Nanotechnology in Agriculture
Prof. Mainak Das
Biological Sciences and Bioengineering and Design Programme
Indian Institute of Technology-Kanpur

Lecture-23
Application of Different Nanoparticles in Agriculture-I

So, welcome back into the lecture series on nanotechnology in agriculture. So as of now we have talked about the seed treatment with iron pyrite, the reason to stress upon it is that there are very few studies as of now which has seen the whole production in the field post seed treatment. As a matter of fact seed treatment as such have been studied with nanomaterial mostly in terms of germination, how it influences the germination.

But to see the whole spectrum of growth in terms in germination to (()) (00:50) and analyzing the final product hardly any studies there almost none, at least which are published. So that was one of the reason why I invested so much time on telling about 1 material which has have a result of the complete spectrum in turns of the final production and the nutrition analysis.

Today what I will do, I will give you a kind of a summary sheet of the other nanomaterial which been investigated currently or under intense investigation primarily at the level of either foliar spray or germination or seed link treatment and the growth but not that I have given you all the productions and everything not in that level. So one of the common nanoparticle which has been used pretty frequently is silver nanoparticle okay.

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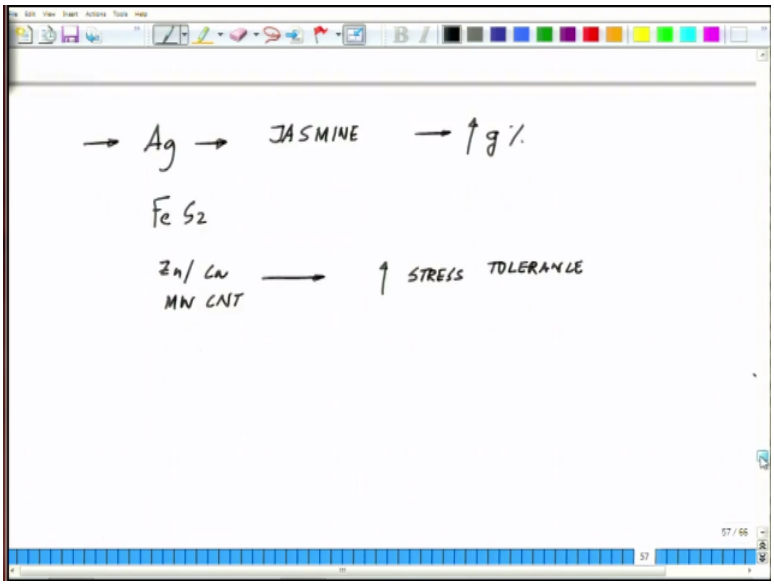

And by the way even if you miss out here I will be giving you some of those publications where these comprehensive tables have an included. So, you can really refer to those table and you can check the cross-references and you will find there are quite a number of studies which is come from India. And there are really pretty neat studies and you will appreciate and there was one which you like which is on hydroponics.

So, there are several line of application which is emerging as nanotechnology is not changed from an intensity to it is maturity. We are realizing many interesting aspects okay, so let us continue silver, silver nanoparticles have been used on jasmine rice okay. On jasmine rice seed priming and it has been shown to enhance germination it was been germination like g enhance germination and it also promotes germination of Ag in seeds.

And in other words as we have mention earlier that you can really stop that aging process within the leaf by manipulating it is enzyme activity that precisely what silver does not, silver is an antibacterial and it has several other antimicrobial activities okay. So this is about silver similarly we have already told about iron especially iron sulfur it has been tried on chickpea.

Similarly zinc, zinc has been tried for seed priming which increases seed wheat and other aspect similarly calcium multi volt carbon nanotube okay. So, zinc, calcium, multi volt carbon nanotube, so these have been treated as a seed priming which has been shown it increase the

stress tolerance. This is another area where people are working and you will have all the references coming up in a publication.

Similarly we have talked about iron pyrite where in chickpea, spinach, beetroot, carrot, fenugreek, alfalfa, mustard, sesame, rice in a whole ring**.**

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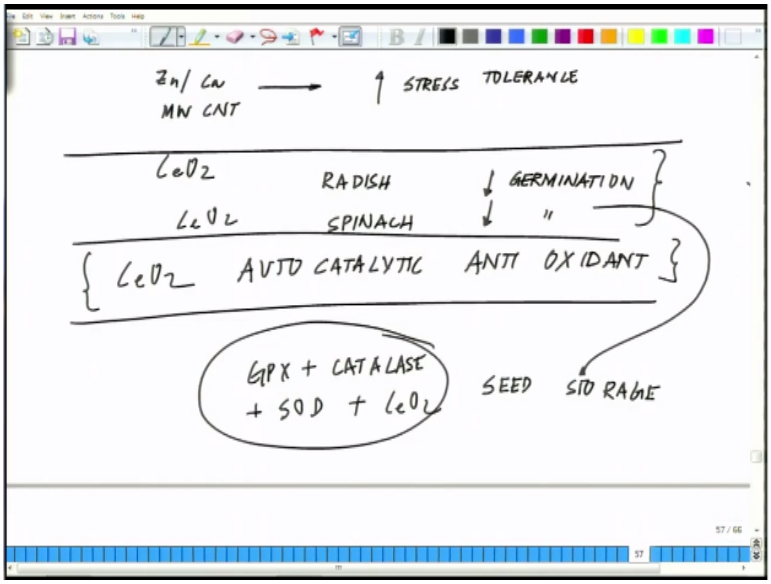

Similarly if we move onto Cerium oxide another very important nanoparticle in terms of it is done for it is biomedical application. It has been tried out in radish germination but it has a negative result and has shown it retards the germination but that has it is own advantage. Because this is a very very similar result what we have observed with spinach it retards or it is slows down the germination, why it slows down the germination.

There is a interesting question we try to answer because it choose a member what promote the germination, germination is promoted by removing the blockage offered by antioxidant enzyme towards that towards amylase not to function. So amylase if you recollect the amylase is the enzymes which involved in breaking down of the starch which is one of the most important event which regulates the germination process right.

Now these antioxidant enzyme catalyze superoxide dismutase, glutathione peroxidase, these antioxidant enzymes prevent the activity of amylase. But then what FeS2 does, FeS2 produces a

trace amount of hydrogen peroxide that hydrogen peroxide grows and breaks down the starch and the releases the reducing sugars and they are avoid a plan get ready source of energy pretty fast as compare to control once and it grows.

Now what Cerium oxide does, why Cerium oxide retard germination, if you think of it Cerium oxide in nature is an antioxidant molecule. It is a 3 atom antioxidant with swap in it is oxidation state from C3 to C4, C4 to C3 is an auto catalytic antioxidant. And this is what Cerium is all about, so and Cerium we new readily in biomedical research especially in spinal cord injury in retinal degeneration of the photoreceptor could be retarded by using a supplementing the retina with Cerium oxide.

Similarly has been used in cancer patient where undergoing radiation therapy because it protects the healthy cells around the affected area of the tumor or the cancer growth. So if you use an antioxidant what you are essentially doing you are adding into the list of 3 antioxidant what I told you right catalyst, peroxidase, superoxide dismutase+Cerium. So, you are actually preventing the seed from germination.

So, in other word that gives us a clue what it is say for example you are storing seed and it is a damp weather when you really have to ensure that you know they get that you can use this as a seed storage material. So any result forth comes it is up to you why not apply it, so it trace amount of it and it is going to work. Because at the nano resume we need to one need the whole amount of it okay.

So, that is why this piece of information that is retard germination could also be used for seed storage okay. So glutathione peroxidase, catalyst, superoxide dismutase+CeO2 this is the battery of (()) (09:10) working.

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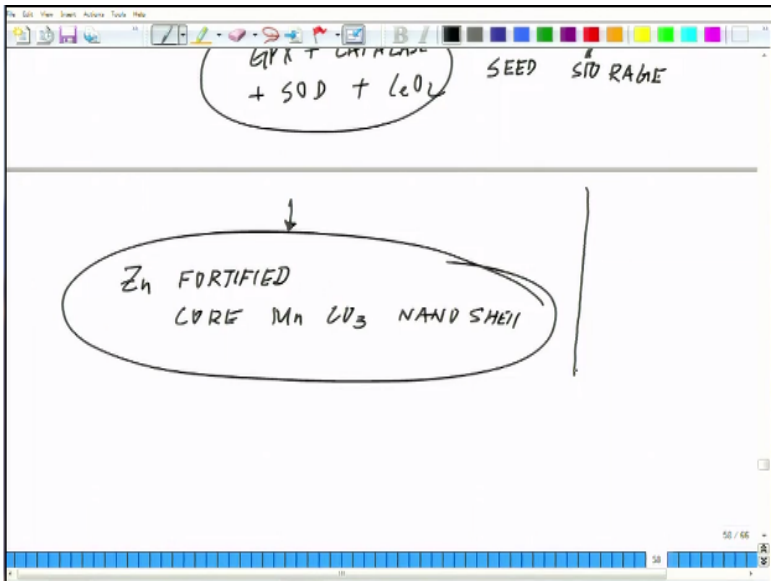

Now from cerium oxide move on to carbon nano tubes, carbon nanotube in tomato has been shown to enhance seed germination. Similarly water soluble carbon nanotubes in chickpea has shown to increase the growth, similarly silver has been treated silver nanoparticle have been treated on fenugreek seed, it increase the fenugreek seedlings sorry it has increase the leaf numbers, shoot length, root length and wet weight.

Similarly molybdenum has been tried on chickpea seedlings, it has been increase the root and nodule number and as development of microorganisms in the (()) (19:53)**.** Similarly manganese has been try in on mong beans seedlings other this is the state where I mention seed or seedling of any other flower spray or something else. This increase the root length, shoot length, dry weight, chlorophyll, carotenoid contained and for synthesis rate.

Citric acid coated Cerium oxide and the radish seedling retarded seed germination but the change the see performance as I have already mention calcium carbonate despite on peanut seedlings it significantly improve seedling growth, magnesium tried on black eyed pea seedlings it increase seed rate similarly iron tried on black eyed pea in hydroponic foliar and seedlings it increased weight and chlorophyll content.

Zinc oxide tried on mong bean and chickpeas seedlings it increase shoot length and root length and biomass. Carbon nanotube tried on anion seedlings it increase the root growth, zinc oxide it

is tried on cucumber in the soil mixture as well on seedling it increase root dry mass and fruit starch, this is very interesting see think about zinc it increase the food starch. So, in other word you have ability to modulate nutrition of status of the fruit okay.

So, now from there we move onto copper oxide Co it was tried on water weed seedlings it increase it is percentage rate Cu2O. Similarly Fe2O3 tried on spinach in hydroponics it increase plant biomass root and shoot. Similarly zinc fortified core manganese carbon at nano shell tried on rice in soil it increase green yield it is pretty complex one though, you have zinc fortified because zinc is (()) (11:54) disease, zinc deficiency zinc fortified core and manganese carbonate nano shell.

It is a pretty complex synthesis process which is directly applied to the soil it increase the grain yield, zinc oxide on chickpea through foliar spray on seedling increase biomass accumulation. Similarly iron tried on wheat foliar spray in as for synthesis chlorophyll and biomass, so this is exhausted really can you know on and on but the fact of matter what I wanted to highlight here is there are series of it so it we really numbered of the kind of nano particle we just now talked about.

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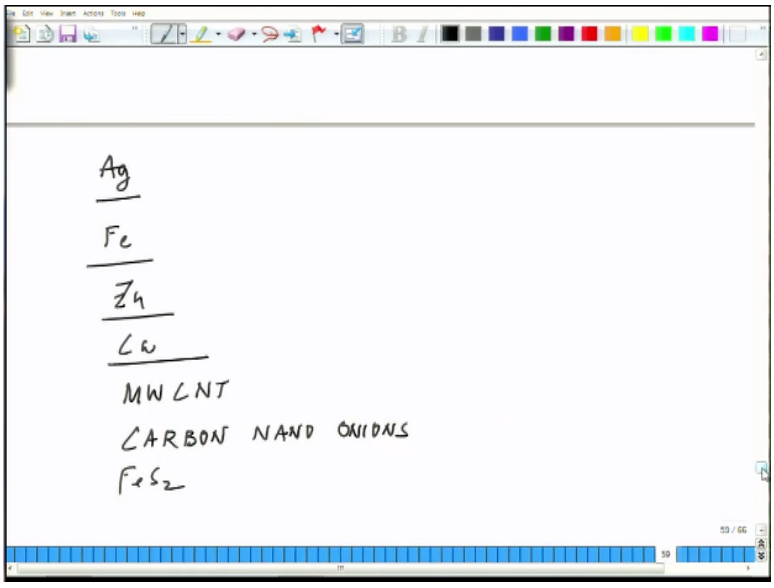

So, if we list then we talked about silver, we talked about iron, we talked about zinc, calcium, multi volt carbon nano tubes, carbon nano anions, FeS2 which is pyrite.

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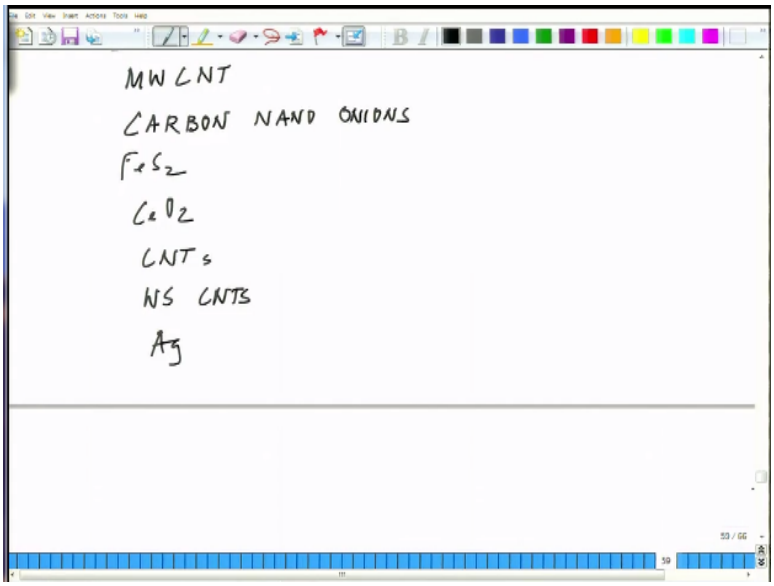

Then we talked about cerium oxide, carbon nanotubes in CNTs and water soluble carbon nanotubes.

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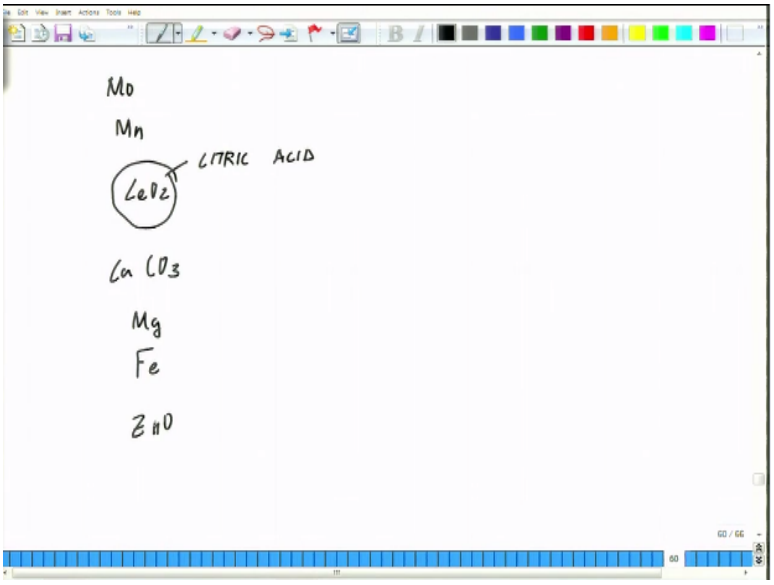

And again a silver, molybdenum, manganese, citric acid coated Co2 which is acting as a carrier calcium carbonate, magnesium, iron, zinc oxide.

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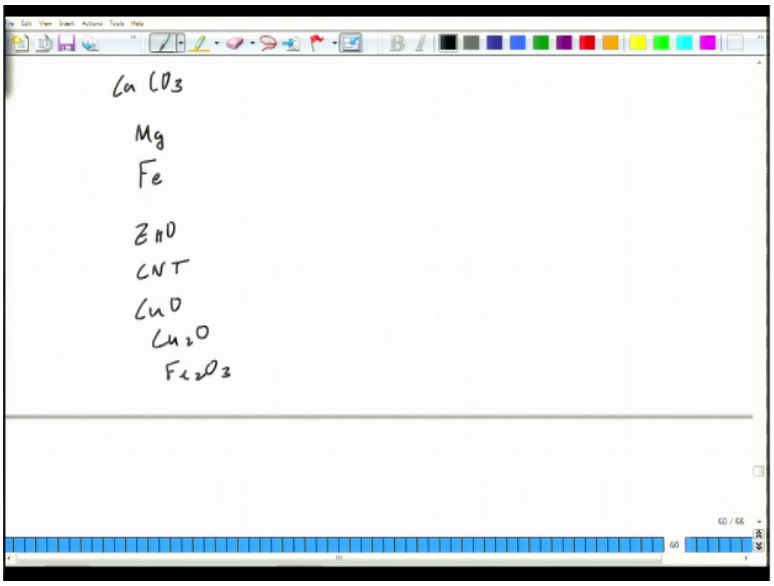

Carbon nanotubes, copper oxide, cuprous oxide, iron oxide so and so forth. So, if you look at the whole list is fairly large.

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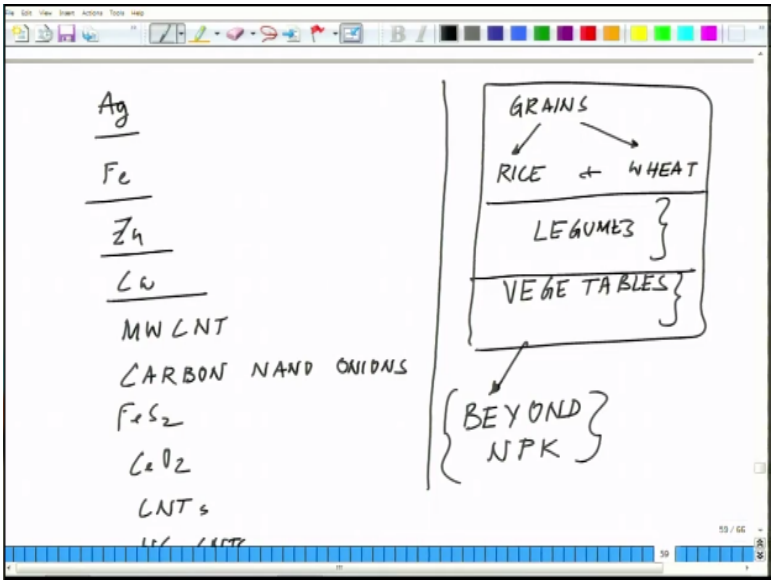

And if you look in terms of the crops where at different stages of it has been tried that is also a very small list in terms of the grains if you look at it, you have both rice and wheat has been tried out legumes all over the place have been tried out different kind of legumes. I am just going that the family then in terms of a series of vegetables which have been tried out. Similarly you have some of the water weeds and all these things have been tried out.

So, to look from the nutritional perspective you have starch, minerals and of course (()) (14:55) and proteins. So if you talk about where are we heading the future is in these kind of nanomaterials which will be dictate, so there will be lot of studies which is going to come up in next 20 years or so. And this is going to change the landscape of agriculture we are heading for a next revolution where beyond will be started will start thinking the word beyond NPK's traditional journey.

This is where we are heading, we started as a race in the last century 1900 beginning 1900 the rise of NPK and 100 years, 100 long years a little more than 100 years actually at 1725 years now about be in and other decade or so. A journey which saw green revolution emergence of low verities of rice and wheat, emergence of different kind of polyploidies in vegetables and other crops in fruit crops.

So tremendous development along with it, tremendous improvement in the productivity it is saw the rice of population. But as a fall out we observe large amount of disbalance in terms of water resources, eco system got put up similarly the soil got fertile. But then the (()) (16:58) grows on we are heading for precision agriculture. And the nanotechnology will play a critical role in precision agriculture where smaller amount maximum output.

So, people have apprehensions what will happen to the fate and all these things and there will continue I am pretty sure when NPK came into the market there were apprehension when you cannot help it. We are the race will keep on exploring just away we explore hybrid seeds will keep on exploring genetically engineered crop which are so common now, that is how a human race about it will keep on trying new and newer things, it will learn to it is mistake and it will again do mistakes.

So, if I see the literature I will say that is where the future lies, so it was not only it concentrated on crops. Already nano medicine is making enroll into our medical world, there are several nanomaterials which have been used from magnetic nanomaterial to antioxidant nanomaterial to drug carriers to anti inflammatory agents series of the anti cancer nanomaterial delivering drugs beyond CSF cerebrospinal fluid into the brain.

So, next what we are talk about will be how this nanomaterials are influencing animal productivity, the animal world, so agriculture has been have started.

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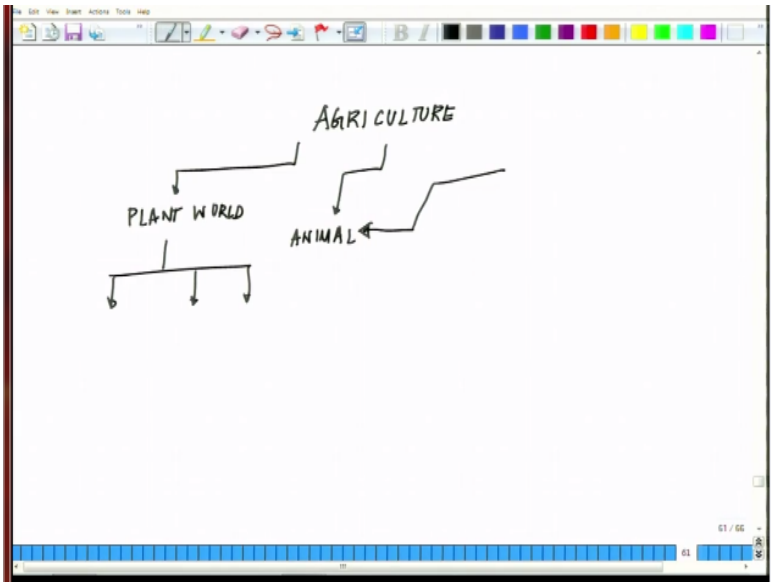

So, if you look at the whole spectrum of agriculture it will be plant world, animal world and within the plant you know all the categories like you know we have the grain, we have the legume or the flowers, you have the trees and all. But before I start the animal world in how the nanotechnology is influencing the animal world. We will talk little bit more in our next class about how nanotechnology can come very handy in nutrient deficient soils of the world which covers a huge huge chunk in Asia, Africa, Latin America.

And where fertilizers is exceptionally cost prohibitive, so I will closing here, in the next we will talk little bit about nutrient deficient soils and the application of nanomaterial. And then we will follow up with the animal productivity, thank you.