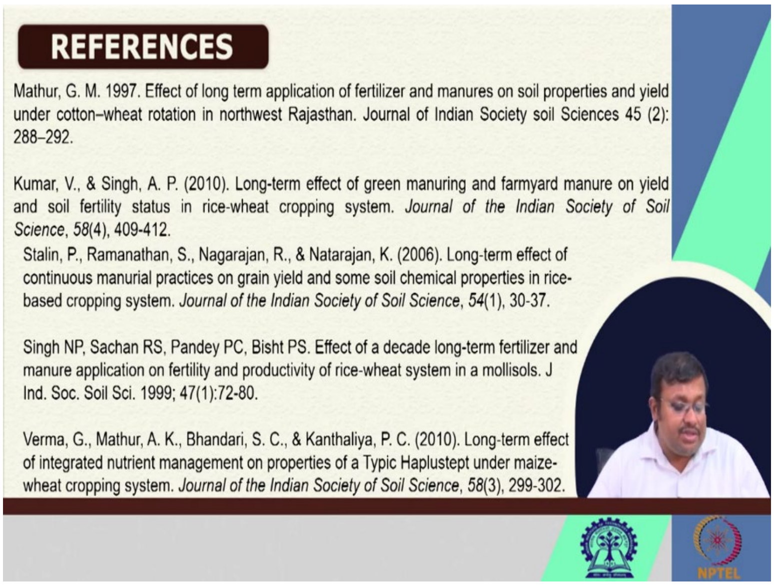

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And these are the references which I have used for this lecture. These are the different different research papers and published research papers which I have used for showing you this case studies. So, you are welcome to go through these research papers to enrich yourself, and if you have any queries, please let me know.

And let us wrap up this this week of lectures, so we have wrapped up this week 11 of lectures, let us meet in week 12 of lectures to discuss more about soil fertility and fertilizers. Thank you.