

Soil Fertility and Fertilizers
Professor Somsubhra Chakraborty
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Lecture 42

Fertilizer Quality Control, Fertilizer Adulteration and Fertilizer Testing (Contd.)

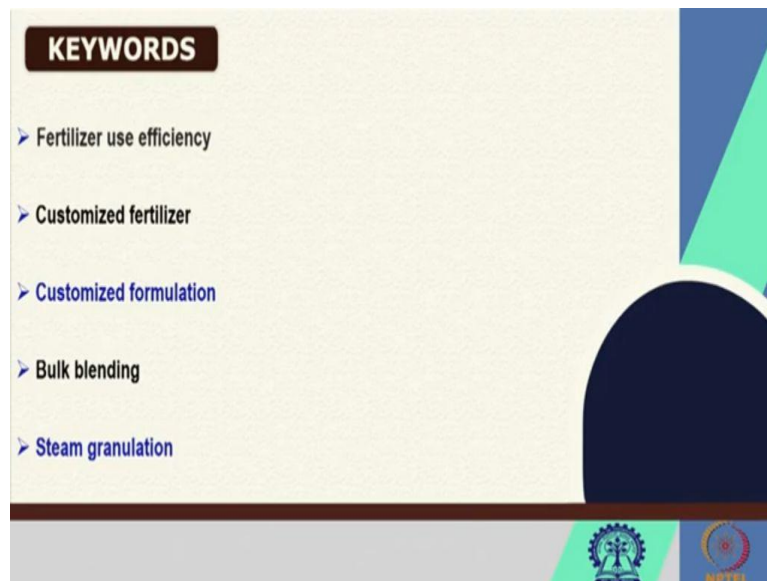
Welcome friends to this new lecture of NPTEL online certification course, soil fertility and fertilizers. We are at week 9, and in this week we are discussing fertilizer quality control, fertilizer adulteration and fertilizer testing. In our previous lecture, we have discussed about the slow release fertilizer and what are the characteristics of the slow release fertilizer? Why we require slow release fertilizer? And in this lecture we are going to cover the following concepts.

(Refer Slide Time: 00:56)



So, the first concept we are going to cover in this lecture is objective of customized fertilizers, then characteristics or quality of customized fertilizers, then method of customized fertilizer manufacturing, then advantages of customized fertilizers, and finally, we are going to discuss some of the customized formulations available in India.

(Refer Slide Time: 01:22)



Now, these are some of the keywords like fertilizer use efficiency, customized fertilizer, customized formulation, bulk blending, and steam granulation. So, these are we these are some of the keywords which we are going to discuss in this lecture.

(Refer Slide Time: 01:52)

A slide titled "Fertilizer use efficiency" featuring a table with two columns: "Fertilizers" and "Efficiency (%)". The table lists the efficiency ranges for Nitrogen, Phosphorus, Potassium, Sulphur, and Micronutrients. A small video inset of a man in a white shirt is visible in the bottom right corner of the slide. The slide has a light beige background with a dark blue and green geometric design on the right side. At the bottom, there are logos for IIT Bombay and NPTEL.

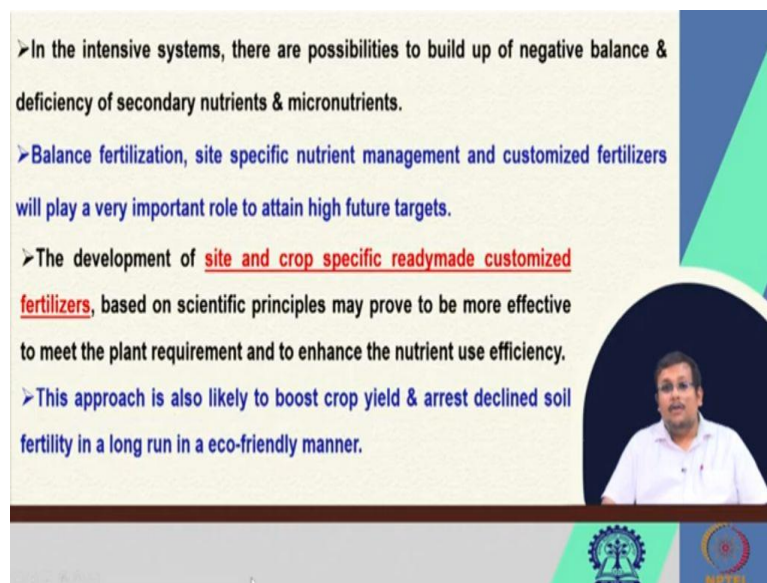
Fertilizers	Efficiency (%)
Nitrogen	40 to 50
Phosphorus	15 to 20
Potassium	50 to 70
Sulphur	8 to 12
Micronutrients	< 5

Now, if we consider the fertilizer use efficiency, you know the definition of the fertilizer use efficiency. Fertilizer use efficiency is the basically the amount of nutrients up taken by the plant, divided by the difference between the nutrient applied through fertilizer, minus the native nutrient concentration in the soil. So, if we consider the fertilizer use efficiency, these are different nutrients and the (fat) and they are and their fertilizer use efficiency you can see for nitrogen, the fertilizer use efficiency goes from 40 to 50. Sometimes it is lower than that;

sometime we can see that people are saying that there are 35 percent accuracy, fertilizer use efficiency for nitrogen.

From phosphor phosphorus, we can see the efficiency varying from 15 to 20 percent; for potassium, we can see the efficiency from 50 to 70 percent. For sulphur, we can see the efficiency varying from 8 to 12 percent. And for micronutrients, we can see the efficiency is very less that is less than 5 percent. So, these are some of the fertilizer use efficiency for different nutrients.

(Refer Slide Time: 03:22)



➤ In the intensive systems, there are possibilities to build up of negative balance & deficiency of secondary nutrients & micronutrients.

➤ Balance fertilization, site specific nutrient management and customized fertilizers will play a very important role to attain high future targets.

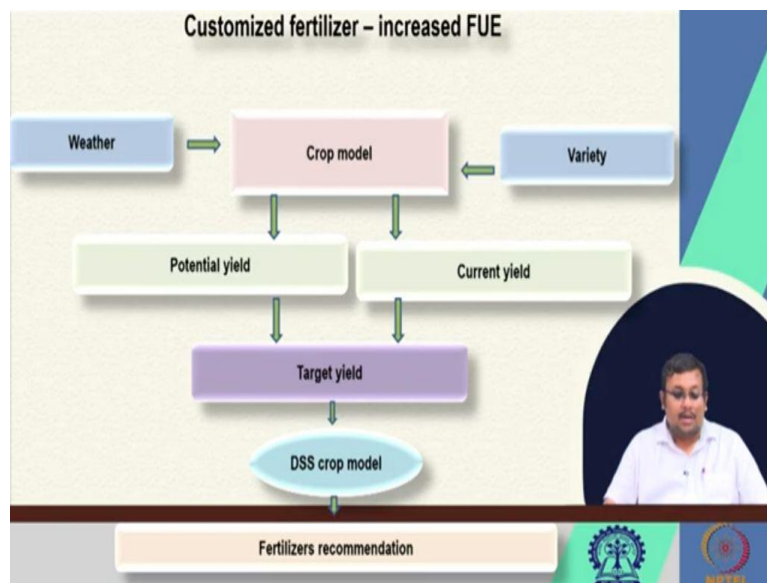
➤ The development of **site and crop specific readymade customized fertilizers**, based on scientific principles may prove to be more effective to meet the plant requirement and to enhance the nutrient use efficiency.

➤ This approach is also likely to boost crop yield & arrest declined soil fertility in a long run in a eco-friendly manner.

Now, in the intensive system, there are possibilities to build up negative balance and deficiency of secondary nutrients and micronutrients. So, when there is an intensive agriculture for example, the current agricultural scenario, we can see there is a possibility is to build up the negative balance and deficiency of secondary nutrients or micronutrients. And balance fertilization, site specific nutrient management and customized fertilizer, in this condition will play a very important role to attain high future targets. Now, the development of site and crop specific readymade customized fertilizers.

We are going to discuss these, these are site and crop specific readymade for customized fertilizer. These are based on scientific principles may prove to be more effective to meet the plant requirement, and to enhance the nutrient use efficiency. This lecture will be focusing on this customized fertilizers. Now, this approach is likely to boost crop yield and arrest declined soil fertility in a long run in a eco-friendly manner.

(Refer Slide Time: 04:43)



Now, if we see the concept of customized fertilizer, the major goal of customized fertilizer is to increase the fertilizer use efficiency. Now, how to determine the customized fertilizer depends on several factors. First of all, we have to take care of the weather parameters, then the variety, and then we have to feed it into the crop model which will analyze the potential yield and current yield, and finalize the target yield. And then it will give the through the decision support system, we can have the fertilizer recommendation. Now, this fertilizer recommendation acts as a major major foundation for developing these customized fertilizers.

(Refer Slide Time: 05:46)

Customized fertilizer??

Customized fertilizers are **multi-nutrient carriers**, designed to contain macro- and/or micro- nutrient forms, manufactured through a systematic process, satisfying the crop's nutritional needs, specific to its **site, soil and stage**, validated by a **scientific crop model** developed by an accredited fertilizer manufacturing/marketing company.

Source: Fertilizer (Control) Order, 1985

The slide includes a video inset of a speaker and logos for IIT Guwahati and NPTI.

Now, what is the definition of a customized fertilizer? Customized fertilizers are multi-nutrient carriers, designed to contain macro and micro nutrient forms, manufactured through

a systematic process, satisfying the crops nutritional needs, specific to its site, soil and stage, validated by a scientific crop model developed by an accredited fertilizer manufacturing company. And this definition of customized fertilizer is given in fertilizer control order of 1985. So again, we can see from this definition, it is a multi-nutrient carrier. It is it has both macro and micro nutrients manufactured through a systematic process, which can satisfy the crop need.

And it is very much specific to soil stage of the crop and site and it has been validated by scientific crop model which has been developed by. And this customized fertilizer is developed by accredited fertilizer manufacturing or marketing company.

(Refer Slide Time: 07:10)

The slide is titled "Objective of customized fertilizers" in a blue header. It contains two main bullet points. The first bullet point, in blue, states: "To provide site specific nutrient management for achieving maximum fertilizer use efficiency for the applied nutrient in a cost effective manner." The second bullet point, in red, states: "The customized fertilizer include the combination of nutrients on the basis of :". Below this, there is a numbered list in green: "1. Site", "2. Soil testing", "3. Crop need", and "4. Stage of crop". In the bottom right corner of the slide, there is a circular inset video showing a man in a white shirt speaking. At the bottom of the slide, there are two logos: the Indian Council of Agricultural Research (ICAR) logo on the left and the National Institute of Technology (NITEL) logo on the right.

Now, if we see the objectives of customized fertilizer, we can see the major objective of customized fertilizer is to provide site specific nutrient management for achieving maximum fertilizer use efficiency for the applied nutrient in a cost effective manner; so, it is very much site specific. And the customized fertilizer generally include the the combination of nutrients on the basis of site, soil testing, crop need, and stage of crop.

(Refer Slide Time: 07:46)



So, if we can see the best management practices based on nutrient stewardship as far as the customized fertilizer are concerned, customized fertilizers are concerned; we can see that customized fertilizer best management practices depends on four major factors. What are the factors? Productivity, then profitability, then favourable biophysical and social environment, and cropping system sustainability; so, these four are the major foundations of customized fertilizer management.

(Refer Slide Time: 08:24)



Now, if we see the characteristics or quality of customized fertilizer, these are some of the features as per the fertilizer control order of 1985. First of all, it has to be granular in size. And it has to be granular and minimum 90 percent should be between 1 to 4 millimeter and

below 1 millimeter should not exceed 5 percent of it. And it should have 100 percent water soluble grade; so, the customized fertilizer should be 100 percent water soluble. And minimum nutrient content in specific grade should contain more than 30 units of all nutrients; so these are some of the important characteristics of customized fertilizers.

(Refer Slide Time: 09:17)



Now, the next question comes to our mind, why we need customized fertilizer? Because we can see nowadays as a result of intensive agriculture, we can see imbalanced use of fertilizers and then we can see continuous increase of secondary and micronutrient deficiency. We can also see stagnation of crop productivity, emergence of multiple fertilizer responsive genotypes, increasing the fertilizer use. So, one of the major reason for cutler, customized fertilizer development is there is an imbalanced use of fertilizer in intensive agriculture. So, we need to develop and customized fertilizers specific to the need of the crop; secondly, continuous increase of secondary and micronutrient deficiency.

So, we can see for last couple of decades, we can see the number of deficient fertilizer elements is increasing and as a result, we have to use this customized fertilizer. We cannot only rely on this NPK anymore. Second, third is stagnation of crop productivity; we can see that there is a stagnation of crop productivity, it is not increasing. So to increase it, we have to take a holistic measurement and customized fertilizer is one of them; then, emergence of multi-fertilizer responsive genotypes. So, nowadays genotypes have been developed which are responsive to multiple fertilizers.

So, that is why we need the customized fertilizer. Then, we need to increase the fertilizer use efficiency, we need to increase or improve the soil health, then we need to reduce the

fertilizer based input cost by applying a customized fertilizer. And finally, but not the least, that is environmental pollution. So, judicious application of fertilizer in the soil can reduce the environmental pollution.

(Refer Slide Time: 11:20)

Farmers prefer customized fertilizers due to:

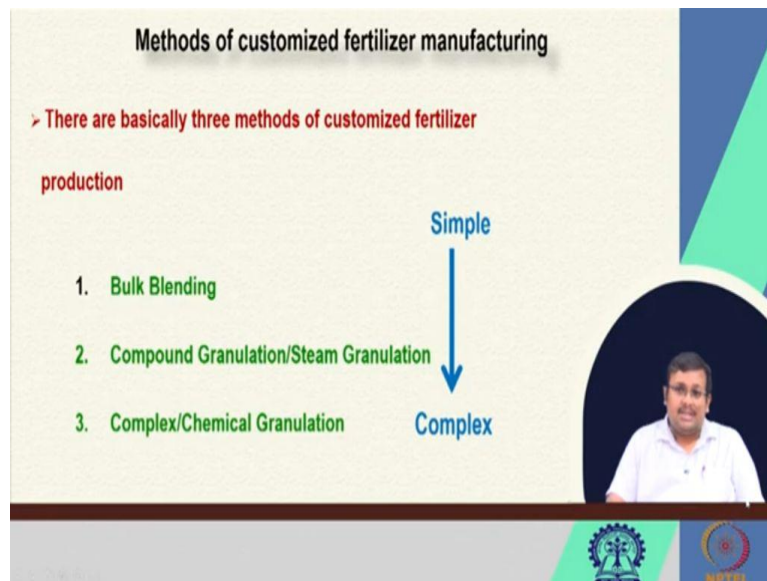
- Better crop quality & productivity
- Max. nutrient use efficiency
- Specific to crop and area based on soil fertility
- Available in ready to use form in balanced way
- Improve soil fertility
- Environment friendly
- Adoptable to varies field application

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

Now, the next question comes to our mind why farmers prefer customized fertilizers. There are several reasons. First of all, the better crop quality and productivity. Because, when you apply the customized fertilizer based on the need for the local crop and the particular site, it can improve the crop quality as well as the crop productivity. It can also maximize the nutrient use efficiency and these customized fertilizers are specific to crop an area based on soil fertility. It, they are available in ready to use form in balanced way, and they can improve soil fertility.

They are environmental friendly, and they can be adapted to various field application. So, these are the reason for which farmers generally prefer customized fertilizers.

(Refer Slide Time: 12:19)



Methods of customized fertilizer manufacturing

> There are basically three methods of customized fertilizer production

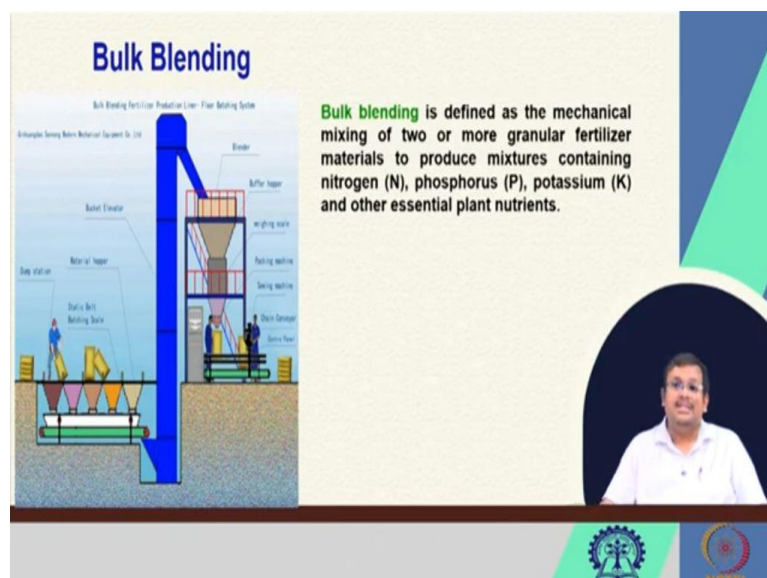
1. Bulk Blending
2. Compound Granulation/Steam Granulation
3. Complex/Chemical Granulation

Simple
↓
Complex

The slide features a list of three methods of customized fertilizer production. To the right of the list, a blue arrow points downwards from the word 'Simple' to the word 'Complex', indicating that the complexity of the process increases from the first method to the third. A small inset video of a presenter is visible in the bottom right corner of the slide.

Now, what are the methods of customized fertilizer manufacturing? There are basically three methods of customized fertilizer production. First of all, bulk blending, second is compound granulation or steam granulation and third one is complex or chemical granulation. Generally, bulk blending is the simplest process and complex or chemical granulation is the complex process. So, as we move from the bulk blending to compound granulation or steam granulation to complex or chemical granulation, the complexity of the processes process increased.

(Refer Slide Time: 12:57)



Bulk Blending

Bulk blending is defined as the mechanical mixing of two or more granular fertilizer materials to produce mixtures containing nitrogen (N), phosphorus (P), potassium (K) and other essential plant nutrients.

The slide includes a detailed diagram of a bulk blending fertilizer production line. The diagram shows a vertical flow of material from a hopper at the top, through a series of conveyor belts and weighing stations, to a final storage or packing area at the bottom. Labels in the diagram include: Bulk Blending Fertilizer Production Line - Floor Mixing System, Hopper, After hopper, weighing scale, Packing machine, Sizing machine, Final Storage, and Storage Tank. A small inset video of a presenter is visible in the bottom right corner of the slide.

Now, what is bulk blending? Bulk blending is defined as the mechanical mixing of two or more granular fertilizer materials to produce mixtures containing nitrogen, phosphorus,

potassium and other essential plant nutrients. So, this is called the bulk blending. In the bulk blending, what we are doing? We are basically mixing two or more granular fertilizer materials to produce mixtures containing nitrogen, phosphorus, potassium and other essential plant nutrients.

(Refer Slide Time: 13:33)

Steam Granulation

- Granulation is part of the value chain and a process that increases particle size, reduces loss and guarantees more precision in field applications of fertilizers. Fertilizers granulation creates the final product.
- Steam Granulation is a modification on wet granulation. Steam is used as a binder instead of water. This process has many benefits. It offers higher distribution uniformity, a higher diffusion rate into powders and more favourable thermal balance during drying.

Shanmugam (2015).

Then, steam granulation is another process. Now, what is granulation? Granulation is a part of the value chain and a process that increases the particle size, reduces loss and grand guarantees more precision in field application of fertilizers. So basically, here we can increase the particle size, we can reduce the loss (fat) fertilizer loss and guarantee more precision in the field application of the fertilizer of fertilizers granulation create the final product. Now, steam granulation is a modification on wet granulation, and steam is used as a binder instead of water.

And this process has many benefits. It offers higher distribution uniformity, a higher diffusion rate into powders, and more favourable thermal balance during the drying. So, what happens in case of thermal granulation? Here steam we use as a binding material instead of water. Now, this process of same granulation as many benefits last, just like it offers higher distribution, uniform distribution, then higher diffusion rate into the powder, and more favourable thermal balance during the drying process.

(Refer Slide Time: 14:57)



Advantages of customized fertilizers

- Customized fertilizers ensure best fertilizers management practices and are generally assumed to maximize crop yields while minimizing unwanted impacts on the environment and human health.
- Application of customized fertilizer is compatible with existing farmers system and hence it is generally comfortably accepted by the farmers.
- Customized fertilizer satisfies crop's nutritional demand, specific to area, soil, and growth stage of plant.

The slide features a blue header with the title, a light beige background for the text, and a circular video inset on the right showing a man in a white shirt. At the bottom, there are logos for a university and NPTEL.

Now, what are the advantages of customized fertilizers? First of all, customized fertilizer ensure best fertilizers management practices and are generally assumed to maximize the crop yield, while minimizing unwanted impacts on the environment and human health. So basically, the crux of the the the advantages of customized fertilizer is, it increases the crop yield while minimizing the unwanted impacts on the environment and human health. Secondly, application of customized fertilizer is compatible with existing farmers system and hence it is generally comfortably accepted by the farmers.

And thirdly customized fertilizer satisfies crops, nutritional demand and specific to area, soil and growth stage of the plant. So, these are the major benefits of customized fertilizers.

(Refer Slide Time: 16:05)



- As the micro-nutrients are also added with the granulated NPK fertilizer, the plants can absorb the micro-nutrient along with macro-nutrient which prevents nutrient deficiency in plant.
- Micro-nutrient with the mixed fertilizer is one of the most convenient methods of fertilizer application and helps in more uniform distribution of nutrient with conventional application equipments.

The slide has a light beige background, a circular video inset on the right showing the same man in a white shirt, and logos at the bottom.

Apart from that, as the micronutrients is also added with the granulated NPK fertilizer, the plants can absorb the micro-nutrient along with macro-nutrient which prevents nutrient deficiency in plant. Remember that micro-nutrient with the mixed fertilizer is one of the most convenient methods of fertilizer application, and helps in more uniform distribution of nutrients with conventional application equipments.

(Refer Slide Time: 16:39)

The slide features a title bar at the top with the text "How to decide the best customized fertilizer ???". Below the title is a list of nine steps, each preceded by a right-pointing arrowhead. The steps are: "Geo-referencing of the selected area", "Selecting sampling points using appropriate statistical procedure", "Actual sampling of sites", "Analysing soil, plant and water samples for nutrients and some soil characteristics", "Defining management zones", "Yield targeting in major management zones", "Computing crop removal of nutrients", "Calculating nutrient requirement", and "Blending of nutrients based on generated information". On the right side of the slide, there is a circular video inset showing a man with glasses and a white shirt. At the bottom of the slide, there are two logos: the Indian Institute of Technology (IIT) logo on the left and the NPTEL logo on the right.

- Geo-referencing of the selected area
- Selecting sampling points using appropriate statistical procedure
- Actual sampling of sites
- Analysing soil, plant and water samples for nutrients and some soil characteristics
- Defining management zones
- Yield targeting in major management zones
- Computing crop removal of nutrients
- Calculating nutrient requirement
- Blending of nutrients based on generated information

Now, how we can decide the best customized fertilizer? Which one is the best customized fertilizer? Or what are the steps of deciding which, which is the best customized fertilizer? First of all, we have to geo-reference the selected area. Second is we have to select the sampling points using appropriate statistical procedure. Thirdly, we have to do the actual sampling of sites. After the sampling, we have to analyze the soil plant and water samples for nutrients and some soil characteristics. We have to then define the management zones; then yield targeting needs to be done in major management zone.

Then, we have to compute the crop removal of the nutrients, then we have to calculate the nutrient requirement. And finally based on the nutrient requirement will blend nutrient based on generated information. So, this is how we can derive the best customized fertilizer.

(Refer Slide Time: 17:46)

Journey of CF in India	
2005	Concept paper in Indian Journal Fertilizers & presented in FAI seminar
2006	FAI working Group
2007	FAI & DAC proposal on CF
2007	CF formulation & field validation trial by Tata, Nagarajuna & Deepak
2007	Series of CF workshops conducted
2008	CF guideline issued by GoI on 11 th March, 2008
2008	DAC approved 12 CF grades
2009	Tata initiates setting up of hi-tech CF plant
2010	GoI support for availability of raw material
2010	Tata's CF Plant starts production on 22 nd Nov., 2010

Now, what is the journey of customized fertilizer in India? So, in 2005, the Concept paper in Indian Journal for Fertilizers and, and this Concept paper first appeared in Indian Journal fertilizer and it was presented in Fertilizer Association of India seminar. In 2006, FAI working group was developed and then in 2007, FAI and Department of Agriculture and Cooperation proposal on this customized fertilizer first surfaced. And then in 2007, the customized fertilizer formulation and field validation trial in it was executed by Tata, Nagarajuna and Deepak fertilizers.

Then in 2007, series of customized fertilizer workshop conducted. And then to the in 2008, the customized fertilizer guidelines guideline issued by government of India in the on 11th March. Then, in 2008, DAC approves 12 customized fertilizer grades; 2009, Tata initiate setting up the high tech customized fertilizer plant. And in 2010, Government of India support for availability of raw material and then in 2010, Tata's consumer's fertilizer plant started starts production on 22nd of November 2010. So, this is how the history of customized fertilizer in India.

(Refer Slide Time: 19:28)

Customized formulations in India

- Fertilizer Control Order (FCO) approved about 36 formulation of customized fertilizers. At present nearly 1 lakh tonne of customized fertilizer is being marketed by four companies in India.
- The important companies in the market, producing customized fertilizers are:
 - ✓ Nagarjuna Fertilizers Ltd.
 - ✓ Tata Chemicals
 - ✓ Indo Gulf
 - ✓ Coromandel Fertilisers Ltd
 - ✓ Deepak Fertilizers

The slide features a speaker in a circular inset on the right and logos for IIT Guwahati and NPTU at the bottom.

Now, customized formulations in India. So, first for Fertilizer Control Order approved about 36 formulation of customized fertilizers so far. At present nearly 1 lakh tonne of customized fertilizer is being marketed by top four companies of India. Who are the important? Now, the question comes who are the important companies in the market, who produce the customized fertilizers? So, Nagarjuna fertilizer is one of them, Tata Chemicals, then Indo Gulf, then Coromandel Fertilizers Limited, and Deepak fertilizers. So, these are the major players of customized fertilizers in India.

(Refer Slide Time: 20:11)

Some example of Customized Fertilizers:

- 14:27:10:4:0.5 (NPKZnS) for paddy in east A.Pradesh (Nagarjuna Fertilizers Ltd)
- 20:0:15:0:0.2 (NPKZnSB) for Paddy and Maize middle A.P. (Coromandel Fertilizers Ltd)
- ❖ These fertilizer manufacturing basically involves mixing and crushing of urea, DAP, MOP, ZnS, bentonite sulphur and boron granules for obtaining the desired proportion of N, P, K, S and micronutrients.

The slide features a speaker in a circular inset on the right and logos for IIT Guwahati and NPTU at the bottom.

Now, let us see some examples of customized fertilizer. So, there is NPKZnS that is top 14, 27, 10, 4, 0.5. So, this is a customized fertilizer; it is used for Paddy in eastern Andhra

Pradesh, which is manufactured by Nagarjuna Fertilizers. Then, NPKZnSB is ZnSB, so, we have zinc (sulf) sulphide and boron. So, we have 20, 0, 15, 0, 0.2 So, we can see 20 percent nitrogen, 15 percent K₂O. And then we have 0.2 percent of boron for Paddy and Maize in middle Andhra Pradesh, which is produced by the Coromandel Fertilizer Limited.

So, these fertilizer manufacturing basically involves the mixing and crushing of urea, the di-ammonium phosphate, Muriate of Potash, zinc sulphide, and bentonite sulphur, and boron granules, for obtaining the desired proportion of NPK, sulphur and other micro-nutrients. So, these are some examples of customized fertilizers.

(Refer Slide Time: 21:29)

Different customized fertilizer formulations available in India

Sr. No.	Crops	Formulations (N:P:K:S:Zn:B)	Geography/area
1.	Wheat	10:18:25:3:0.5:0	Muzaffarnagar, Barielly, Bijnore, Hathras, Pilibhit, Mathura, Meerut
2.	Sugarcane	7:20:18:6:0.5:0	Moradabad, KR Nagar, Farukhabad
3.	Rice	8:15:15:0.5:0.15:0	Ghaziabad, Rampur, Shahjahanpur, Mainpuri
4.	Groundnut	15:15:15:9:0.5:0.2	Andhra Pradesh
5.	Maize	20:0:15:0:0:0.2	Andhra Pradesh
6.	Potato	8:16:24:6:0.5:0.15	Agra, Aligarh, Budan, Bulandshahar

Sr. No.	Crops	Formulations (N:P:K: Zn/ N:P:K:S:Mg:Zn:B:Fe/ N:P:K:S:Zn:B)	Geography/area
7.	Paddy	15:32:8:0.5 18:33:7:0.5 18:27:14:0.5	Andhra Pradesh
8.	Mentha	8:20:20:4:0.3:0.2	JP Nagar, Lakhimpur Kheri
9.	Grape, Sugarcane	10:20:10:5:2:0.5:0.3:0.2	Aurangabad, Nasik, Pune Ahmednagar
10.	Paddy (basal)	16:22:14:4:1:0	East & West Godawari, Krishna, Guntur
11.	Maize (basal)	14:20:15:4:0.6:0	Karimnagar, Warangal, Nizamabad
12.	Groundnut (basal)	17:17:17:4:0.5:0.2	Anantapur, Chittoor, Kadapa, Kurnool, Mahaboobnagar

So, let us see what are the different customized fertilizer formulations, which are available in India. So, if you can see the wheat, so these are the formulations like 10, 18, 25, 3, 5; so,

these are available for these geographical area. Then sugarcane, we have 7, 20, 18, 6, 0.5, 0 which are available in Moradabad, KR Nagar, Farukhabad. So, similarly for rice, groundnut, maize, potato, and for paddy, mentha, (soup) grapes, sugarcane, paddy and then maize, and basal groundnut; so, all these are having their own formulations. And there is restricted geographical areas, where these are, these customized fertilizers are useful.

(Refer Slide Time: 22:19)

**Effect of customized fertilizers on yield attributes and yield of rice
(2 locations pooled)**

Treatments	Productive tillers (No./ hill)	Panicle length (cm)	Filled grains/ panicle	Grain yield (kg/ha)	% yield Increase over control
T ₁ :100% RDF +25 kg ZnSO ₄ /ha	19	22.8	152	5628	-
T ₂ :50% RDF as CF I +25 kg ZnSO ₄ /ha	15	20.5	117	5061	-10.1
T ₃ :75% RDF as CF I +25 kg ZnSO ₄ /ha	20	24.7	171	6250	11.1
T ₄ :100% RDF as CF I +25 kg ZnSO ₄ /ha	20	26.6	187	6622	17.7
T ₅ :50% RDF as CF II	17	22.7	144	5372	-4.5
T ₆ :75% RDF as CF II	21	25.4	180	6478	15.1
T ₇ :100% RDF as CF II	21	27.7	203	6878	22.2
C.D. (P=0.05)	3	0.7	19	218	-

- RDF-150:50:50:25 N:P:K:Zn(kg/ha)
- CF I-150:50:50 N:P:K(kg/ha) as straight fertilizer
- CF II- 150:50:50:25 N:P:K:Zn(kg/ha) as mixed fertilize
- Soil Status: pH- 7.55, 229:30.9:290 N:P:K (kg/ha):3.02 Zn(ppm) pH- 8.25, 275:28.3:680 N:P:K(kg/ha) :5.16 Zn (ppm)

Coimbatore (Taminadu) Kaleeswari (2013)

Now, let us see effect of customized fertilizer on yield attributes and yield of rice. So, we can see here two locations pooled; so, if we consider that these T7 that is 100 percent of recommended dose of fertilizer plus customized fertilizer; we can see the number of productive tillers per hill increased as compared to the the only the recommended dose of fertilizers. And then we can see that panicle length is also increased, filled grains per panicle also increased as compared to the other treatments. Grain yield, you can see highest grain yield you can see here in case of this combined recommended dose of fertilizers, plus a customized fertilizer.

So, we can see that around 22 percent increase in yield over the control. So, this is an example of effect of customized fertilizer on yield of rice.

(Refer Slide Time: 23:21)

Effect of customized fertilizers on soil available nutrients after harvest of rice (2 locations pooled)

Treatments	OC (g/kg)	Available nutrients (kg/ha)		
		N	P	K
T ₁ : 100% RDF +25 kg ZnSO ₄ /ha	6.6	307	33.9	469
T ₂ : 50% RDF as CF I +25 kg ZnSO ₄ /ha	5.3	253	27.1	355
T ₃ : 75% RDF as CF I +25 kg ZnSO ₄ /ha	4.8	289	42.0	509
T ₄ : 100% RDF as CF I +25 kg ZnSO ₄ /ha	5.6	312	40.0	537
T ₅ : 50% RDF as CF II	5.6	272	25.8	384
T ₆ : 75% RDF as CF II	6.3	322	38.5	528
T ₇ : 100% RDF as CF II	5.7	343	35.7	543
C.D. (P=0.05)	0.9	NS	6.4	NS

> RDF-150:50:50:25 N:P:K:Zn(kg/ha)
 > CF I-150:50:50 N:P:K(kg/ha) as straight fertilizer
 > CF II- 150:50:50:25 N:P:K:Zn(kg/ha) as mixed fertilizer
 > Soil Status: pH- 7.55, 229:30.9:290 N:P:K (kg/ha):3.02 Zn(ppm) pH- 8.25, 275:28.3:680 N:P:K(kg/ha) :5.16 Zn (ppm)

Coimbatore (Tamilnadu) Kaleeswari (2013)

So, this is again effective customized fertilizer on, on soil; available nutrients after harvest of rice. You can see in this T7, which can which has 100 percent RDF as CF two, which is basically 100, 50, 50, 25; that is NPK zinc as mixed fertilizers. So, we can see that when we are using these, we are getting the highest organic carbon of 5.7 kg gram per kg and we are getting the highest nitrogen of 343 kg per hectare. We are getting the almost high very very high available phosphate; that is that 35.7. And potash that is highest 543 kg per hector. So, you can see these are the benefits of using the customized fertilizers.

(Refer Slide Time: 24:22)

Effect of customized fertilizer on growth, yield attributes and yield of wheat

Treatments (11:18:9:5:3:0.7 N:P:K:S:Zn %)	Plant height (cm)	Effective tillers/ m ² (No.)	Spikelet length (cm)	Test weight (g)	Grain yield (t/ha)
T ₁ : Absolute Control	70.8	201.7	8.16	36.2	1.59
T ₂ : 50% CF dose	79.1	254.3	8.40	36.3	2.57
T ₃ : 75% CF dose	81.6	254.2	8.81	36.7	3.33
T ₄ : 100% CF dose	83.5	304.2	9.20	37.4	3.72
T ₅ : 125% CF dose	85.1	318.0	9.37	37.4	3.87
T ₆ : 150% CF dose	89.4	372.7	10.02	37.8	4.40
T ₇ : 100 % RDF	83.7	280.8	9.10	37.0	3.43
C.D. (P=0.05)	4.9	40.0	0.51	0.80	0.30

> 100% RDF- 60:40:0:0:25 N:P:K:S:Zn(kg/ha)
 > 100% CF dose- 41.3:67.5:33.8:19.9:2.6 N:P:K:S:Zn(kg/ha)
 > Initial soil status- pH- 6.95, 190:19:290 N:P:K(kg/ha)

Raipur (Chhattisgarh) Dwivedi et al. (2014)

Also, you can see effect of customized fertilizer on growth, yield attributes, and yield of wheat. You can see that when we are using the customized for 150 percent of the customized

fertilizer dose, we are getting the plant height that is 89.4 centimeters; so, the highest height we are getting. Then, effective tillers, we are getting highest that is 372.7 tillers per square meter and then spikelet length also is the highest in case of the customized fertilizer, plus RDF. And then test weight is also highest among all the treatments and then grain yield. We can see it is also highest in case of combined RDF. You know customized fertilizer dose 150 percent of the customized fertilizer dose.

(Refer Slide Time: 25:22)

Effect of customized fertilizer on yield attributes and yield of onion

Treatments (20:12:10:4:0.25:0.50 :0.50 N:P:K:S:Mg:Zn:Fe %)	Plant height (cm)	Yield (t/ha)		FUE (kg bulb/ kg fertilizer)
		Onion	Green leaves	
T ₁ : Absolute Control	47.7	13.8	8.9	-
T ₂ : 100% RDF	53.2	19.1	12.0	19.1
T ₃ : 75% CF dose (2 equal split)	51.8	17.2	12.1	17.1
T₄: 100% CF dose (2 equal split)	56.8	21.9	13.0	21.8
T ₅ : 125% CF dose (2 equal split)	55.4	20.9	12.1	19.8
T ₆ : 75% CF dose (3 equal split)	54.9	19.6	12.8	19.5
T₇: 100% CF dose (3 equal split)	57.7	22.3	12.6	22.2
T ₈ : 125% CF dose (3 equal split)	57.6	20.2	12.2	19.1
C.D. (P=0.05)	5.4	2.8	2.1	2.9

➤ 100 % RDF- 100:50:50 N:P:K (kg/ha)
 ➤ 100 % CF- 100:50:50 N:P:K (kg/ha)
 ➤ Initial soil status: pH:8.2, 178:10:50:732 N:P:K (kg/ha)

Kamble and Kathmale (2015)

We can see here effect of customized fertilizer on yield attributes and yield of onion. So, we can see that when there is an 100 percent customized fertilizer dose in three equal split, we can get the plant height of highest plant height that is 57.7 centimeter. And we can have the highest yield 22.3 tonne per hectare and then we are getting the fertilizer use efficiency that is 22.2. So, also when we are using this 100 percent of customized fertilizer in two equal split, we can get the green leaves of; we can get the green leaves highest green leaves of 13 tonne per hectare. So, you can see these are the benefits of application of customized fertilizers.

(Refer Slide Time: 26:16)

Effect of customized fertilizer on soil available nutrients after harvest of soybean

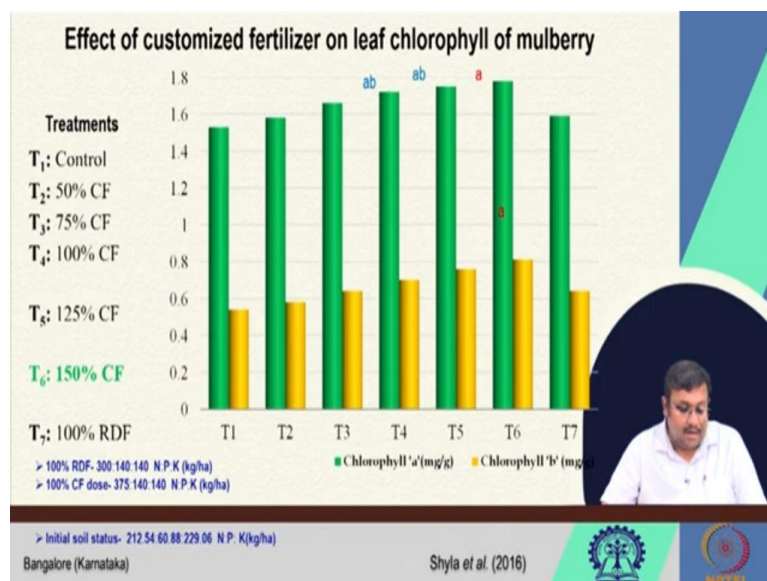
Treatment	Available nutrients (kg/ha)			ppm
	N	P	K	Zn
T ₁ : 50% RD of CF	220.0	15.35	411.22	0.18
T ₂ : 75% RD of CF	222.5	16.07	418.64	0.20
T ₃ : 100% RD of CF	229.5	17.78	421.69	0.35
T ₄ : 125% RD of CF	249.0	20.36	432.73	0.50
T ₅ : 150% RD of CF	273.0	23.20	448.63	0.58
T ₆ : 100% RDF	225.0	18.18	439.03	0.29
Control	198.5	10.98	355.19	0.12
CD (P = 0.05)	13.8	2.13	NS	0.09

> 100% RDF- 20:60:40 N:P:K (kg/ha)
 > 100% CF dose- 37.5:42.5:27.5:1.0 N:P:K:Zn (kg/ha)
 > Soil Status- pH-7.0, 225:22:367 N:P:K (kg/ha)

Raipur (Chhattisgarh) Verma et al. (2015)

Also, we can see effect of customized fertilizer on soil available nutrients after harvest of soybean. We can see here that when we are using the customized fertilizer, we are getting the highest available nutrients.

(Refer Slide Time: 26:30)



This slide shows the effect of customized fertilizer on leaf chlorophyll of mulberry, and you can clearly see that when we are using the customized fertilizer that can increase the the chlorophyll content leaf, chlorophyll content of mulberry and you can see the differences.

(Refer Slide Time: 26:51)



The image shows two identical reference slides. Each slide features a dark blue header with the word 'REFERENCES' in white. Below the header, there is a list of references in black text. On the right side of each slide, there is a circular inset video showing a man with glasses and a white shirt speaking. At the bottom of each slide, there are two logos: the Indian Council of Agricultural Research (ICAR) logo on the left and the National Program on Technology Enhanced Education (NPTEE) logo on the right. The background of the slides is a light beige color with a decorative blue and green geometric shape on the right side.

REFERENCES

Kaleeswari, R.K.(2013). Impact of Customized Fertilizers on Yield and Soil Properties of Lowland Rice Ecosystem. *Madras Agricultural Journal*. 100. 150-152.

Fertilizer (Control) Order, 1985 <https://cfqeti.dacnet.nic.in/1st9.1fco.htm>

Shyla, P. N. Sadatulla, F., Prabhakar, V., Rashmi, P., Harish Babu, S., and Sharma, R. C. (2016). Influence of customized fertilizers on bio-chemical composition of V1 Mulberry. *Int. J. Adv. Res. Biol. Sci.* 3(3): 261-264.

Verma, A. K., SS KOLHE T PANDAGARE, GK SHRIVASTAVA, and N. PANDEY. "Assessment of Customized Fertilizer for Soybean [Glycine max (L.) Merrill] in Chhattisgarh Plains under Rainfed Condition." *Soybean Research* (2015): 19.

Mudalagiriappa, B., Ramachandrappa, B. K., & Nanjappa, H. V. (2015). Influence of Customized Fertilizers on Growth and Yield of Finger Millet (Eleusine coracana (L.) Gaertn.) in Alfisols of Southern India. *Indian J. Dryland Agric. Res. & Dev*, 30(1), 50-54.

REFERENCES

Kamble BN, Kathmale DK. Effect of different levels of customized fertilizer on soil nutrient availability, yield and economics of onion. *J App. Nat. Sci.* 2015; 7:817- 821.

Dwivedi, A., Rana, N. S., Naresh, R. K., Dhyani, B. P., & Singh, A. (2017). Effect of Nutrient Management strategies on Performance of wheat (Triticum aestivum L.) in North West Zone. *Bull. Env. Pharmacol. Life Sci*, 6, 94-100.

Kaleeswari, R. K. (2013). Impact of customized fertilizers on yield and soil properties of lowland rice ecosystem. *The Madras Agricultural Journal*, 100, 150-152.

Shanmugam, S. (2015). Granulation techniques and technologies: Recent progresses. *Bioimpacts*. 5. 55-63. 10.15171/bi.2015.04.

So guys, this makes the end of this lecture number 42. I hope we have learned about these customized fertilizer and their benefits. And these are the references for this lecture. Let us wrap up this lecture and let us meet in our next lecture to discuss more about the fertilizer control and fertilizer quality. Thank you.