Nanotechnology in Agriculture

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Lecture-01
Introduction

Welcome you all to this new course what we have introduced in NPTEL that is nanotechnology in agriculture. So the first question arises why and what is the philosophy of having a course like this, of course it is a pretty popular thing currently there is enormous interest in nanoscience and nanotechnology for various applications in our society starting from medical to energy, to agriculture, to water purification and several other applications.

But the question is it just because there are a lot of applications we are offering a course like that or there is a philosophy behind this course or where it all started. So this journey with you all will be a journey of philosophizing the subject, understanding the basics premise and realizing that unknowingly or maybe knowingly, we have been following traditional agricultural practices over the years which are setting the paradigm for modern nanotechnology in research for agricultural application.

Just to give you a couple of example almost 30 years back while I was in my first year undergraduate student in agriculture sciences I used to observe something which all of you must have seen while travelling during the winter months especially if you are from Northern part of the country must have seen very frequently after the kharif season which is the rainy season which is the currently when I am recording this it is a rainy season going on.

And all over the place whether it is down south or north the paddy fields it will be showing paddy transplanting paddy after this season is over which is a 90 days down line August, September, October, once we reach November and December especially during that time you will see or maybe that time or maybe after the next winter crop we will see people burn the crop residues.

So whatever harvest the stuff and you burn it and it is tremendous problem in the Northern part of India where because of the burning the snow creates a lot of issues in terms of fog and everything and apparently there are ban also that you cannot in a burn so much of it. But the point is not that, point is what is this burning, so if you look in this crop field you will see half burn residues of crops kind of in a partly charred.

And once they are partly charred what a farmer does is they again plow the land, and mix those charred stuff into the soil. Of course a farmer will say that traditionally this is how we increase the organic matter of the soil, and this is how we make the soil rich. But on the other hand with the modern nanotechnology research if you look at it what they are essentially doing, when you are burning something.

You are converting a biomass, so it is basically a crop residue which is a biomass correct, a biomass is nothing but carbon, hydrogen, oxygen, nitrogen and full of elements which constitutes the biomass, the major chunk of the biomass. So while you are burning you are leaving behind a burnt carbon residue in the soil. Now when you talk about a burn carbon residue, so we are talking about from the nanotechnology perspective.

We are talking about real carbon where you have heard about carbon nanoparticles, carbon nanotubes, if you go look it advance than graphene like structure, carbon quantum dots in all these things and the question arises whether our ancestors were aware of it or not we do not know we cannot go back in time to figure that out. But essentially what they were doing is enriching their soil with carbon particle which is of course organic pattern.

But then when you are enriching a soil like with such carbon what is the benefit, what it does, so in other word if you think of it that carbon which is added back to the soil is now at a much more smaller dimension, it is no more a huge biomass kind of stuff and the availability of such carbon to the plant will be much more higher or such carbon along with other thing can form compact structures which may be helpful for storing nutrients of the soil or that may help to purify the water.

Or that may be able to chelate some of the nutrients which plant will be needing, they may be acting as a slow realizing gel after mixing with the clay of the soil, there are humpty number of possibilities which may arise out of it, this is one example. So this is 30 years back I as a young student believed wow wow this is a good idea to increase carbon, but then today while I am teaching a course in this area a kind of look back to my own journey and see wow.

It means somebody thought it out I do not know who are they our ancestors who realized it works. So to save that nanotechnology is a very new branch, yes indeed man has been rediscovered an effort of understanding or going down to the level of atoms, molecules, small number of molecules in a cluster calling nanoparticles or arranging them in a self-assembly calling a nano tubes or arranging them in a certain bonding symmetry calling them graphenes.

But our ancestors maybe knowingly or unknowingly have not using it, next example what I wanted to highlight with you is you will hear this pretty frequently that you add organic matter into the soil to certain amount before you start the cropping season and that will increase the availability of nutrient, that will increase the microbial activity of the soil. Now when we talk about organic matter adding to the soil what does that essentially means.

Again going back by my undergraduate training for us we really never thought beyond it what it is doing, but in the light of the modern research it looks like organic matter which is nothing but carbon different kind of carbohydrate, different kind of multi chain polymers, natural polymers which are mixed together and put into the soil. They are just like a mesh where things get trapped.

In other word we did talk about slow releasing gel, all have heard this word there are gels which are slow releasing the drug or some kind of encapsulated like a capsule it is almost like these are capsules in the soil which are trapping several things, so they are acting like a mesh network from where slow releasing the different nutrients all over the place, not only that such structures can even have to modulate or balance the pH of the soil.

So now the question arises when we talk about nano carriers or nano gels, these are the interesting bulk words which are slowly populating the literature or as a matter fact in the field of agriculture there is another interesting aspect which is slowly taking the central stage is precision agriculture. I will come to that aspect but all these things if you look from a perspective just if we pull our self-back and look at it.

So will realize by simple wisdom of mankind through the ages, through centuries and millionaire. We have acquired this wisdom and that helps what led to today's modern agriculture with the advent of nanotechnology I will say we are realizing or appreciating some of the naturally acquired wisdom of our ancestors. So I gave you 2 simple example, one is of burn carbon, the other one is of organic matter addition to the soil.

For me today 30 years later after completion or after starting my undergrad training, back in 89 I will say that I am rediscovering myself what I have read and this journey will be with you people this time rediscovering agriculture in the light of modern research in nanotechnology realizing the wisdom of our ancestors, realizing how they did certain practices, they may not have or had the privilege of seeing this particles under high-resolution transmission electron microscopy.

Which are one of the tools will be using scanning electron microscopy or x-ray photoelectron spectroscopy or atomic force microscopy or they did not have the tool to measure the surface area using BT or using other technique;. They never had the tools to understand or evaluate the porosity of the particles and yet by sheer trial and error through the ages they fine tune the techniques.

And what we are doing I just left you few minutes back with a word called precision agriculture will come to that now precision agriculture is essentially telling that how precisely we can apply nutrient to an individual plant. So that it consumes that and rest what we do say for example when you talk about a field we spray but between 2 plants there are certain things will go waste which is never utilized, unutilized.

So precision agriculture a very simplistic sense is you are ensuring an individual plant gets that much what it is needed. In other word it is almost like personalizing the plants or personalizing the crop, ok.