Nanotechnology in Agriculture
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Lecture-19
Nano-Pyrite and its Lab trial with Chickpea

Welcome back to the lecture series in nanotechnology in agriculture, so as of now we have talked about iron pyrite and the role iron pyrite in the evolution. And apart from it we discussed how iron pyrite is synthesized in the lab. And if you follow up the lecture previously, so this is an inert environment where you make polysulfide and the polysulfide is allow to react with ion salt and this whole thing happens in an inert environment. Because as soon as iron comes in contact with air it will get converted into Fe+ okay it will get oxidized.

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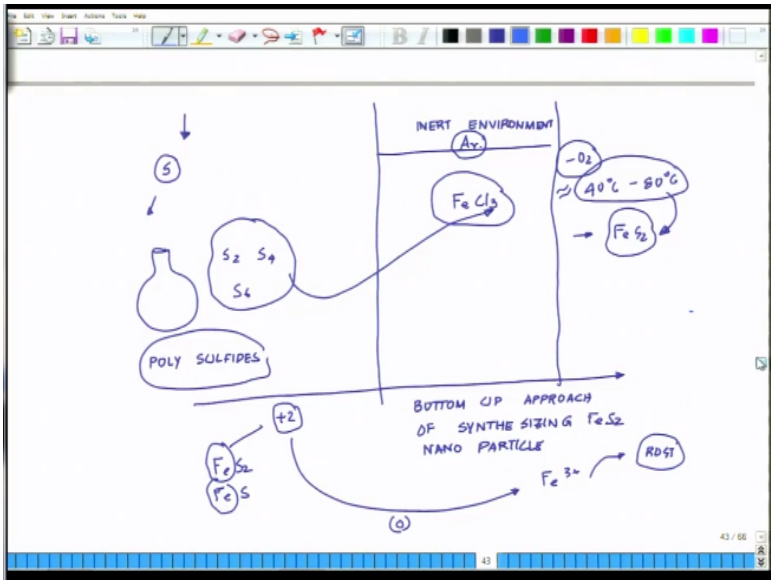

So, in order to avoid that oxidation you have to carry out this reaction in at inert environment and apart from it as soon as you synthesize these particles, you have to characterize them. So, if you remember all the characterization tools what we talked about XPS which will help you to test what is oxidization state.

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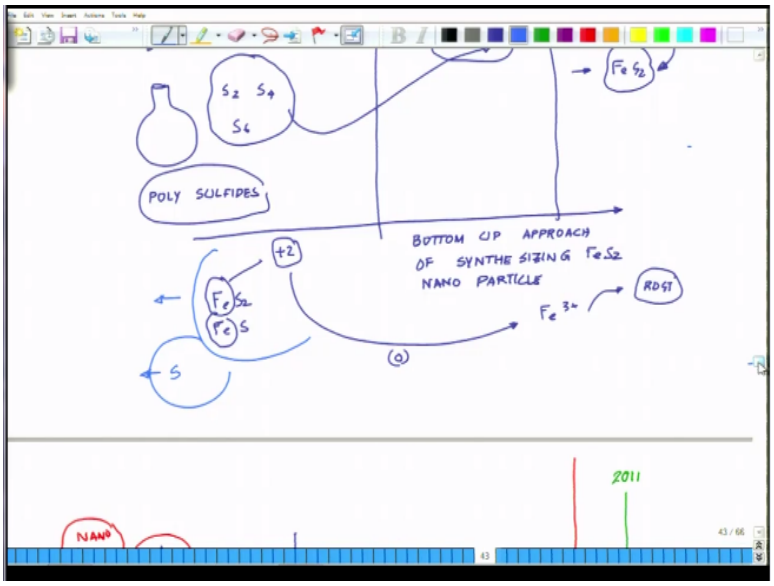

Then the presence of sulfur and the different form of sulfur it is present, the amount of oxygen in the system and all other different residual atoms which are present here okay. It is a most critically it will be these 2 detecting iron and sulfur. Then for the structural characterization one can perform scanning electron microscopy and transmission electron microscopy. In order to understand that depth profile one can go to one can use atomic force microscopy.

And in order to understand crystallinity of the structure or the amorphousness of the structure one has to do an XRD X-ray diffraction not to figure this out. So, these are the basic parameters what has to be worked out and of course the particle size distribution at working particles are when you are synthesizing in such a situation. Now from here I told you that there was seed treatment study.

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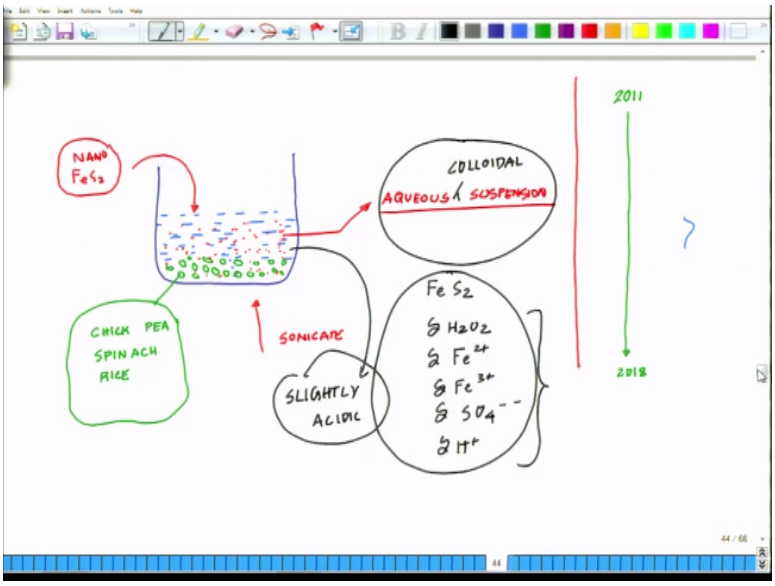

So, it is a 8 years long study which have been published in different form of manuscripts over the years with different crops. So, what we will do we will go to the very genesis of this study how it all started, so since nanotechnology is assuring into the agriculture. So every step we are making we have to make it with a word of caution that you know we are not unnecessarily tinkering with nature.

As we have already discuss that over last 100 years, several things are changed and there is lot of environmental concern which has been raised over the use of it is fertilizers and the contamination of the fertilizer into the water table so and so forth. So the first set of experiment what was done was nano FeS2 or nano pyrite, this in itself is not soluble in water, that is a insoluble.

So in other word when you add pyrite in water it remains as a suspension, so it you can call it as colloidal suspension. So essentially it is an aqueous you can put it as aqueous colloidal suspension, so now this colloidal suspension does couple of things. We have already talked about the stoichiometric defect if you remember.

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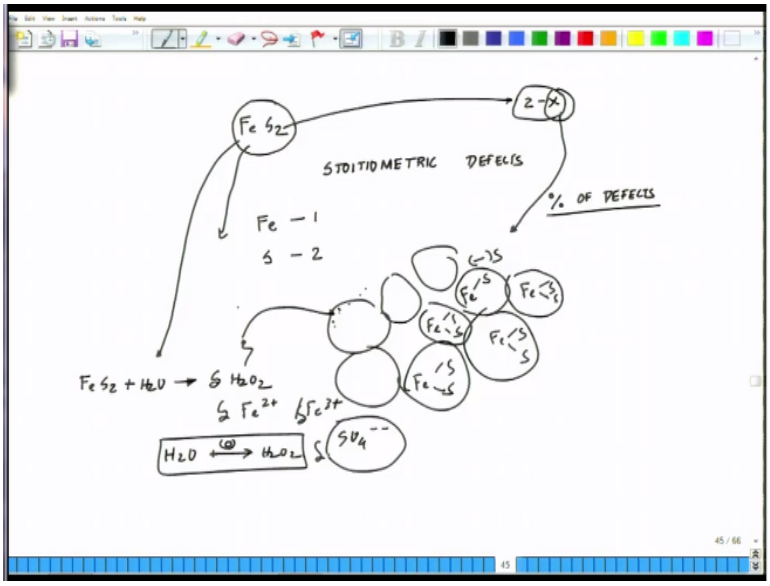

So, just to recollect it FeS2 when you talk about molecule like this there are certain such sulfides with come with a word called stoichiometric defect. In stoichiometric defect what happen, so our assumption is there is 1 atom of iron and 2 atoms of sulfur. But when they form a mass then there will be fuse iron pyrite molecules, say for example something like this, and each one of these circles are representing a single molecule of FeS2 okay.

So then there will be some molecule where there will be a surface defects and which will make them divide of sulfur. So, in other word there will be some, there will be very few but there will be some and that leads us to write 2 as 2-X and that X is essentially the percentage of defects and this is what we call as stoichiometric defects. So this stoichiometric defect in FeS2 leads to some unique surface reactions what happens in this is FeS2+water which is insoluble.

It leads to formation of a very very trace amount of H2O2 okay. In other word water is getting oxidized, this is precisely one of the trace this H2O2 further kind of act on the surface it kind of release some of Fe2+, Fe3+ and SO4- minus signs. And all these are present in a very very trace amount, so in other word when we talk about a mixture like this or a colloidal suspension like this.

So your predominant compound is FeS2+a very trace amount of H2O2, a very trace amount of Fe2+, very very trace amount of Fe3+ and a very trace amount of SO4- and there are photons

which are present and such suspensions are slightly acidic. So in other word it leads to a very complex milieu of ions are there. Now when the very first experiment was done, it was done in a very simple way.

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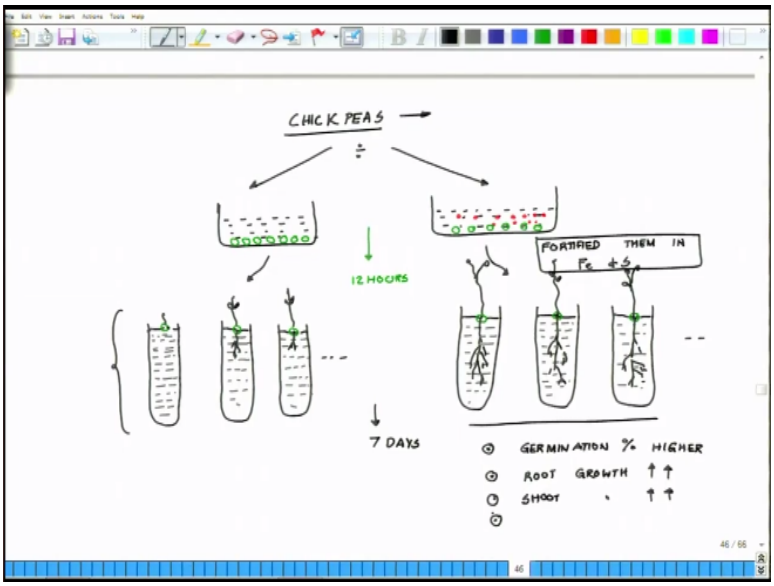

So, chickpeas where taken all of your aware about chickpeas okay, these chickpeas were triggered with surface reactions to get rid of any kind of fungus or microbes or something okay. And then this chickpeas where divided into 2 categories okay, so 1 category was kept overnight in de-ionized water and other one was kept in FeS2 suspension with equal amount of water, red ones are the FeS2 okay, and here you are having the chickpeas.

Next is after 12 hours of treatment these were placed on test tubes like this, all of them are placed on test tubes. So initially seeds were taken out both the cases there washed and they are placed in test tube having de-ionized water, here you have the test tube okay. Now you put in thin films out there, on that film this is film you can make with some of those sealing agent or something a small tube with small hole.

And you place the seed out here like this, place single seed on each one of this parafilm which have placed and on that you are having this simple water okay. Now what you are essentially trying to do you are a germination test and you wanted to see the growth in pure water. So what

you have done you have exposed these seeds to an ionic milieu of iron and sulfur and pyrite in a slightly acidic environment for 12 hours and then you are growing them.

So whose this experiment, this experiment was continue for 7 days and after 7 days the results were evaluated.

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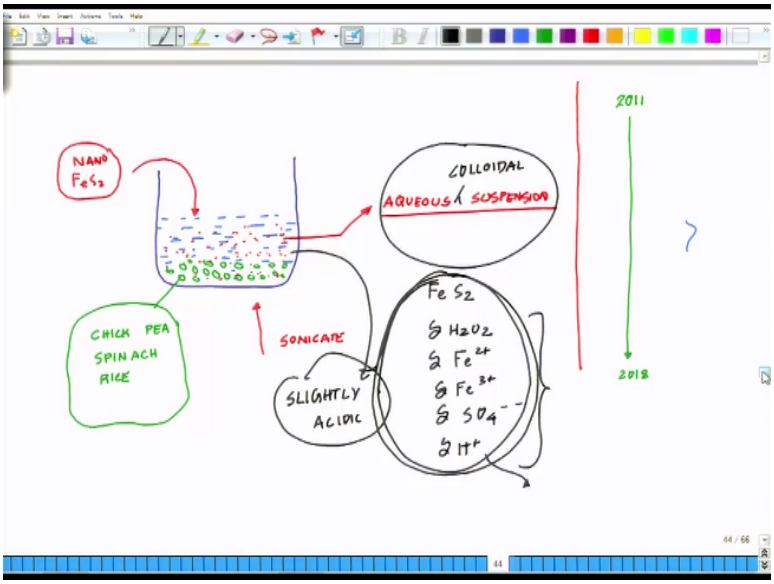

And all these 7 days they will kept in water, so the early phase they only get a booster of 12 hour boosting of these different ionic milieu. So this was the only nutrient which was given to these 6 okay, iron and sulfur, in other word we have fortified them in iron and sulfur okay. Now the results were very interesting, so after 7 days what was observed was, so when to germinate the germinate like this and they form the root system.

The one which we were treated were more taller and having a much more well spread out root systems. And this was the basic difference which was observed in these treated seeds there germination percentage was higher as compare to control point 1, point 2 was their root growth was significantly more, their shoot growth was significantly more and a fourth interesting aspect was overall biomass was significantly higher.

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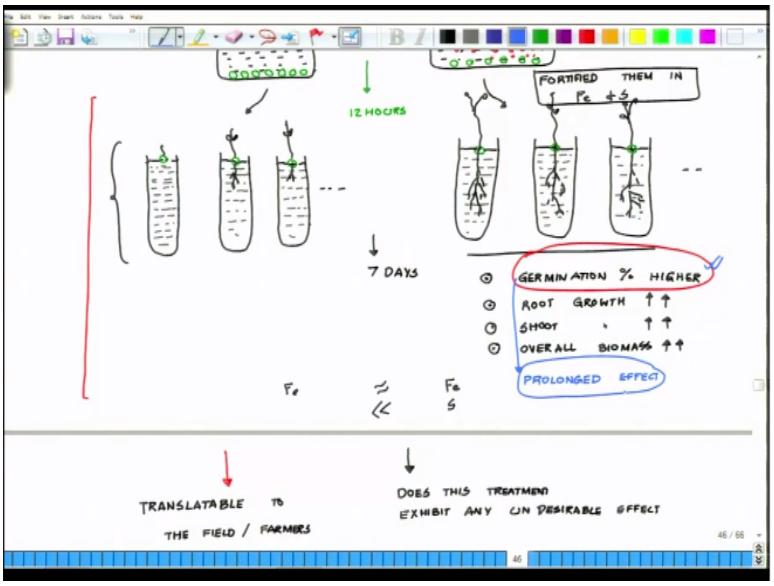

Apart from it, it was observed upon analysis that iron concentration in both these plants remain more or less constant okay. But definitely there was a difference in the sulfur concentration, sulfur is higher on these plants and apart from it there was a difference in few other elements. But this was the very first clue to tell that here is a feet bio-stimulant, very simple seed bio-stimulant which could increase the germination percentage.

And this aspect is very critical for a former because if the germination does not happen right, the crop is standing what we call as the height of the crop if it is not uniform height of the crop of the crop standing will be very poor. So, here is a very interesting chemical tool in armory which helps in increasing the germination percentage. But when you do these kind of studies very next question comes the 2 things which comes.

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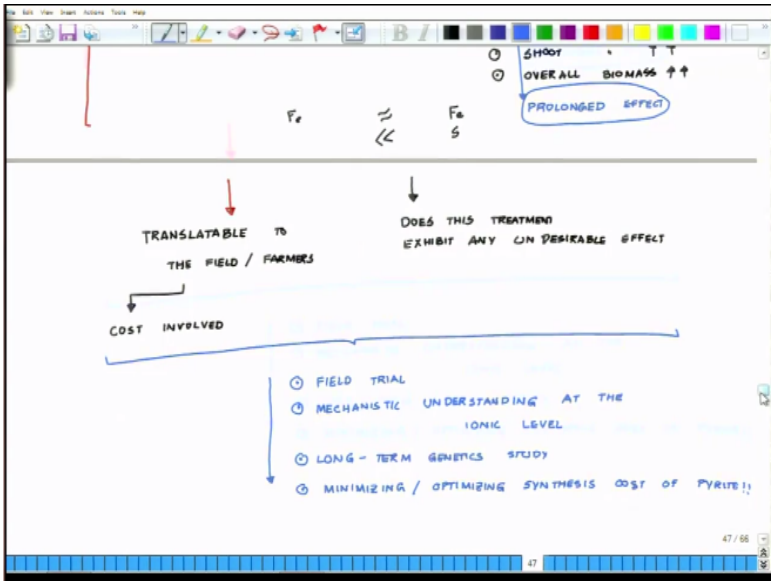

The first question which come is could you translate this to the field, is it translatable to the field to the formers. Second when you talk about translatability what is the cost involved, second does this treatment exhibit any undesirable effect. Now both these questions could be answered by performing 2 things, first a field trail because that is essential to prove that how long this effect remain is it only up to germination or this effect of germination has some kind of a prolonged effect okay.

Now apart from it the next set of analysis is what is the possible mechanism of it is action on the seed without understanding it, it kind of becomes a black box what is happening. So field trail and next is the mechanistic understanding at least at the ionic level. And long term genetics study and minimizing/optimizing synthesis cost of pyrite having seed this let me tell you there are pyrite mines all over the world where the problem with pyrite mines are the bulk pyrite what is obtained has to be either free from the contaminants like cadmium, Arsenic and all other things.

And it has to be either ball mill or using the techniques what you have learned it size has to be reduced down into the nano dimension okay. So that is that issue which has to be addressed before we kind of get a grip on using the huge amount of pyrite which is available. Now coming back, so these are some of the stuff what needed to be answered before this study could we taking to the next level.

Then comes the next set of the study what will be talking about soon is the field trail. So, in order to the field trail one has to first of all those of you are from agricultural background with their life you have to do a possible the double blind experiment. You have to really divide the field in a random fashion like your plots which are obtaining equal amount of all the resources and then you have only one parameter what you wearing**.**

So in order to test this technology, the basic conditions which were laid with like the fields what will be use for the field trail.

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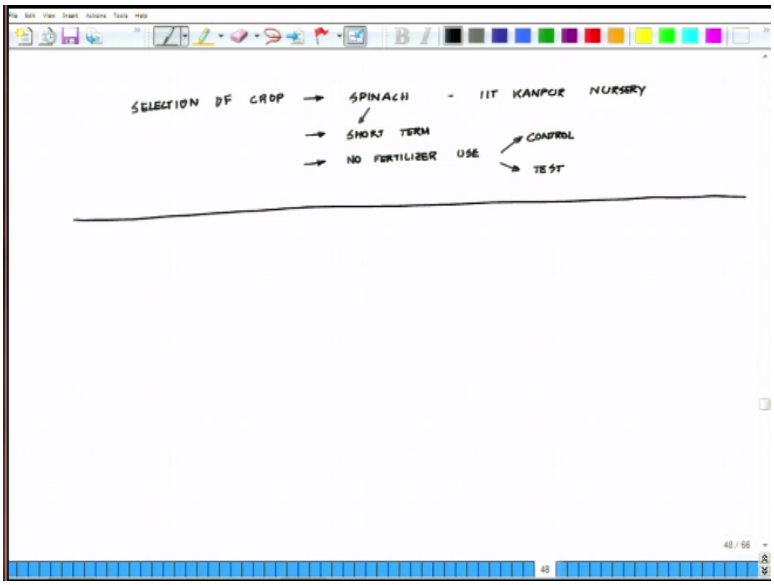

So, the first is select the crop okay, selection of crop, so the first crop which where you can see the profound effect in a short term spinach and this experiment was done in IIT-Kanpur nursery okay. Second thing is of course the criteria for selecting spinach is the short term and second aspect is no fertilizer will be used because that will make the things way more complex, no fertilizer use neither in control nor in test okay.

So these were the basic criteria which was lead before this field trail was initiated and whenever you do field trail you should have multiple replications, so that you can really compare the data neatly what is happening okay.

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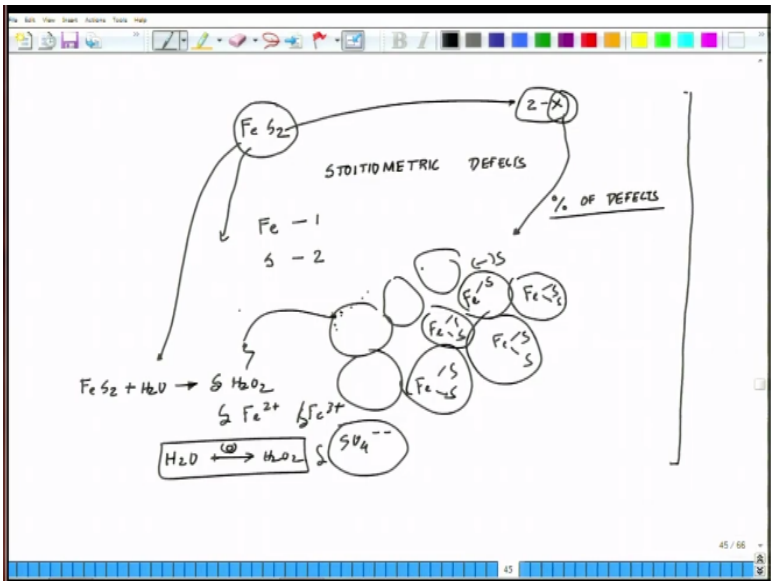

So, let us recap what we talked as of now, so we talked about the stoichiometric defect out here where I told you there are some of these atoms where there is a sulfur is deficient. Then we talked about the aqueous suspension have all these component present and slowly we will diverge what are the roles of individual components which are present there.

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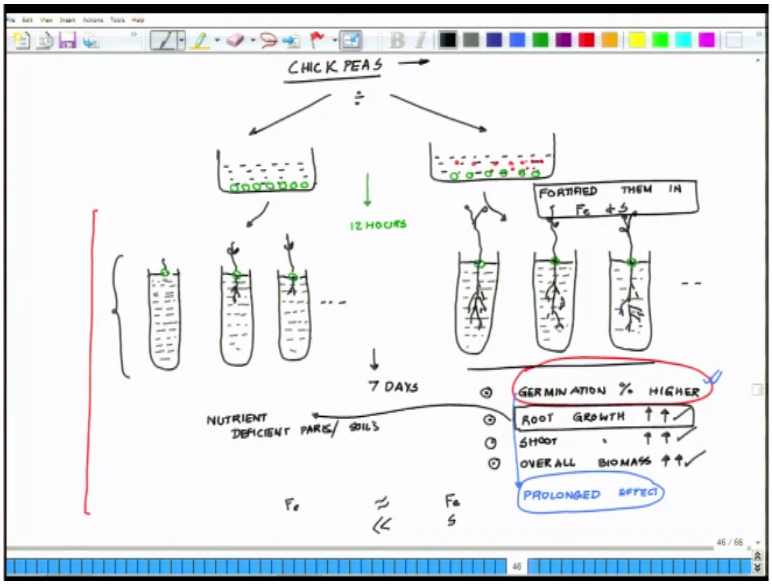

And then we talked about the experiments and the key results where the germination percentage got higher, the root growth goes higher, shoot growth goes higher and the overall biomass got higher. So the root growth more root growth has a different significance and which will be coming while will be concluding this iron pyrite part what does that mean. Because that is something really really very interesting for nutrient deficient soils okay.

We will come to this part once we finish these field trails okay, nutrition deficient paths or the soils okay. So in the next lecture we will talk about the detail field trail using spinach as a test crop, thank you.