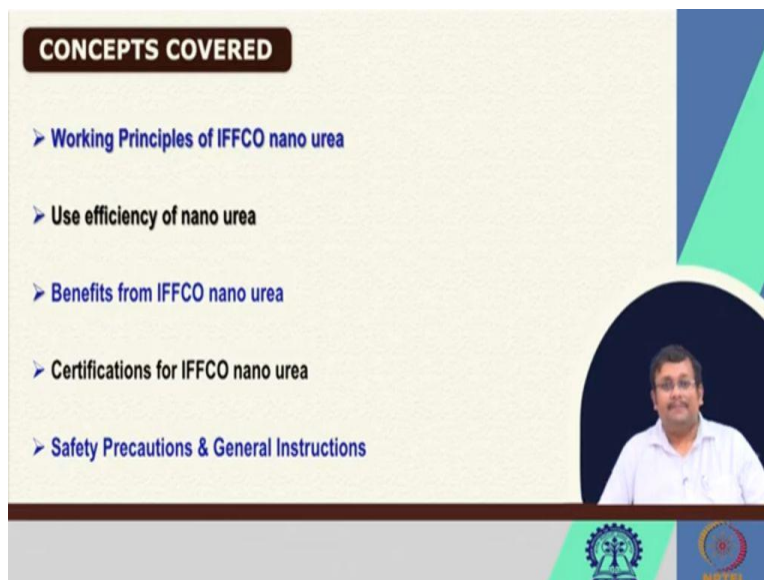


Soil Fertility and Fertilizers
Professor Somsubhra Chakraborty
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Lecture – 49

Biofertilizers and Management of Fertilizers and Manures in Soil (Contd.)

Hello students. Today we are going to start another new lecture, lecture number-49 of our NPTEL online certification course of soil fertility and fertilizers. And in this week 10, we are discussing about biofertilizers and management of fertilizers and manure. In this week in this week, we are discussing different types of management practices as far as the soil fertility is concerned. We have already discussed biofertilizers; we have already discussed biochar. In the last lecture we have discussed about mulching. And in this lecture we are going to discuss in details about a new liquid fertilizer or nano-fertilizer which is produced by Indian Farmers Fertilizer and Cooperative Limited or IFFCO. So, these are the concepts which we are going to cover in this lecture.

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The slide features a title 'CONCEPTS COVERED' in a dark blue box at the top left. Below it, a list of five topics is presented with blue arrowheads. On the right side, there is a circular inset video of the professor. At the bottom, there are two logos: the IIT Kharagpur logo on the left and the NPTEL logo on the right. The background of the slide is light beige with a blue and green geometric design on the right side.

- Working Principles of IFFCO nano urea
- Use efficiency of nano urea
- Benefits from IFFCO nano urea
- Certifications for IFFCO nano urea
- Safety Precautions & General Instructions

KEYWORDS

- Nano urea
- FCO
- Nitrogen use efficiency
- Testing of Nano Agri-inputs
- Water-soluble fertilizers



First of all, we are going to first cover working principle of IFFCO nano urea. So, they have created this nano fertilizer; we call it nano urea. And then use the efficiency of nano urea, and then benefits from IFFCO nano urea, then certification for IFFCO nano urea, and safety precautions and general instructions. Now, again, the full name of IFFCO is Indian Farmers Fertilizers and Cooperative Limited. Now, so these are the important concepts of nano urea, which is a novel urea fertilizer for crop application we are going to discuss. Now, these are the keywords nano urea, FCO, nitrogen use efficiency, testing of Nano Agri-inputs, and also water soluble fertilizer; so these are the keywords for this lecture.

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NANO UREA (LIQUID)
A boon towards sustainable agriculture



Now, if IFFCO has created this nano urea which is a liquid urea, which is a boon towards sustainable agriculture. There are several reasons that people; I mean the farmer should use these nano urea because it has got several benefits. And we are going to discuss those benefits. This nano urea liquid nano urea generally comes in bottles, which are available in the market for procurement.

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- IFFCO Nano Urea is the only Nano fertilizer approved by the Government of India and included in the Fertilizer Control Order (FCO).
- It is **developed and Patented** by IFFCO.
- Application of **1 bottle of Nano Urea** can effectively replace at least **1 bag of Urea**.

Now, IFFCO nano urea is the only nano fertilizer approved by Government of India and included in the Fertilizer Control Order; we have discussed our Fertilizer Control Order in our last week of lectures. Now, it is developed and patented by IFFCO. Remember that application of one bottle of nano urea can effectively replace at least one bag of urea, solid urea fertilizer. So, not only it is reducing the handling problems of urea, but also it can be also it has other benefits over using the solid urea fertilizers which we are going to discuss.

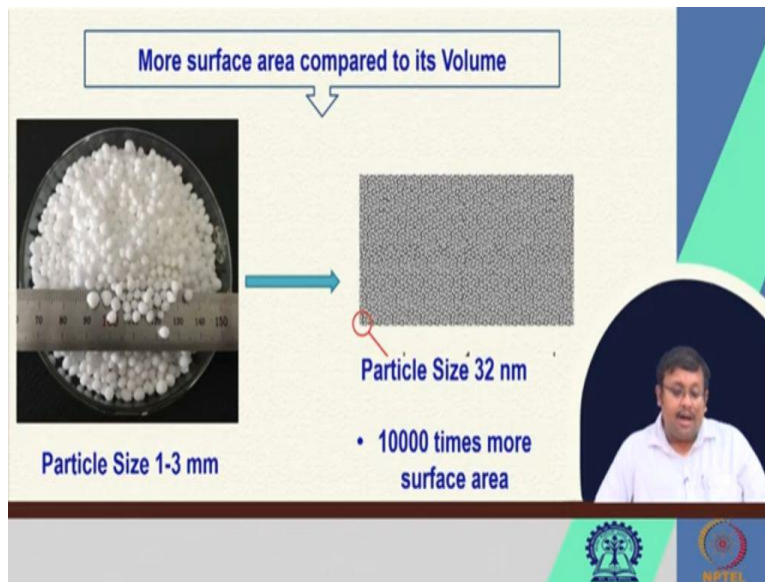
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Now, this nano urea generally provides nitrogen without environmental hazards. It has got higher use efficiency than granular urea; and it requires less as per volume. So, first of all, it provides nitrogen without any environmental hazard. Because, whenever we apply the urea fertilizer in the soil, we apply in high quantity. And, and of course, the majority of that applied urea gets washed away with water, and they leach down; and ultimately goes to the groundwater. And they create different types of and also they move to different types of water bodies creating different types of environmental problems.

However, the nano urea can produce, nano urea is devoid of those environmental hazards. So, you can expect the nitrogen fertilization of the crop without creating any environmental hazard. Secondly, higher use efficiency than granular urea. Whenever you are using the granular urea, you can get a use efficiency varying from 30 to 40 percent or 45 percent. However, you can get higher nutrient use efficiency when you are using the Nano urea. Third is, it is required in less quantity than solid urea fertilizers.

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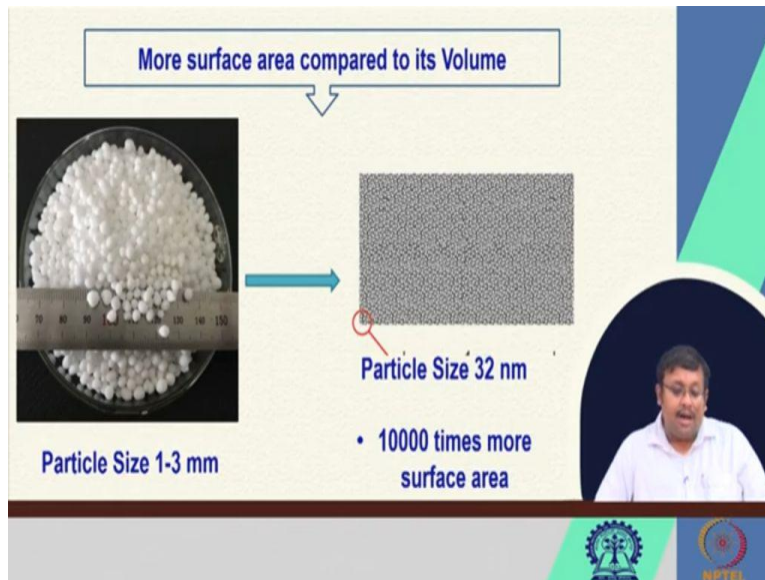
So, if you compare the particle size of solid urea fertilizers or the urea prills, and the particle size of the nano urea, you can see that nano urea has particle size of 32 nanometer. And the normal urea pre new particles have the particle size of 1 to 3 millimeter. And so basically, you can see that these nano urea has more surface area as compared to the more surface area as compared to the urea particles; almost 10,000 times more surface area. And when there is a more surface area, it is always beneficial.

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IFFCO Nano Urea

- IFFCO Nano Urea is a nanotechnology based revolutionary Agri-input which provides nitrogen to plants.
- IFFCO Nano Urea (liquid) is world's first Nano fertilizer which has been notified by Fertilizer Control Order (FCO, 1985), Government of India.
- Nano Urea contains 4.0 % total nitrogen (w/v). Nano nitrogen particle size varies from 20-50 nm. These particles are evenly dispersed in water.
- This fulfils the plant nutrient requirements as a fertilizer since Nano urea is bio available to plants because of its desirable particle size about 20-50 nm and more surface area (10,000 times over 1 mm urea prill) and number of particles (55,000 nitrogen particles compared to 1 mm urea prill).

The slide features a list of bullet points describing IFFCO Nano Urea. A small inset video of a man is visible in the bottom right corner.



Now, let us see more details about IFFCO nano urea. Now, IFFCO nano urea is a nanotechnology based revolutionary Agri-input which provides nitrogen to the plant. And this liquid IFFCO nano urea is world's first nano fertilizer, which has been notified by Fertilizer Control Order of 1985. And nano urea contains 4 percent of total nitrogen; and nano nitrogen particle size varies from 20 to 50 nanometer; and these particles are evenly dispersed in water. So, if you see that the particle size generally vary from around for 20 to 50 and nanometer; and these particles are evenly dispersed in water.

So, this fulfills the plant nutrient requirement as a fertilizer since nano urea is bio available to plants, because of his desirable particle size about for about which varies from 20 to 50 nanometer. And more surface area we have already discussed, it has got more 10,000 times more surface area than the normal urea and number of particles. So, 55,000 nitrogen particles compared to 1 millimeter urea prill. So, you can see that it it fulfills the plant nutrients because of its desirable particle size, and higher surface area; and also more number of particles because of its nano structure.

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IFFCO Nano Urea

- Nano Urea increases its availability to crop by more than 80% resulting in higher Nutrient Use efficiency.
- When sprayed on leaves of plant at **critical growth stages**, it enters through **stomata and other openings** and is **assimilated by the plant cells**.
- Because of **phloem transport** it is distributed from **source to sink** inside the plant, wherever it is required. **Unutilized nitrogen is stored in the plant vacuole** and is slowly released for proper growth and development of the plant.

The slide features a video inset of a man in a white shirt speaking. At the bottom, there are logos for IFFCO and WAPDA.

Now, nano urea generally increases its availability to crop by more than 80 percent resulting in higher nutrient use efficiency. So, if you see if you compare the nutrient use efficiency of normal urea fertilizer, these are less. However, in case of nano urea, they have more than 80 percent availability to the plant. Now, when sprayed on leaves of plant at critical growth stages, it enters through stomata and other openings and is assimilated by the plants. So, the most important benefit, if you can literally spray these nano urea at critical growth stages directly to the crop; and due to its nano size, it can easily enter through the stomata and other openings, and it can be assimilated by the plant cells.

Now, because of phloem transport, it is distributed from source to sink inside the plant, wherever it is required. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. So, this is how IFFCO nano urea basically works.

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IFFCO NANO UREA

- Nano Urea is a sustainable option for farmers towards smart agriculture and combat climate change.
- It promotes clean and green technology as its industrial production is neither energy intensive nor resource consuming.
- In addition to this, Nano urea helps in minimizing the environmental footprint by reducing the loss of nutrients from agriculture fields in the form of leaching and gaseous emissions which used to cause environmental pollution and climate change.

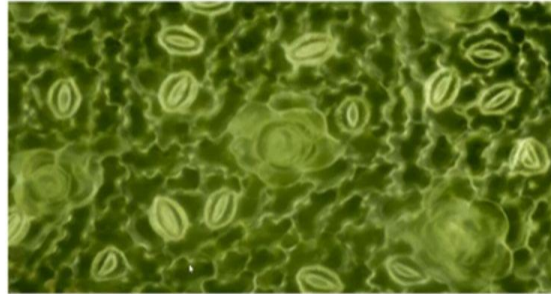
Now, nano urea is a sustainable option for farmers towards smart agriculture and combat to combat the climate change. Generally, it promotes clean and green technology as it is industrial; its industrial production is neither energy intensive or resource consuming. If you remember the urea fertilizer production is the normal urea production is a very energy intensive. However, the nano urea production is less energy consuming. In addition to these, nano urea helps in minimizing the environmental footprint by reducing the loss of nutrients from agricultural fields in the form of leaching and gaseous emission, which used to cause environmental pollution and climate change.

Now, we know that when there are excess of nitrates that will leach and that will go to different water bodies to to basically pollute those water bodies. And also there are chances of gaseous emission due to denitrification process; and these can be reduced by application of nano urea.

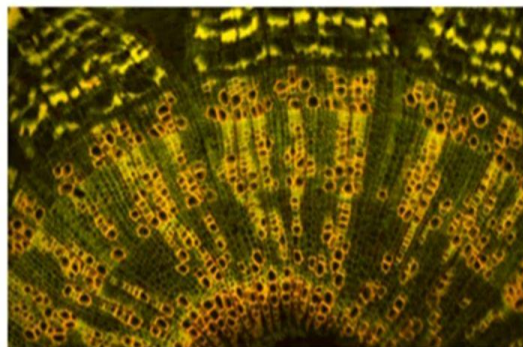
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THE SCIENCE BEHIND IT

Nano urea (Liquid) contains 4% Nano scale nitrogen particles. Nano scale nitrogen particles have a small size (20-50 nm); more surface area and number of particles per unit area than conventional urea.



They can easily penetrate through the cell wall or through leaf stomata pores



After entering the plants, they are transported to other plant parts via phloem cells, Plasmodesmata (40nm diameter) or can bind to carrier proteins through aquaporin, ion channels and endocytosis.





Therefore, foliar application of Nano Urea liquid results in more efficient Nitrogen absorption, better physiological growth, grain production and better quality of fruits.

Now, how this nano urea basically works? So, this nano urea which contains 4 percent nanoscale nitrogen particles, and they have very small particle size 20 to 50 nanometer. So, more than also they have more surface area and more number of particles per unit area than conventional urea of particles. So, they can easily penetrate through the cell wall or through leave stomata pores. And once they can do that after entering into the plants, they are transported to other plant parts via phloem cells, plasmodesmata which has 14 nanometer 40 nanometer diameter. Or, can bind to carrier proteins through aquaporin ion channels and endocytosis.

So, it can move inside the plant through different components. And therefore, foliar application of nano urea liquid results in more efficient nitrogen absorption, better physiological growth, and grain production, and better quality of the fruits. Instead of applying fertilizer in the soil, in this case of nano urea we are giving the foliar application with a desired particle size. And these particles or nano particles can easily enter through the stomata; and they can move through phloem and they can be stored in different plant parts to satisfy the plant requirements. In this way, they can ensure the efficient nitrogen absorption or increase nitrogen use efficiency, better physiological growth, grain production and better quality of fruits.

So, of course we can see that how use of these nano fertilizer as foliar application can improve the fertility, or can improve the growth of the plants.

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Nanoscale particle uptake efficiently due to ultra small size.

- Released in slow and controlled manner.
- Translocated through symplast/phloem pathways.

1. NP design, formulation
Foliar application

2. Adsorption & Uptake

3. Phloem loading & translocation
Source → Sinks

4. Interplays
Physiology, NP properties, Morphology, Stresses, Transformation, Time

Photo source: American Chemical Society

Now, nanoscale particle uptake efficiently due to ultra small size; because these particle size is very small size 20 to 50 nanometer. So, they can be easily absorbed or uptake by the plant. So, and released in slow and controlled manner, and translocated through simplest or phloem pathways. So, you can see that this picture shows the movement of these nano fertilizer or nano urea through different parts of the plant. And then it basically moves from phloem to different things, and thereby stored there for use of the plant.

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BENEFITS FROM IFFCO NANO UREA

- **Higher Crop Yields**
 - Due to small size and more surface area to volume ratio, IFFCO Nano Urea particles are easily available to crops.
 - Higher crop yields are observed due to enhanced chlorophyll and photosynthesis in leaves and increase in root biomass and number of effective tillers /branches etc.
 - Average yield increase up to 8 % have been recorded as per 11,000 field trials conducted across India during 2019-20.

Now, what are the benefits from IFFCO nano urea; first of all, higher crop yield. So, due to small size and more surface area to volume ratio, IFFCO nano urea particles are easily available to crops. I have already told you that this fertilizer has higher surface to volume ratio or surface area to volume ratio; and thus, they can be easily available to the crops. Higher crop yields also observed due to enhance chlorophyll and photosynthesis in leaves. Since, these nano fertilizer can be sprayed directly onto the leaves, and they can enter into the leaves, and they can store there.

We can see enhance chlorophyll and photosynthesis in leaves, and increase in root biomass and number of effective tillers or branches et-cetera. So, we can see direct impact on plant growth by the application of nano urea. Average yield increases up to 8 percent have been recorded as per 11,000 field trials conducted across India during 2019 and 20. So, we have, it has been seen that 8 percent average increase by the application of nano urea because of this factor; because they can be easily taken by the plant. They can be easily utilized by the plant and they can ultimately enhance the chlorophyll and photosynthesis in the leaves. So, these are the reasons which governs the increase in yield in the crop by using this nano urea.

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➤ **Increased income for farmers**

IFFCO Nano Urea leads to increase in farmers' income due to:

(1) Reduction in Input Cost, (2) Higher Crop Yield, (3) Better Quality of Crop

Produce

Average increase in income of Rs 2000 per acre has been registered

➤ **Better food quality**

- Crops harvested using IFFCO Nano Urea are safe for consumption
- Nutritional quality of harvested produce is better in terms of protein and nutrient content.

The slide features a video inset of a man in a white shirt speaking. At the bottom, there are logos for IFFCO and NPTEL.

And another important benefit of using nano urea is it can increase income of the farmers. So, IFFCO nano urea can increase the farmer's income; there are several ways. First of all, reduction in input cost; of course, when we are using 100 kgs of urea, instead of it we are replacing that by

use single bottle of urea. And that can of course reduce the input cost; and also it gives higher crop yields and better quality of the crop produce; so, all of them ultimately helps in increasing the farmer's income.

So, we have seen that there is an average increase in income of rupees 2000 per acre while using this nano urea. We can also see better food quality and crops harvested using IFFCO nano (par) IFFCO nano urea are safe for consumption; and nutritional quality of harvested produce is better in terms of protein and nutrient content. So, these are some of the reasons which are helpful for increasing the income for income of the farmers by using this IFFCO nano urea.

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➤ Reduction in Chemical Fertilizer Usage

- Nano Urea reduces application of bulk nitrogenous fertilizers like Urea.
- Foliar application of Nano Urea at critical crop growth stages meets nitrogen requirement effectively.
- Enhanced use efficiency of one bottle (500 ml) of Nano Urea.
- Can potentially replace at least 1 bag of conventional urea.

And also reduction in chemical fertilizer usage. So, nano urea reduces the application of bulk nitrogenous fertilizers like urea. And foliar application of nano urea at critical crop growth stages meets nitrogen requirement effectively, we have seen that. So, instead of bulk nitrogenous fertilizers like normal urea fertilizer, we can use this nano urea fertilizer as foliar application; and that can reduce the chemical fertilizer use and we can directly apply as foliar application. It can enhance the use efficiency of one bottle of nano urea. So, we can see that one bottle of nano urea which actually 500 mls that can enhance the use efficiency of nitrogen.

And then can it can potentially replace at least one bag of conventional urea. So, one bag of urea, so, around 50 kg of urea bag can be replaced by only one bottle. So, instead of using 100 kgs of urea, we can we can use only 2 bottles of nano urea to cover the same area of the crop.

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Environment Friendly

- Agricultural sustainability and **environmental safety** can be ensured with the application of Nano Urea.
- Production of Nano Urea is **energy and resource friendly**.
- It **reduces excess application** of bulk urea and associated volatilization as well as leaching and runoff losses.

Easy to store and transport

- Nano Urea is required in **small quantity** vis-à-vis bulky nitrogenous fertilizers like urea. This has a **significant impact** in terms of relative logistics and warehousing cost.
- Farmers can easily **carry** bottles of Nano Urea physically

Nano Urea is easy to carry and store.

Life Cycle: Two years from date of manufacturing.

One Bottle is equal to one bag of urea with respect to its performance on crop growth and development.

Also it is very much environmental friendly; because agricultural, it is agriculturally sustainable and environmentally safe. We can ensure these agricultural sustainability and environmental safety by the application of nano urea. And, production of nano urea is energy and resource friendly as we have already mentioned. It reduces excess application of bulk urea and as stated volatilization as well as leaching and runoff losses. It is easy to store and transport; this is another very important aspect. So, nano urea is required in small quantity as compared to the bulky nitrogenous fertilizers like urea; and this has a significant impact in terms of relative logistics and warehousing cost.

So, you do not have to store your, your bags of urea if we are using the Nano urea liquid fertilizer; and farmers can easily carry the bottles of nano urea physically into the field. So, you can see it can be easily; so, nano urea is easy to carry and store. And generally the lifecycle is 2 years from the date of manufacturing. And one bottle is equal to one bag of urea with respect to its performance, and crop growth, and development. So, one bottle of 500 ml of urea nano fertilizer can replace one bag of urea, which weighs around 45 to 50 kilo.

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CERTIFICATIONS

- IFFCO Nano urea is an **approved product** both nationally and internationally.
- IFFCO Nano Urea is in sync with **OECD testing guidelines (TGs)** and guidelines for **Testing of Nano Agri-inputs (NAIPs)** and food products by Department of Biotechnology, Government of India.
- Independently, Nano urea has been tested and certified with **bio-efficacy, biosafety-toxicity and environment suitability** by NABL-accredited laboratories.
- IFFCO nano fertilizers meet all the **current national and international guidelines** related to nanotechnology or nano scale Agri-inputs.

The slide features a video feed of a man in a white shirt in the bottom right corner. At the bottom, there are logos for IFFCO (International Fertilizer Federation) and NPTI (National Platform for Technology Innovation).

Now, certifications. If you consider the certification IFFCO nano urea is an approved product both nationally and internationally. And IFFCO nano urea is in sync with OECD testing guidelines and guidelines for testing of nano Agri-inputs and food products by Department of Biotechnology, Government of India. Independently, nano urea has been tested and certified by bio-efficacy, biosafety-toxicity and environmental sustainability by environmental suitability, by NABL accredited laboratories. And IFFCO nano fertilizers meet all the current national and international guidelines related to nanotechnology or nanoscale Agri-inputs.

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Nano Urea: Spray on Plant Leaves

1st Spray : 30 days after seed germination.
2nd Spray: 2-3 weeks after or one week before flowering.

The slide features two photographs: on the left, a drone is shown spraying a field of green crops; on the right, a person in a yellow protective suit is manually spraying a field. A small inset video of a man speaking is visible in the bottom right corner of the slide area. The slide is part of a presentation with logos for IIT Guwahati and NITRR visible at the bottom.

So, the application of nano urea can be done either using a spring drone or you can do by manual spraying. So, first spray you should do at 30 days after seed germination; and second spray you can do after 2 to 3 weeks after or 1 week before the flowering.

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Safety Precautions & General Instructions

- Nano urea is **non-toxic, safe for the users, safe for flora and fauna** but it is recommended to **use face mask and gloves while spraying on the crop.**
- Store in a **dry place** avoiding high temperature
- Keep **away from the reach of children and pets.**



The slide includes a small inset video of a man speaking in the bottom right corner. Logos for IIT Guwahati and NITRR are visible at the bottom of the slide.

Now, safety precautions and general instructions. So, nano urea is non-toxic for the users and safe for flora and fauna. But, it is recommended to use face mask and gloves while spraying on the crop and store. You should store it in a dry place, avoiding the high temperature; and we should keep away from the reach of the children and pets.

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Below are the general instructions

- Shake the bottle well before use.
- Use flat fan or cut nozzles for uniform spraying on the foliage.
- Spray during morning or evening hours avoiding dew.
- It is advised to repeat the spray, if rain occurs within 12 hours of Nano urea spray.
- Nano Urea can easily be mixed with bio stimulants, 100% water-soluble fertilizers and compatible agrochemicals.
- For better result Nano urea should be used within 2 years from the date of its manufacturing.




Now, there are some general instructions. First of all, you have to shake the bottle well before use; then, you have to use the flat fan or cut nozzles for uniform spraying on the foliage. And then spray during morning or evening hours avoiding the dew. It is advised to repeat the spray, if the rains occurs within 12 hours of the nano urea spray. And nano urea can easily be mixed with different bio stimulants, 100 percent water soluble fertilizer and compatible agrochemicals. For better results, nano urea should be used within 2 years from the date of its manufacturing.



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Using Nano Urea, it is possible to reduce conventional urea by 50%

Healthy Soil = Nutritious Food = Better Health



100% Urea 50% Less Urea + Nano Urea

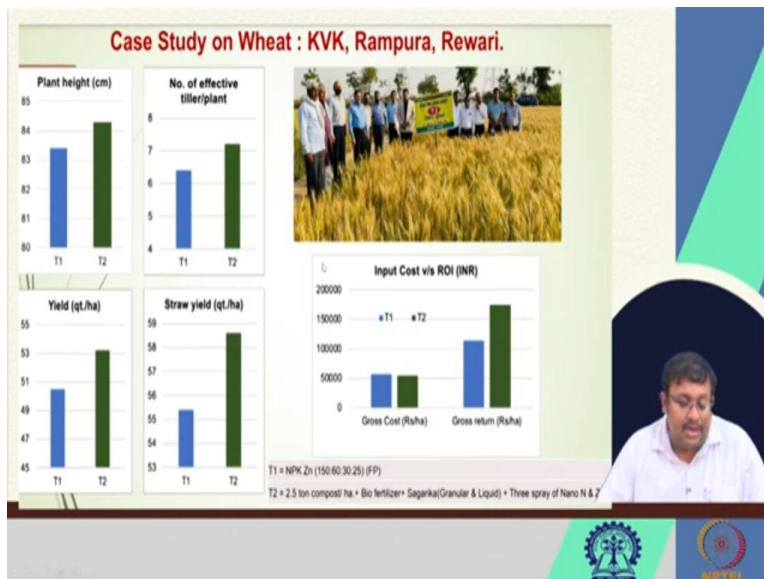




Now, you can see using nano urea, it is possible to reduce the conventional urea application by 50 percent. So, you can see here we, people have used 100 percent urea. And here you can see 50 percent less urea plus nano urea; and both of them are showing almost similar performances. So, that shows that using nano urea, we can reduce the traditional bulky urea application. And thereby, maintaining the agriculture sustainability and increasing the profitability of the farmers.

So, nano urea can be also used for crops for all crops and for better productivity. So, you can use the nano urea for different crops and for better productivity.

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And there is a case study in KVK, Rampura, Rewari; and it can be seen that when there is there are 2 treatment; treatment 1 is NPK and zinc fertilizer; and then T2 stands for 2.5 ton of compost per hectare plus bio fertilizer, plus granular and liquid fertilizer as well as 3 sprays of nano nitrogen and zinc. So, when they have applied these in T2, we can see higher plant growth and also higher number of effective tillers per plant, higher yield and higher straw yield. So, all these are higher quantity when nano fertilizer or nano urea were applied; nano urea was applied.

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Nano Urea: Developed & Tested in India, 1st time in the world.

Tested on 94 crops at over 11000 locations including 20+ institutes of ICAR, SAUs and KVKs

Nano Urea increase crop productivity by 8% (based on national average)

Reduction in the use of conventional urea by 50% is possible with Nano Urea.

Now, nano urea has been developed and tested in urea, first time in the world; and tested on 94 crops at over 11,000 location (including) including more than 20 institutes of ICAR or Indian Council of Agricultural Research, State Agriculture Universities or Krishi Vigyaan Kendras. Generally, nano urea increases crop productivity by 8 percent based on the national average; and there is a reduction in the use of conventional urea by 50 percent is possible with the application of nano urea.

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Nano Urea: Require less to produce more and better

50 mL IFFCO Nano Urea

Require less compare to conventional urea.

Increase crop productivity

Economically affordable

Safe and sustainable for Food and Environment

Non-Toxic for Flora and fauna

The slide features a central graphic with icons representing each benefit: a bag of fertilizer, a plant, a person, a smiley face, and a globe. A small inset video shows a man in a white shirt speaking.

We know that nano urea requires less to produce more and better. So, if we are using 50 ml of IFFCO nano urea instead of one bag of fertilizer it is reducing the amount of fertilizer being used; and also it increases the crop productivity. It is environmentally afford economically affordable; and it is safe and sustainable for food and environment. And it is also non-toxic for flora and fauna. So, ultimately it is a kind of a win-win situation when we are applying the Nano fertilizer in the field.

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Summary

- Nano Urea is a revolutionary product developed by nanotechnology. This provides nitrogen to the crops.
- Easy to use: mix with water (2-4 mL in 1 Litre) and spray on crop leaves.
- Tested on 94 crops at over 11000 locations including 20+ institutes of ICAR, SAUs and KVKs
- The first nano-fertilizer, approved by the Govt of India.
- Tested on the basis of national and international guidelines.
- Useful for environmental sustainability and precision agriculture.

The slide features a large image of an IFFCO Nano Urea bottle on the left. A small inset video shows a man in a white shirt speaking.

So, in a summary we can see that nano urea is a revolutionary product developed by nanotechnology, and these provides nitrogen to the crops; and it is easy to use mix. We can mix it with water 2 to 4 ml in 1 liter and spray on the crops; and tested in 94 crops at our 11,000 location including more than 20 institutes of ICAR, State Agriculture Universities, and KVKs. The first nano fertilizer approved by the Government of India and it is tested on the basis of national international guidelines. And it is useful for environmental sustainability and precision agriculture.

So guys, let us wrap up this lecture here. I hope you have you have been exposed to a new technology of nano fertilizer, liquid fertilizer. And please go through the other literature and different web resources to learn more about these nano fertilizers, and how to apply these nano fertilizer in the field. We will discuss the other aspects of fertilizer and manure management in our last lecture, upcoming lecture of this week; that is lecture number-50. So, we will discuss about fertigation in our lecture number 50; and let us discuss the fertigation in details in that lecture. Thank you.