FERTILIZER AND FERTILIZATION

LECTURE 3
Fertilizer

- **Fertilizer** is any material that supplies one or more of the essential nutrients to plants.

- Fertilizers typically provide, in varying proportions, the three major plant nutrients (nitrogen, phosphorus, and potassium), the secondary plant nutrients (calcium, sulfur, magnesium), and sometimes trace elements (or micronutrients) with a role in plant nutrition.
• **Straight Fertilizers:** These are products where a nitrogen, phosphate or potassium fertilizer has a declared content of only one of the primary plant nutrients, N, P or K.

• **Compound Fertilizer:** Fertilizer is having a declared content of at least two of the nutrients, nitrogen, phosphorus and potassium, obtained chemically or by blending, or both.

• **Complex Fertilizer:** Fertilizer having a declared content of at least two of the nutrients nitrogen, phosphorus and potassium, obtained by chemical reaction.
Types of fertilizers

- Fertilizers are broadly classified into Organic and Inorganic/Chemical fertilizers.

1. **Organic Fertilizers**

- Organic fertilizers are derived from living or once living material. These materials include animal wastes, crop residues, compost and numerous other byproducts of living organisms. Naturally occurring minerals like sulfate of potash, limestone and rock phosphate are also considered very good Organic Fertilizers.
Advantages of Organic Fertilizers

- Improve the structure of the soil.
- Retain soil moisture.
- Release nitrogen slowly and consistently.
- Mobilize existing soil nutrients.
- Do not burn the plants like some chemical fertilizers.
- Organic fertilizers also breakdown and release nutrients slowly which helps to prevent leaching.
Disadvantages of Organic Fertilizers

• Organic fertilizers, especially those that contain animal and plant feces are contaminated with pathogens. Make sure they are properly composted to reduce the risk of pathogens.

• Organic fertilizers also have lower nutrient content compared to inorganic fertilizers and this means that more material has to be applied in order to get the same nutrient amount from inorganic fertilizers.

• More labor is needed to compost organic fertilizer, increasing labor costs.

• They are usually bulky and difficult to apply.
Inorganic/chemical fertilizers

- Inorganic or Chemical Fertilizers are primarily derived from non-living sources and include most of our man-made, commercial fertilizers.

**Advantages of Inorganic Fertilizers:**
- Higher and accurate amount of nutrients.
- They are cheap, easy to apply and distribute.
- The addition of inorganic fertilizer gives the plants the basic nutrient required by the plant like the Phosphorous, nitrogen and potassium.
- They can release nutrients fast.
- The use of inorganic fertilizers is time and money saving.
Disadvantages of Inorganic Fertilizers

• Inorganic fertilizers can burn plants and distort the quality of the soil when applied excessively.

• They can be easily lost through leaching and surface runoff, which can cause environmental pollution.
Methods of Fertilizer application

Generally 3 methods of application of fertilizers are in practice:

- **Broadcasting**: Uniform distribution over the whole cropped field.
- **Placement**: Application in bands or in pockets near the plants or plant rows.
- **Foliar application**: Using low or high volume sprayers, the fertilizers are sprayed covering the plants.
- **Fertigation**: Applying fertilizer through irrigation water.
Fertilizer Quality

• The quality of a fertilizer is determined by its elemental ratio or grade.

• Fertilizer grade refers to the minimum amounts of N, P$_2$O$_5$ and K$_2$O in the fertilizer.

• A 10-10-10 fertilizer would contain 10 percent nitrogen (N), 10 percent P$_2$O$_5$ equivalent and 10 percent K$_2$O equivalent.
<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>% N</th>
<th>% P$_2$O$_5$</th>
<th>% K$_2$O</th>
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<tbody>
<tr>
<td><strong>Nitrogen Fertilizers</strong></td>
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<tr>
<td>1. Ammonium sulphate (NH$_4$)$_2$SO$_4$</td>
<td>21</td>
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<tr>
<td>2. Calcium nitrate Ca(NO$_3$)$_2$</td>
<td>16</td>
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<td>3. Ammonium nitrate NH$_4$NO$_3$</td>
<td>35</td>
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<tr>
<td>4. Calcium ammonium nitrate NH$_4$NO$_3$ + CaCO$_3$</td>
<td>27</td>
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<td>5. Urea CO(NH$_2$)$_2$</td>
<td>46</td>
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<td><strong>Phosphate Fertilizers</strong></td>
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<tr>
<td>6. Single superphosphate (SSP), CaH$_4$(PO$_4$)$_2$+ CaHPO$_4$· 2H$_2$O</td>
<td>16-18</td>
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<tr>
<td>7. Triple superphosphate (TSP), Ca(H$_2$PO$_4$)$_2$+ CaHPO$_4$</td>
<td>46</td>
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<tr>
<td>8. Phosphate rock (PR), finely ground (&lt; 0.16 mm)</td>
<td>22-40</td>
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<td>9. Diammonium phosphate (DAP)</td>
<td>18</td>
<td>46</td>
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<td><strong>Potassium Fertilizers</strong></td>
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<td>10. Potassium chloride (MOP), KCl</td>
<td>60</td>
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<tr>
<td>11. Potassium sulphate (SOP), K$_2$SO$_4$</td>
<td>50</td>
<td></td>
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<td>12. Potassium nitrate, KNO$_3$</td>
<td>13</td>
<td>44</td>
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<td><strong>Compound Fertilizers (examples)</strong></td>
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<td>13. NPK</td>
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<td>14. NPK</td>
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<tr>
<td>15. NPK</td>
<td>22</td>
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Properties of Fertilizers

• The physical and chemical characteristics of fertilizers are important in determining their quality.

• Physical properties of fertilizer determine how easily and uniformly the fertilizer spreads during application.

• Fertilizers with poor physical properties form lumps or dust, flow badly, accumulate too much water or become segregated. The following are factors related to physical properties of fertilizers:
Physical Properties of Fertilizers

1. Particle Size

• Particles in a particular fertilizer have a range of different diameters. This range is called the particle size distribution.

• In a fertilizer, smaller particles dissolve in water faster. This quickly releases nutrients.

• Particle size also affects application and storage of the fertilizer.
2. Density

• Density compares the weight of fertilizer to the volume. It depends on how closely packed the particles are.
• A low-density fertilizer will take up more space than the same weight of a high-density one.
• This has implications for storage and is important when calibrating machinery.
3. **Granule Hardness**

- Fertilizer particles need to be hard enough to withstand the pressures of handling and storing them.
- Granule hardness will depend on the chemical composition of the fertilizer as well as its other physical properties such as the shape of the particles and how much moisture they contain.
- Granules need to be strong enough to cope with crushing forces, abrasion and impacts (such as hitting a hard surface during spreading).
- Hard particles also make fertilizers less dusty.
4. Moisture Content

- Moisture absorption depends on the chemical composition of the fertilizer, environmental conditions and the shape and size of the particles.
- Granules with larger surface areas absorb relatively more water.
- Critical relative humidity (CRH) is the level of humidity required for the fertilizer to absorb water.
- Fertilizers with high CRH values can be handled and stored in wetter environments.
- If the CRH is too low, the fertilizer can clump together and be difficult to spread, and will need to be stored more carefully to prevent it from getting wet.
Chemical Properties of Fertilizers

• Chemical properties of fertilizers imitate the properties found in the soil's natural mineral and nutrient components.

1. Nutrient Properties

• Nitrogen, phosphorous and potassium are the main elements in fertilizer mixes, which come in liquid and solid forms. Packaged fertilizers are labeled according to the ratio of nitrogen, phosphorous and potassium (NPK), in that order.
2. Acidic Properties

- Fertilizer materials can affect a soil's pH, which is a measure of the soil's acidity or alkalinity.
- Some plant types require more acid soils than others, so fertilizers may help or hinder growth, depending on the needs of the plant.
- When acidity levels are too high, needed minerals and nutrients may be prevented from reaching a plant's root system.
- Some fertilizers are specifically packaged for plants that require a more acid soil.
Nutrient Availability in Chemical Fertilizers

- The chemical interactions between the soil and the fertilizer can help or hinder plant growth, depending on the amounts used and the time of application.
- Water levels in the soil also affect nutrient availability, especially in the case of phosphorous materials, which rely on water to dissolve them in the soil.
- Potassium nutrients tend to cling to clay and organic matter, and will tend to remain at their initial point of contact in the soil, so careful placement around plant root system structures can help ensure this nutrient's availability.
Liquid Fertilizers

• The important physical properties of fluid fertilizers are density, viscosity and pH.
• The strength of the gelling agent is also important.
• It should be strong enough to keep the solids in suspension, but not so strong that the liquid is too thick to be pumped and poured.
Fertilizer Calculation

• It is common to recommend the crop nutrient requirements in terms of the nutrient values.
• For example, recommendation for rice is 150 kg N/ha. But the field application has to be on the basis of the quantities of fertilizer/s required to meet the recommended rates of N.
• This conversion involves some amount of calculations.
Two Basic Types of Calculations (nutrient vs. fertilizer)

• You have a given amount of fertilizer and you need to calculate how much nutrient is in it.

• You have a given amount of a nutrient to apply and you need to calculate how much fertilizer to use.
1. How many kg of N are in a 50 kg bag of ammonium nitrate (35-0-0)?

Amount of N in 50 kg NH₄NO₃ = \( \frac{35}{100} \times 50 \) kg

= 17.5 kg N
2. How many kg of N are in a 150 kg bag of urea CO\((\text{NH}_2)_2\)\)?

Amount of N in 150 kg CO\((\text{NH}_2)_2\)\) = \(\frac{46}{100} \times 150\) kg

= 69.0 kg N
3. How many kg of NPK (15-15-15) do you need to give you 5 kg of N?

15 kg N = 100 kg NPK

5 kg N = X kg NPK

X kg NPK = (5 kg N) x (100 kg NPK)/(15 kg N)

Amount of NPK = 33.3 kg
Fertilizer Efficiency

• The term efficiency is defined by Barber (1976) as "the amount of increase in yield of the harvested portion of the crop per unit of fertilizer nutrient applied where high yields are obtained".

• Efficient fertilizer use on many tropical soils apparently still presents severe and unresolved problems.

• Compared to temperate regions recovery of fertilizer nutrients by crops in tropical soils is lower.
Fertilizer efficiency in the tropics is affected by:

a) Soil factors
b) Efficiency of crops
c) Climatic factors e.g. rainfall
d) Nature of fertilizer materials
e) Methods of fertilizer application
f) Fertilizer efficiency modifiers - amendments.
1. Soil factors:

- Soil factors have a large influence on the transformation, fixation (adsorption) and leaching losses of N, P and K.

- Among the soil factors are its texture, proportion and amounts of clay (expanding, non expanding and amorphous material), organic matter content, the cation exchange capacity, the concentration of ions on the exchange complex, the capacity of soil to release or renew the levels of exchangeable ion or to fix ions, soil pH, soil moisture, soil temperature, soil aeration and soil compaction.
2. Efficiency of crops:

- Species or cultivars with a high growth rate generally respond more favorably to fertilizer application than those with low growth rate.
- Baligar and Barber (1978) have listed the following plant factors that influence nutrient absorption:
  1. Ion influx rate;
  2. Root radius;
  3. Rate of water uptake per unit of root;
  4. Root length, and number and length of root hairs;
  5. The number of roots (root density);
  6. Rate of root growth.
2. Climatic factors:

- Availability, movement and uptake of nutrients are affected by climatic factors such as moisture and temperature conditions.
- In tropical farming climatic factors like rainfall and temperature play an important role on nutrient efficiency. Rainfall leaches away the soluble nutrients like $\text{NO}_3$ and K.
- Water logging of lower areas cause denitrification of NO3, and extensive evaporation during dry spells means ammonia losses. Under high temperature mineralization of soil organic matter, crop and animal waste is rapid and the rate of soil weathering is high.
3. **Nature of Fertilizer**

- The source of fertilizer can affect its solubility. For example, phosphate rocks have low water solubility as compared to superphosphate.

4. **Practices of fertilizer application**

- In tropical soils volatilization losses of ammonia and leaching losses of nitrate are common forms of N losses.
- Volatile losses could be minimized by incorporating ammonium form or urea-form N sources with soil.
5. **Soil Amendments**

- Liming acid soils to neutralize aluminium helps to increase effective cation exchange capacity.
- Such increase in CEC might reduce the potential for leaching loss of K by reducing the concentration of K in soft solutions.
- The application of nitropryn inhibits the nitrosomonas bacteria activity, thereby keeping ammonium in soil for a considerable length of time in a form not subjected to loss by leaching.

6. **Controlled released Fertilizers**

- Limited leaching and greater fertilizer efficiency is attained with the use of controlled Release Fertilizers.
Tips for Efficient use of Fertilizers

1. Select the most fertilizer responsive and best-suited crops and their varieties for the locality.
2. Balanced fertilization should be practiced based on soil test.
3. While all of phosphate and potash are applied as basal dressing, nitrogen should be applied in split doses.
4. Urea can be cured with soil for top dressing to reduce nitrogen losses by thoroughly mixing 1 part of urea with 5 to 10 parts of moist soil and keeping it for 24 hours.
5. Phosphate should be placed 4 to 6 cm below and 4 to 6 cm away from the seeds to ensure maximum availability.
6. Top dressing nitrogen and potassic fertilizers should be mixed properly with the layer of soil.
7. In dry soil, fertilizers should be placed only in the moist zone.
8. Weeds should be effectively controlled during the early stage of crop growth.
9. Sowing of crop should be done at the normal time suited for the locality to get the benefit of maximum efficiency of applied fertilizers.
10. Optimum plant population of the crop needs to be maintained by adopting proper plant spacing.
11. Timely control of pests and diseases will help in realizing maximum effectiveness from fertilizers.
Organic Waste Management

- Many organic wastes contain nutrients and organic matter that can benefit plant growth and soil productivity.
- Recycling these materials onto land captures nutrients that would otherwise be lost, and helps sustain resource base.
- Organic wastes are utilized in agriculture mainly for improving the soil physical and chemical properties and for nutrient sources for growing crops.
- Organic wastes include animal manures, crop residues, and food processing wastes, municipal biosolids and wastes from some industries.
• Possible uses of organic wastes include use as fertilizer and soil amendment, energy recovery (heat, liquid fuels, electricity), and production of chemicals (volatile organic acids, ammonium products, alcohols).

• Agriculture has traditionally used animal manures for fertilizer and improving soil physical and chemical properties, and to a much lesser degree has also utilized municipal biosolids and industrial organic wastes for this purpose.
Biofertilizer

- Biofertilizer' is a substance which contains living microorganisms which, when applied to soil, colonizes the rhizosphere and promotes growth by increasing the supply or availability of primary nutrients to plants.

- Biological wastes do not contain any chemicals which are detrimental to the living soil.

- They are extremely beneficial in enriching the soil with those micro-organisms, which produce organic nutrients for the soil and help combat diseases.
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Types of biofertilizers

• **For Nitrogen:**
  - Rhizobium for legume crops.
  - Azotobacter/Azospirillium for non legume crops.
  - Acetobacter for sugarcane only.
  - Blue –Green Algae (BGA) and Azolla for low land paddy.

• **For Phosphorous:**
  - Phosphatika for all crops to be applied with Rhizobium, Azotobacter, Azospirillium and Acetobacter.

• **For enriched compost:**
  - Cellulolytic fungal culture.
  - Phosphotika and Azotobacter culture.
CLASSIFICATION OF BIOFERTILIZERS

Biofertilizer

- Nitrogen fixer
  - Azolla
    - Azolla filiculoides
    - Azolla rubra
  - Phosphate solubilizing microbes
  - Vesicular Arbuscular Mycorrhiza (VAM)
  - Plant Growth Promoting Rhizobacteria (PGPR)
  - Sulphur solubilizing microbes

Bacteria

- Rhizobium
- Azotobacter
- Mycobacterium
- Azospirillum
- Bacillus etc.

Blue green

- Anabaena
- Nostoc
- Tolypothrix
- Anabaenopsis
Benefits of using Biofertilizers

1. Increase availability or uptake of nutrients through solubilization or increased absorption.
2. Stimulate plant growth through hormonal or antibiotics action or by decomposing organic waste.
3. Increase crop yield by 20-30%.
4. They are cheap, hence, reduced cost of cultivation.
5. Improves soil properties and sustaining soil fertility.
6. Lead to soil enrichment.
7. Are compatible with long term sustainability.
8. Build up soil fertility in the long term.
9. Curtails the requirement of inputs.
10. They are eco-friendly and pose no damage to the environment.
Disadvantages of biofertilizers

1. Specific to the plants.
2. Rhizobiurn spp. culture doesn't work well in high nitrate tolerant strains of soybean.
3. The acceptability of biofertilizers has been rather low chiefly because they do not produce quick and spectacular responses.
4. Require skill in production and application.
5. Difficult to store