Nanotechnology in Agriculture
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Lecture-22
Application of Pyrite Nanoparticle in Different Crops

Welcome back to the lecture series in rollup nanoparticles and nanomaterials in agriculture. So in the last class we talked about the mechanism of action of iron pyrite nanoparticle in keys of spinach crop. In general that is possibly the most accepted theory by virtue of it iron pyrite act. So just for a small recap where we finish the previous class, so look at it.

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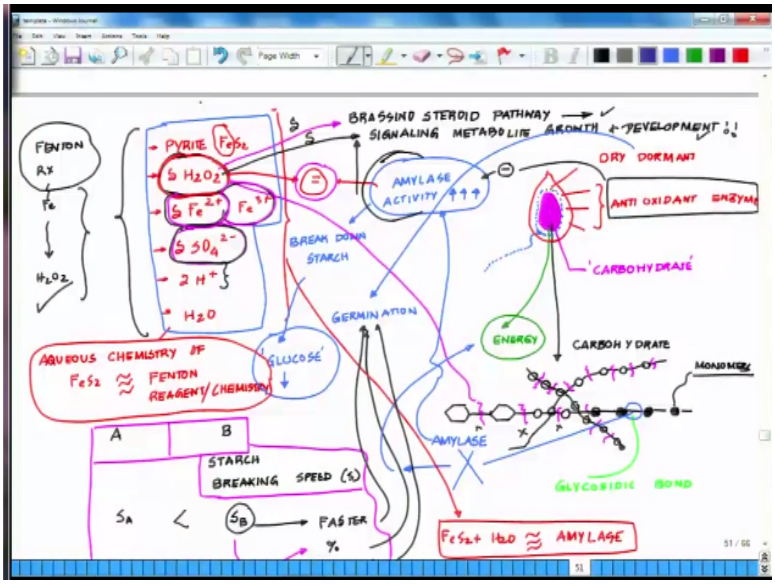

So, this is where we showed that pyrite particles producing trace amount of hydrogen peroxide and iron in +3 and +2 state and So4 2- that is the aqueous chemistry of iron pyrite which is essentially a Fenton like reagent it is acting like a Fenton like reagent okay, so use Fenton like reagents okay. And this hydrogen peroxide is involved in breaking down of those huge starch molecules which essentially is mimicking the amylase activity.

And due to this breakdown of the starch molecule this plants or these treated plants get a better start off as compare to the plants which are not getting that fast supply of energy. This is precisely what we believe is happening out there okay.

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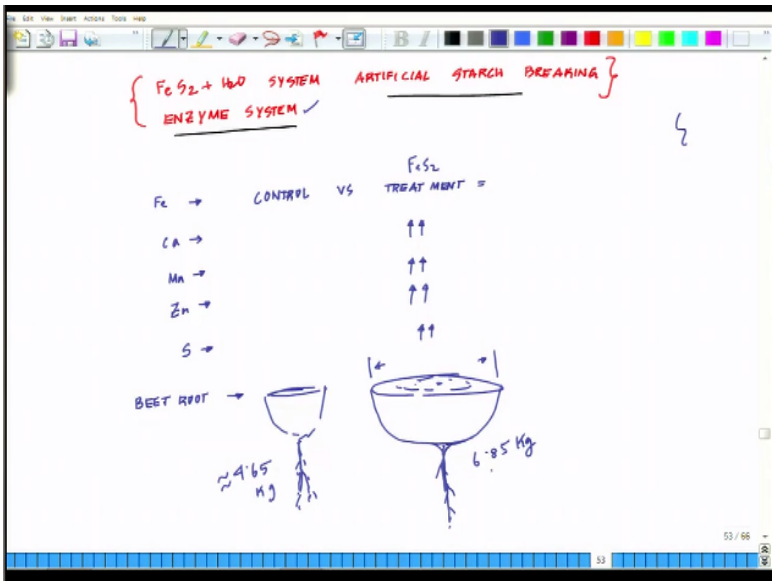

So, in other word we can call FeS2 water system has an artificial starch breaking enzyme system okay.

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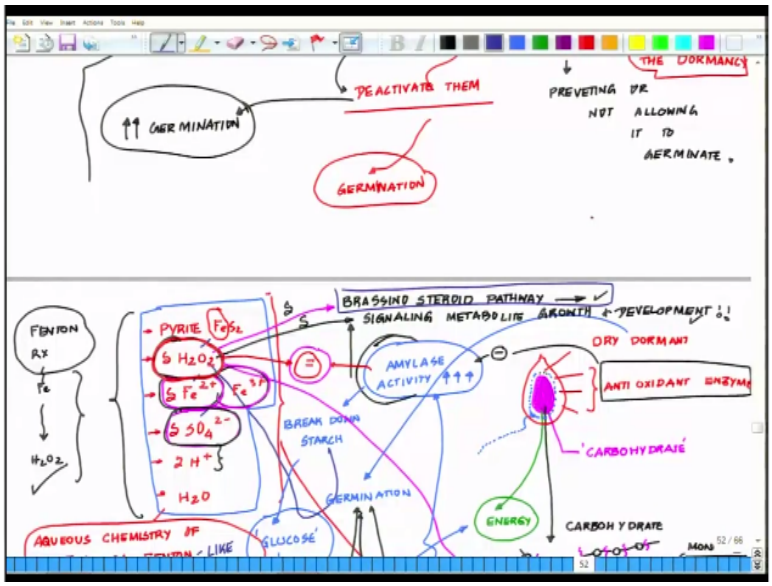

And apart from it, it is believed that it triggers another pathway which is yet to be explode is called brassinosteroid pathway which is essentially a pathway which gets activated when plants realize that it has to acquire more nutrients in a short period of time maybe it is kind of related to some way to the stress pathway. It is not very clear but it seems that this is one of thing which is happening apart from the H2O2 signaling.

And of course fortifying the plant in environment iron and sulfur. Now if you look at the concentration of different elements which are increasing in these plants. If you look at it iron that remains constant, there is no different with treated and the control okay. So control versus treatment is same. Now if you look calcium it is definitely in the treatment seed treatment this is higher, if you look at manganese this is higher.

So manganese being higher makes does make sense because chlorophyll is higher, so it means your manganese clusters will be higher. If you look at zinc, zinc is higher similarly if you look at sulfur, sulfur is higher. So these elements are higher in the case of the seeds which are treated with iron pyrite nanoparticles. So these plants have this added feature in them, now from here if you look at the different kind of crops where it has shown.

So in the field trials which were done with beetroot showed a very profound impact, in case of beetroot we observed a much modified or does the modification in the root structure, root is much more thicker. So, if you take a cross-section of beetroot then you will observe the beetroots which are treated as a much more thicker cross section as compare to the beetroot which are untreated okay something like this.

As you know the beetroots are like this as compare to the one which are untreated. So, much more thicker cross section. So it is found that there was a significantly higher beet production by nano FeS_2 seed treatment and the total yield of control and FeS_2 pretreated is in the range of in the case of control it is approximately 4.65 kilogram whereas in the case of FeS_2 treated it is almost like 6.85 kg okay, similarly if you look at the carrots this is the case of beetroot.

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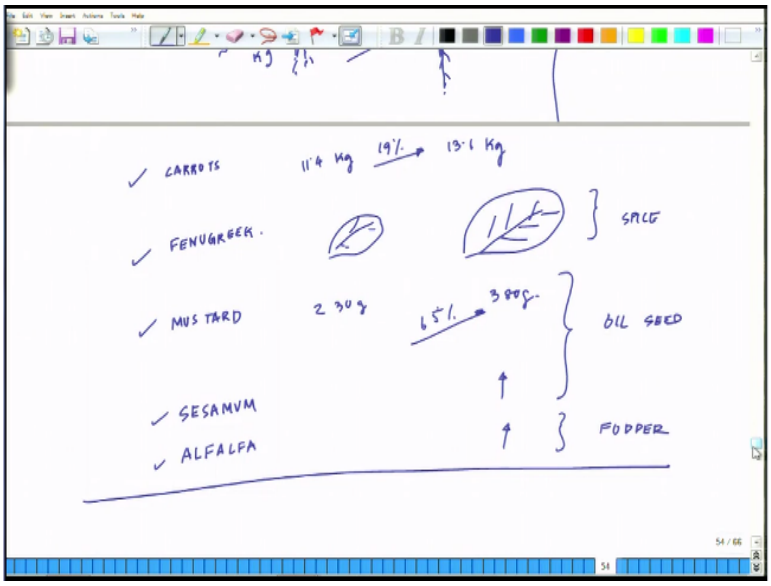

And if you look at carrots then you observe a very interesting improvement in the case of control it is 11.4 kgs whereas in the case test and this is all for unit area whatever we are talking about trail okay. So, there is an increase in approximately 19% and the contrary in the case of beetroot you observe increase of approximately 47% increase okay. So, similarly if we go to fenugreek which is a commonly use a spice in African Asian and North American continent.

You will observe that the leaf area is much more bigger in case of fenugreek, so the leafs of the fenugreeks out here are much more larger as compare to the leafs of the control okay. Similarly and a case of mustard it was observe that there is approximately 65% increase in the yield that is so here now you are talking about a oil seed which is 230 grams whereas in case of 380 grams, so it is 65% increase in the mustard.

Similarly in case of sesame if you look at it, so what will observe is there is a higher production of sesame which is another oil seed (()) (07:30) and similarly in the case of alfalfa which is fodder crop there is higher increase. So, if you look at it the profile of crop it observe beetroot, these are the roots, carrots, fenugreek, mustard, sesame, alfalfa that almost covering to vegetable crops.

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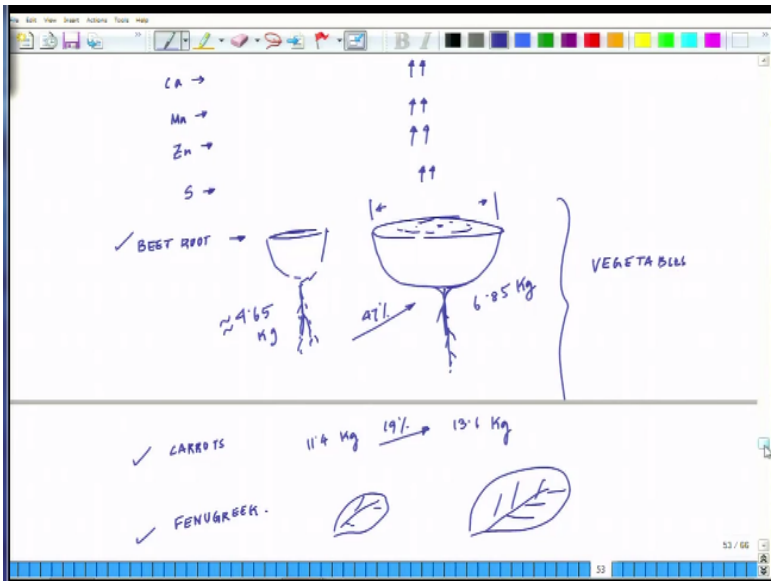

These 2 are the vegetables, then of course some people use fenugreek also as a vegetable or as a spice and a spice crop, then you have mustard which is all seed crop mustard and sesame. And here you are having a fodder crop, so these are the ranges of crop which have been already tried out and it has been observed in the field trails and this is the data we are talking from the field trails.

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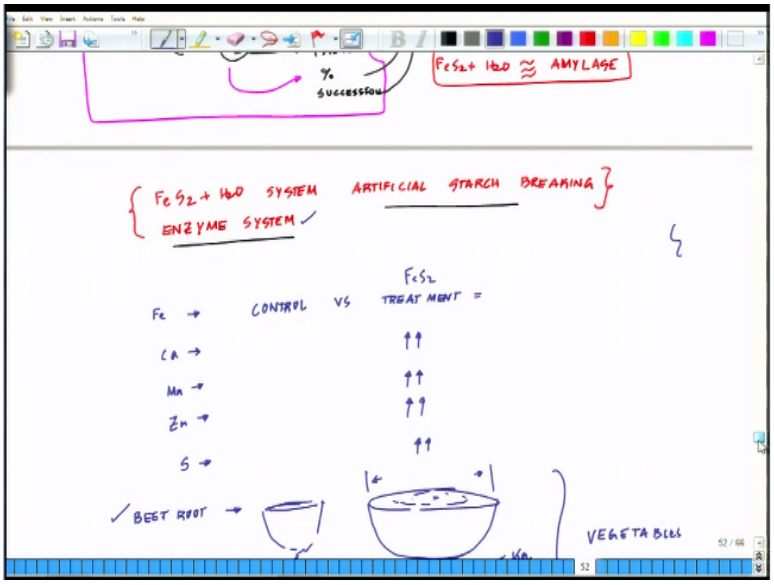

These field trails have clearly shown that nano FeS2 application is improving the yield just by simple seed treatment okay. So, now if you look at this chart you realize that is 1 set of crop which is missing here. The one which is the major chunk of our food which is a grain crop, so challenge was that time to try out grain crop something like rice or wheat. So next set of trail

data what I am going to show where FeS2 has been used is seed treatment of rice well rice is grown in 2 different ways.

Either it grown by direct seed treatment or it is grown during transplantation, so you grow the rice crop in the nursery and then you bring them back into the field and grow them. So let us see what is the seed treatment data of rice see but before I get into that these crops what I talked about.

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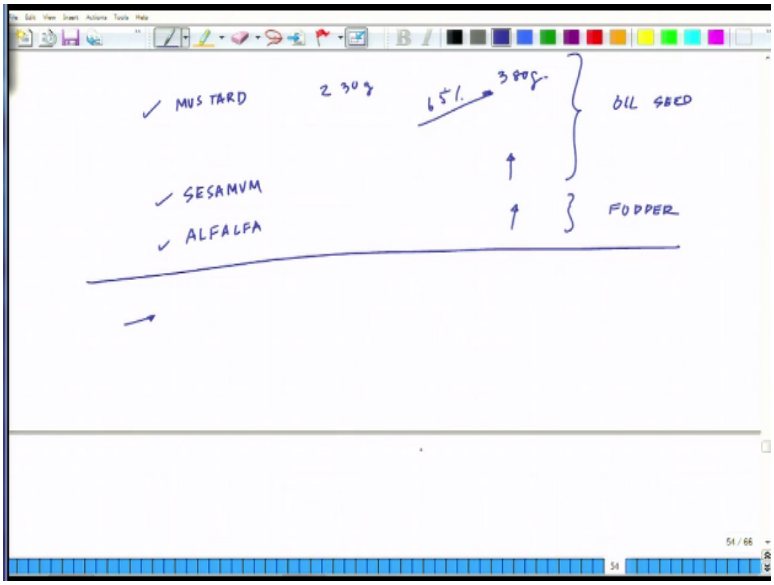

At least in the case of analysis of the fenugreek, the flavonoid contents what has been observed has shown. Then most of the flavonoid which are present quercetin, garlic, ascorbic, (()) (10:42) they are more or less same okay there is not much difference in their concentrations okay. So this is one piece of information what I wanted to share with you, now coming to rice.

So, the way rice experiment was done and well for those of you I will be providing all these papers for you to read. So, you can download these papers and read them that will kind of give you an idea how these kind of experiments are being done. So, in the case of rice the experiment was done slightly differently, so what you wanted to observe was does of course by this time it was clear with this multiple crop that FeS2 seed treatment indeed increases the production of the crop.

Now the question was thus this production how far it is from NPK treatment, so as I told you in the beginning excess use of fertilizer is a challenge. Because excess use of fertilizer lead to contamination of the soil resources, water resources and it creates a lot of other problems, this is 1 aspect of the story. But other aspect of the story is a large continent called Africa where a possibility of fertilizer is not easy, it is a huge challenge there.

Similarly they are parts of Latin America their affectability of fertilizer is a big challenge and the say by the same token the small and marginal formers of Asia South east Asia cannot afford fertilizer unless it is a government subsidy. And this government subsidy and availability of fertilizer is not something so easy, it is a very tricky bargain in the agro-economic center of a country.

So one of the major requirement is somewhere other you have to reduce the fertilizer consumption how one can do it. So, in order to test this, so if you look at it the major fertilizer consumption happens in the grain crops where the big chunk of a land investment goes for this growing this grains. So this experiment was done in a way, so the seeds where taken, now we talk about the rice crop okay.

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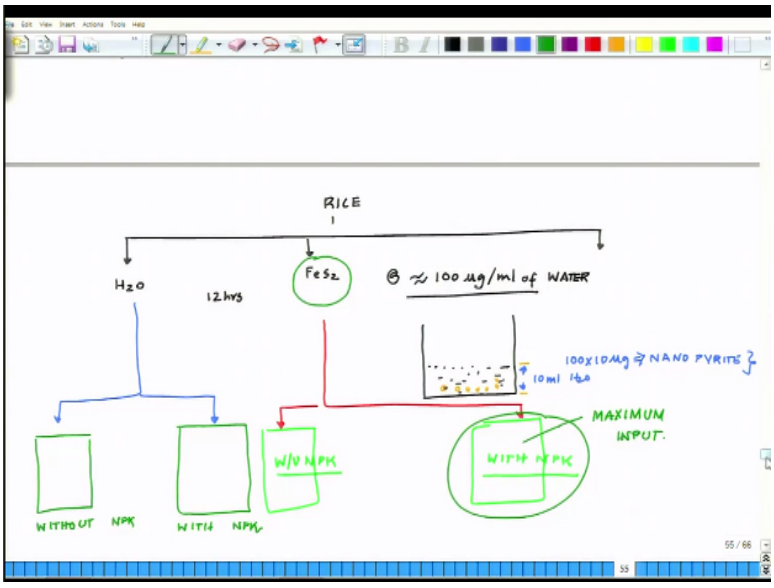

So, seeds were divided into 4 different categories as we did in the beginning simple water control, simple FeS2 control. So, the first what you get like this FeS2, now after 12 hours of

treatment and by the way the dose is approximately 100 microgram per ml of water. So that essentially means suppose we have for all the seeds whatever you are going to treat if you have 10 ml of water for that then you will have that will contain 10 microgram of nano pyrite okay.

So post treatment that FeS2 fragment was divided into 2 parts until what makes done and the water treated were divided into 2 parts this is equal number okay. Now what was being done is these were grown in field without just whatever residual nutrients was present in the soil. So without supply of any NPK whereas the other water treatment seeds were grown just normally the way you grow with NPK.

Now these 2 sets FeS2 treated, these were also done the same way here without NPK treatment and with NPK treatment. So, you observe there are 4 different categories simple water treatment of the seeds divide in 2 parts, 1 was driven in a complete control condition though no additional fertilizer whatsoever, whereas the other group get a normal fertilizer those what has been given currently across the country or the particular regional location where this experiment was conducted.

So then the FeS2 treated seeds also underwent the same thing 1 was given a control like you know grown and of field where there is no added fertilizer was given the other one was given fertilizer. This is the case which has the maximum input if you look at it, this one has maximum input both seed treatment as well as fertilizer okay. So, now after treatment what was observed whereas 2, 3 interesting observations which emerged out from this study. And observations are as followed if you look at the base to majority for these crops.

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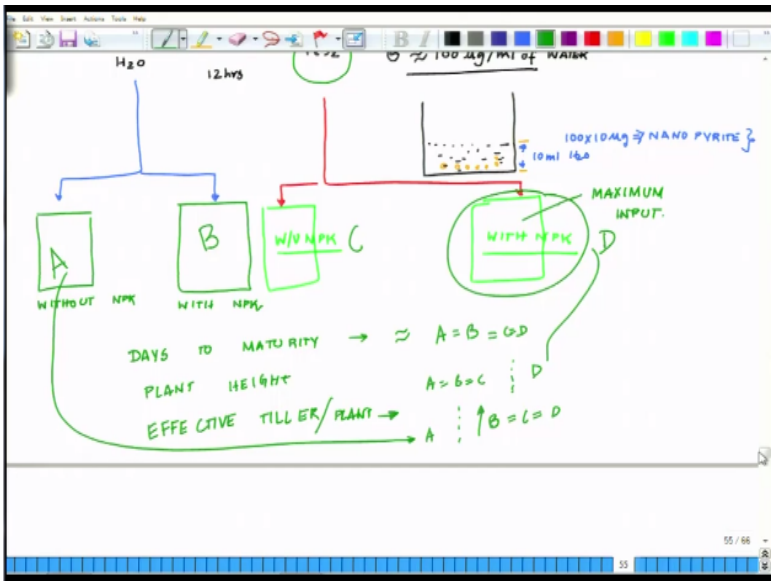

So, now and these are normal field, so if you look at days to maturity is for all the growth, so if I named as A, B, C, D. So, for all A, B, C, D is all more or less the same okay, there is no different, now if you look at the plant height. So, if you look at plant height you observe a slight increase in this growth by aside A=B=C where you know here B is slightly more but not significantly okay.

Now if you receive the effective tiller per plant, in that case what you observe is there is a significant increase in as compare to A which is without NPK and just water treatment B, C and D are higher okay more or less same.

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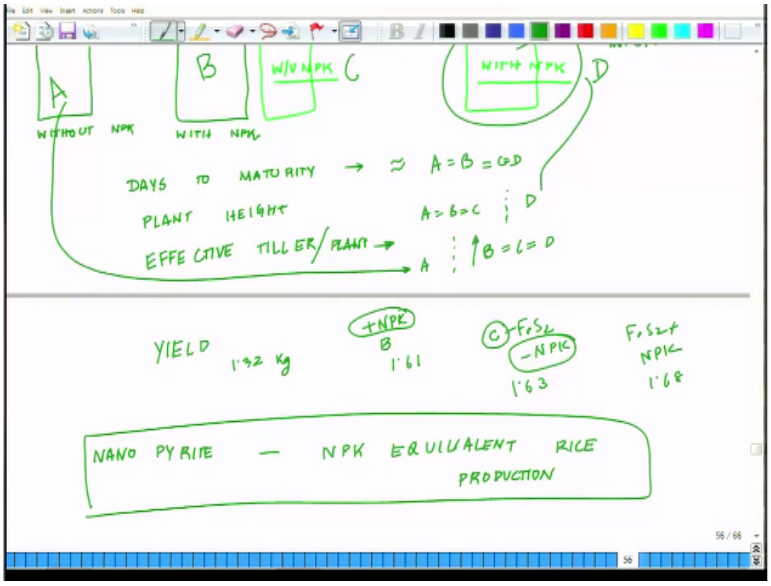

And in terms of the yields per kilogram what was being observed was in the case of control whatever talk about this situation A it was 1.32 okay kilogram/hectare whereas in the case of standard fertilizer application that is which is a group D which is 1.61 in the case of NPK only, only NPK which is a C without sorry only FeS2 without NPK, no NPK –NPK and this is just +NPK.

The number of whether on 1.63 whereas in the case of FeS2+NPK value is 1.68, so in other word what you are observing is that nano pyrite seed dressing. In the case of rice leads to a NPK equivalent rice production, so this is what emerged out from much of these field trials that FeS2 indeed does some very interesting change, it brings about in the seed which is manifested in the form of grain yield as well as vegetable production.

So now if you look at what all crops have been covered as of now in terms of the vegetable field trails the crop, in terms of the vegetable spinach then you have beetroot then your carrot and fenugreek as a leaf. There are several people use fenugreek as a green leaf for dietary consumption, in terms of oil seeds sesame and mustard okay and partly sunflower. Then in terms of for rich crop alfalfa, spices of course we have talked about fenugreek.

And in the green crop that is rice, so rice is the only one which is a mono crop, so if you look at the spectrum from dicot to monocot it is pretty much working for the whole spectrum of gross family to legume family to (()) (23:13) all other families. So, the rice trail clearly indicated now we are equip with a tool which the rice NPK equivalent production which is a feed which was never achieved earlier.

So, this is something exceptionally interesting to know as it is possible that 1 can get an NPK equivalent system. So, in other word biology has way to more to offer NPK is not the only way you can get higher yield but then what are those other ways. So, in the next class we will talk about another aspect of iron pyrite, how this protein molecule can come very handy to grow crop in nutrient deficient soil.

Because here you will observe that it can help in producing equivalent amount of yield as compare to NPK okay, thank you.