**Third Lecture**

**Nitrogen fertilizers or industrial N- fixation**

Nitrogen fertilizers play a crucial role in providing essential nutrients to plants, promoting their growth and improving crop yields. However, **the reactions of nitrogen fertilizers** in soils can have both positive and negative environmental implications.

The primary nitrogen fertilizers used in agriculture include urea, ammonium nitrate, ammonium sulfate, and others.

**Here are some key reactions that occur when nitrogen fertilizers are applied to soils:**

1. **Urea Hydrolysis:**
   * **Urea (CO(NH2)2)**
   * is a common nitrogen fertilizer. When applied to soil, urea undergoes hydrolysis, a reaction catalyzed by the enzyme urease, which is present in soil microorganisms. The reaction is as follows:
   * **CO(NH2)2+2H2O→2NH4++2HCO3−CO(NH2​)2​+2H2​ O →2NH4+​+2HCO3−​**
   * This process converts urea into ammonium ions (NH4+) and bicarbonate ions (HCO3-). Ammonium is then available for plant uptake.
2. **Ammonium Adsorption and Cation Exchange:**
   * Ammonium ions released from nitrogen fertilizers are **adsorbed onto** soil particles.
   * The positively charged ammonium ions (NH4+) can undergo cation exchange with other cations (e.g., calcium, magnesium, potassium) on soil particles, making them available for plant roots.
3. **Nitrification:**

Nitrification is

a biological process in soil that involves the conversion of ammonium (NH₄⁺) into nitrite (NO₂⁻) and then further into nitrate (NO₃⁻) by specific groups of soil bacteria.

This process is crucial for the transformation of nitrogen in a form that is more readily available for plant uptake.

The primary stages of nitrification are mediated by different groups of bacteria:

1. **Ammonium (NH₄⁺) to Nitrite (NO₂⁻):**
   * In the first step of nitrification, certain bacteria belonging to the genus
   * **Nitrosomonas** oxidize ammonium ions (NH₄⁺) to nitrite ions (NO₂⁻).
   * The overall reaction is **represented as follows**:
   * **NH4+→NO2−+2H2ONH4+​→NO2−​+2H2​O**
2. **Nitrite (NO₂⁻) to Nitrate (NO₃⁻):**
   * The second step involves the oxidation of nitrite ions (NO₂⁻) to nitrate ions (NO₃⁻) by bacteria of the genus **Nitrobacter.** The reaction **can be expressed** as:
   * **NO2−→NO3−+H2ONO2−​→NO3−​+H2​O**

**Both of** these steps are aerobic processes, meaning they occur in the presence of oxygen.

Therefore, nitrification is most active in well-aerated soils with sufficient oxygen levels.

The overall process of nitrification **can be summarized as follows**:

**NH4+ + NO2−→NO3−NH4+ ​→ NO2−​ → NO3−​**

Nitrification is an essential part of the nitrogen cycle and plays a critical role in **soil fertility.**

**Nitrate**, the end product of nitrification, is a form of nitrogen that many plants prefer for nutrient

uptake.

However**, excessive** nitrification can lead to **nitrate leaching,**

posing environmental concerns such as **groundwater** contamination.

**Management practices** that optimize nitrification and minimize nitrogen losses are important for **sustainable agriculture**.

**Denitrification**

is a microbial process in soil that involves the **reduction of** nitrate (NO₃⁻) and nitrite (NO₂⁻) to **gaseous f**orms of nitrogen,

primarily nitrogen gas (N₂) or nitrous oxide (N₂O).

**what is the optima conditions encourage (N₂O) formation ?**

1- This process occurs in **anaerobic (low-oxygen) conditions**

2-Is carried out by specific groups of bacteria.

Denitrification acts as **a sink for nitrogen in the soil**, leading to the loss of nitrogen from the terrestrial ecosystem and returning it to the atmosphere.

**What is The primary steps of denitrification ?**

include:

1. **Reduction of Nitrate (NO₃⁻) to Nitrite (NO₂⁻):**
   * Certain bacteria first reduce nitrate to nitrite in **anaerobic conditions**.
   * The reaction is represented as:
   * **NO3−→NO2−+gaseous byproductsNO3−​→NO2−​+gaseous byproducts**
2. **Reduction of Nitrite (NO₂⁻) to Nitric Oxide (NO):**
   * Nitrite is further reduced to nitric oxide (NO) by denitrifying bacteria:
   * **NO2−→NO+gaseous byproductsNO2− ​→NO + gaseous by products(منتجات ثانوية )**
3. **Reduction of Nitric Oxide (NO) to Nitrous Oxide (N₂O):**
   * Nitric oxide is then reduced to nitrous oxide, which is another greenhouse gas:
   * **NO→N2O+ gaseous byproducts NO→N2​O + gaseous  byproducts**
4. **Reduction of Nitrous Oxide (N₂O) to Nitrogen Gas (N₂):**
   * **Finally**, nitrous oxide can be reduced to nitrogen gas: **N2O→N2+gaseous byproductsN2​O→N2​+gaseous byproducts**

Denitrification reduces the availability of nitrogen in the soil for plant uptake and returns it to the atmosphere as gaseous forms of nitrogen.

While denitrification is a natural part of the nitrogen cycle, **excessive or uncontrolled**

denitrification can result in nitrogen **loss from agricultural systems**, contributing to

environmental issues such as **greenhouse gas emissions** and nitrogen **pollution of water** bodies.

**Balancing nutrient management practices** to minimize nitrogen losses through denitrification is important for sustainable agriculture and environmental conservation.

1. **Ammonia Volatilization:**
2. **What is the optima conditions to occurs Ammonia Volatilization ?**
   * 1- In alkaline soils
   * 2- under high-pH conditions,
   * ammonia (NH3) can be released into the atmosphere through a process called ammonia volatilization .
   * **what is positive or negative effect when** **Ammonia Volatilization happen ?**
   * Negative effect lead to nitrogen loss and reduce the **efficiency o**f nitrogen fertilizer application.

**Nitrogen leaching**

from soil refers to the process by which nitrogen compounds, particularly nitrate ions (NO₃⁻),

are washed out of the soil and transported through the soil profile **by water.**

This **movement** can lead to the loss of nitrogen from the root zone of plants, with potential environmental implications.

**What are main factors influencing nitrogen leaching ?**

The primary factors influencing nitrogen leaching include **soil properties ( pH, texture , Ec, -----) , climate,** and **agricultural practices( tilth, irrigation , ----) .**

**How can be leached nitrogen typically ?**

1. **Application of Nitrogen Fertilizers:**
   * Nitrogen fertilizers, such as **ammonium-**based fertilizers, urea, or other nitrogen-containing compounds, are applied to the soil to enhance plant growth.
2. **Conversion of Ammonium to Nitrate:**
   * **In the soil,**
   * ammonium ions (NH₄⁺) released from fertilizers can undergo nitrification, a process in which **soil bacteria** convert them to nitrate ions (NO₃⁻). Nitrate is the
   * form of nitrogen that is **highly mobile in water**.
3. **Water Movement Through Soil:**
   * When water moves through the soil profile due to **rainfall,** **irrigation**, or other factors, it carries dissolved nitrate ions along with it.
4. **Leaching of Nitrate:**
   * Nitrate is highly soluble in water and does not bind strongly to soil particles. As a result, it can be easily leached downward through the soil, **away from the root** zone where plants can **take it up.**
5. **Groundwater Contamination:**
6. )
   * If the leached nitrate reaches the groundwater, **it may contaminate** groundwater. Elevated ( مرتفعة) **nitrate levels** in drinking water can have adverse effects on **human health**, especially for **infants,** and can also contribute to the contamination of surface water bodies.

**Excessive nitrogen leaching**

poses several environmental concerns, including **water pollution** by

Eutrophication of water bodies.(**define ?)**

**Eutrophication** is a process that occurs in water bodies, such as lakes, rivers, and coastal areas, where

there is an **excessive accumulation of nutrients**, primarily nitrogen and phosphorus. These nutrients can come from various sources, including agricultural runoff, industrial discharges, and wastewater.

**Eutrophication** occurs when nutrient-rich runoff, including nitrogen, promotes the rapid growth of algae in water bodies, leading **to oxygen depletion** and negative impacts on **aquatic ecosystems**.

**The excessive growth of algae can have several negative impacts on the ecosystem:**

**Such as :**

1. **Reduced Oxygen Levels:**
2. As the algae and plants die and decompose, bacteria consume the organic matter, leading to an increased demand for oxygen. This can result in reduced oxygen levels in the water, a phenomenon known as hypoxia or anoxia, which can harm fish and other aquatic organisms that depend on oxygen.
3. **Fish Kills:**
4. Low oxygen levels and the decay of organic matter can lead to fish kills and the decline of fish populations in affected water bodies.
5. **Disruption of Ecosystem Balance:**
6. Algal blooms can alter the balance of the aquatic ecosystem, negatively affecting other organisms such as zooplankton, insects, and fish.

**7-Water Clarity:**

8 The excessive growth of algae can decrease water clarity, limiting sunlight penetration and negatively impacting the growth of submerged plants.

Eutrophication is often accelerated by human activities that release large amounts of nutrients into water bodies. Efforts to mitigate eutrophication involve managing nutrient inputs, improving agricultural practices, and implementing **wastewater treatment technologies** to reduce nutrient loading into water systems.

Farmers and land managers implement various practices to minimize nitrogen leaching, such as **using precision nutrient management**, for example :

1. **applying nitrogen fertilizers at the right time**.
2. **using cover crops.**
3. **and adopting conservation practices that reduce soil erosion**.

These measures help balance the need for nitrogen in agriculture with the goal of environmental sustainability.

Essentially all N-fertilizers are produced from ammonia gas

There are three methods by which atmospheric elemental N can be converted into chemical Form that can be directly used as a

Chemical fertilizer , these methods or processes are :

1. **Cyanamide process**

Involves passing purified N-gas over calcium carbide at 1100C

**CaC2 + N2 --------heat------🡪 CaCN2 + C**

**CaCN2 has some toxic effect on crops plants , so application**

**Recommended 4 to 6 weeks before sowing**

**CaCN2 has been used as a herbicide**

1. **Arc Process**

**Passing N2 and O2 through electromagnet as reaction :**

**N2 + O2 -----🡪 2NO**

**2NO + O2 -----🡪 2NO2**

**2NO2  + H2O -----🡪 HNO3 + NO**

1. **Harber – Bosch process**

**Scientific discovered of early twentieth century , it lead to harber receiving a Nobel prize for this invention ,NH3 synthesis by the**

**Main component is magnetite Fe3O4  as catalyze and up 1200C**

**And pressure 200 to 1000 atm. , as below**

**3 H 2 + N2 ----🡪 2 NH3**

**N2 ----- from atmosphere**

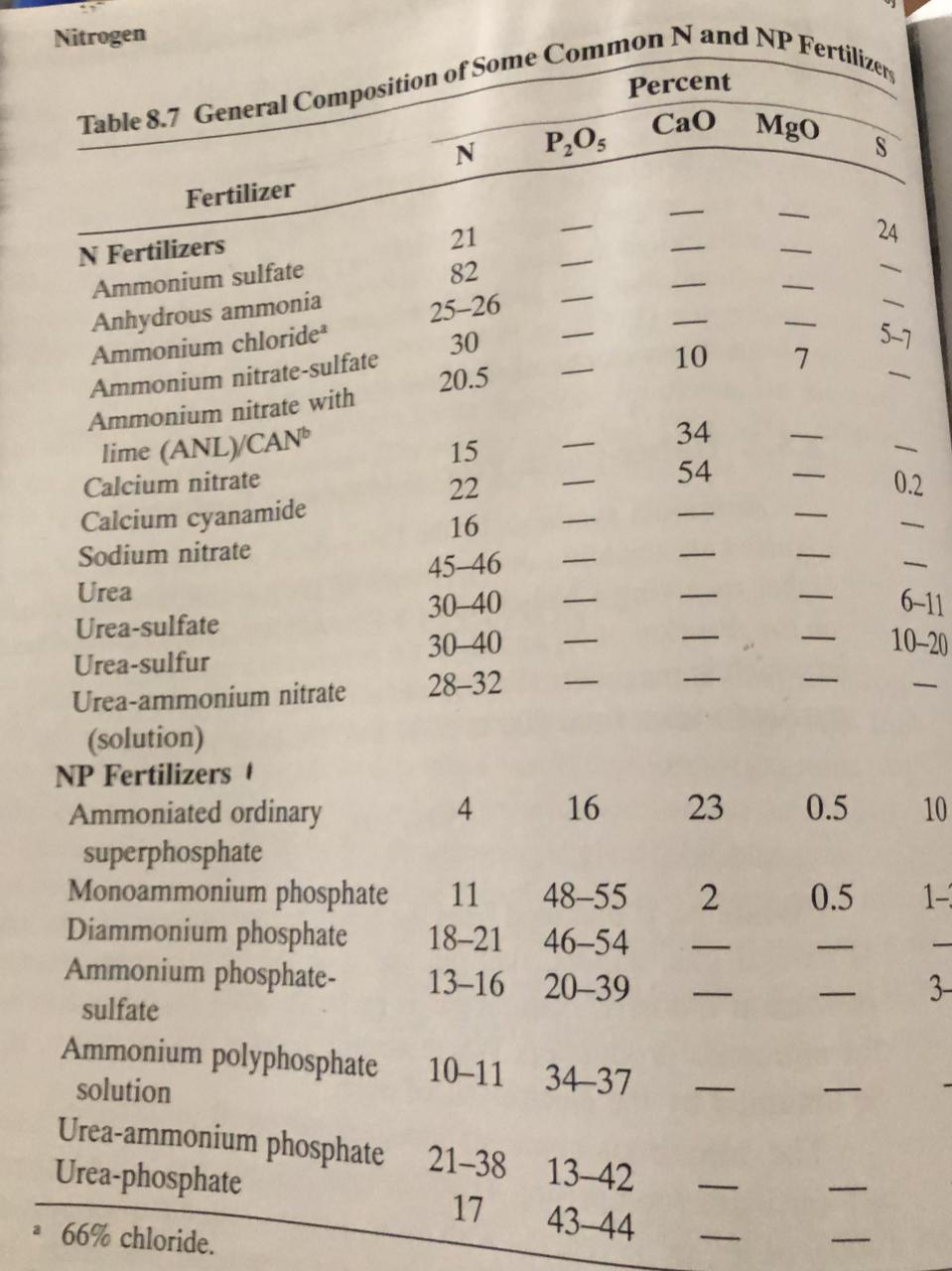
**H 2 ------- from nature gas , fuel oil , coal**

**Anhydrous NH3 can be reacted with nitric , sulfuric , phosphoric**

**Acids to make ammonium nitrate , ammonium sulfate and ammonium phosphate can be used as fertilizer**

**As table 8.7 : general composition of some common N and NP**

**Fertilizers**



* + Nitrogen management
  + Recovery of N – fertilizer
  + Is calculated as fraction of N – fertilizer applied that is removed in harvested crop , vary from 20% to 80%
  + **Depending on crop , amount of N , source of N , soil properties , frequency and amount of precipitation**
  + **% Recovery = (Ntr. – N co. ) \ N ap. \*100**

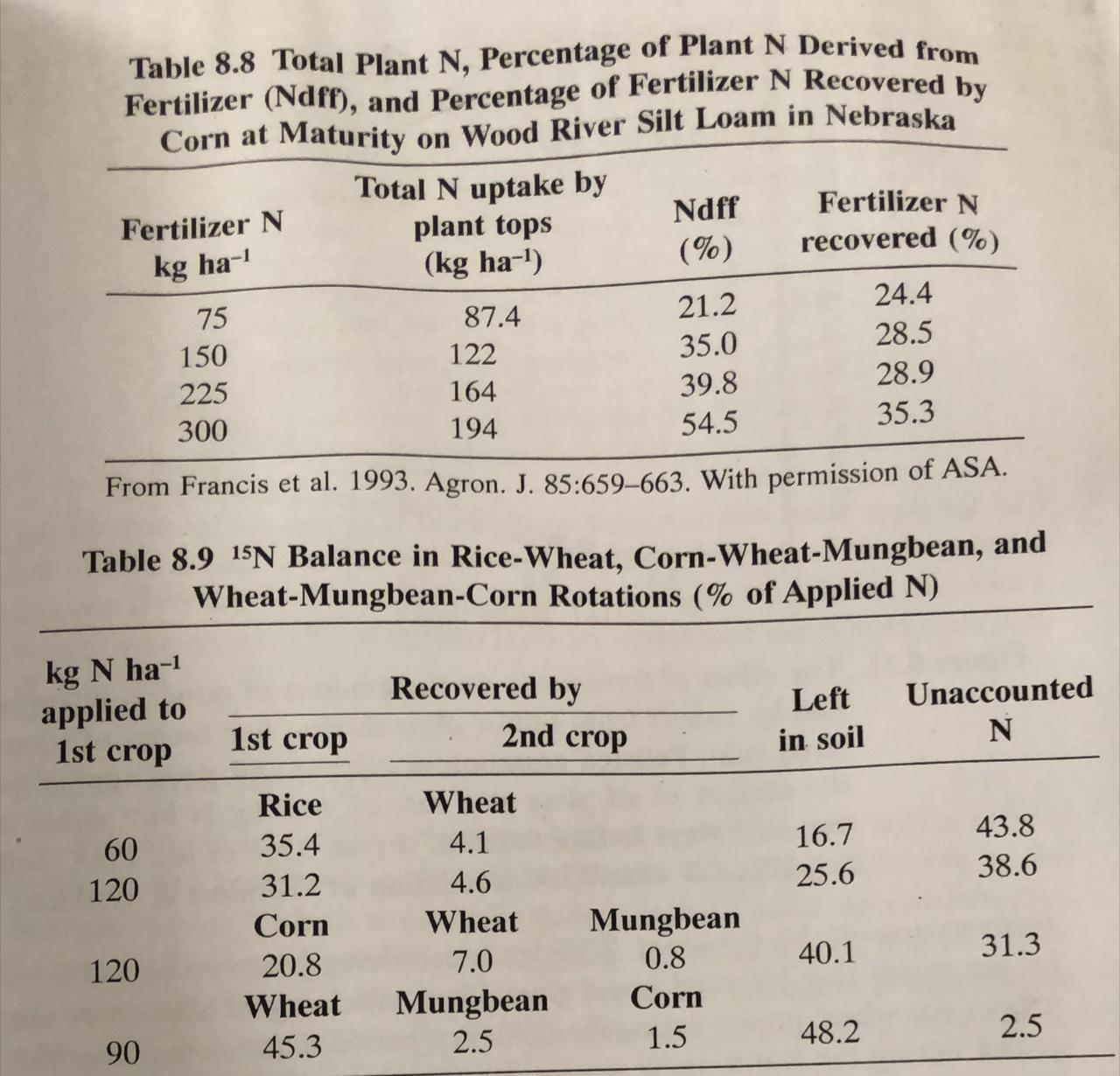


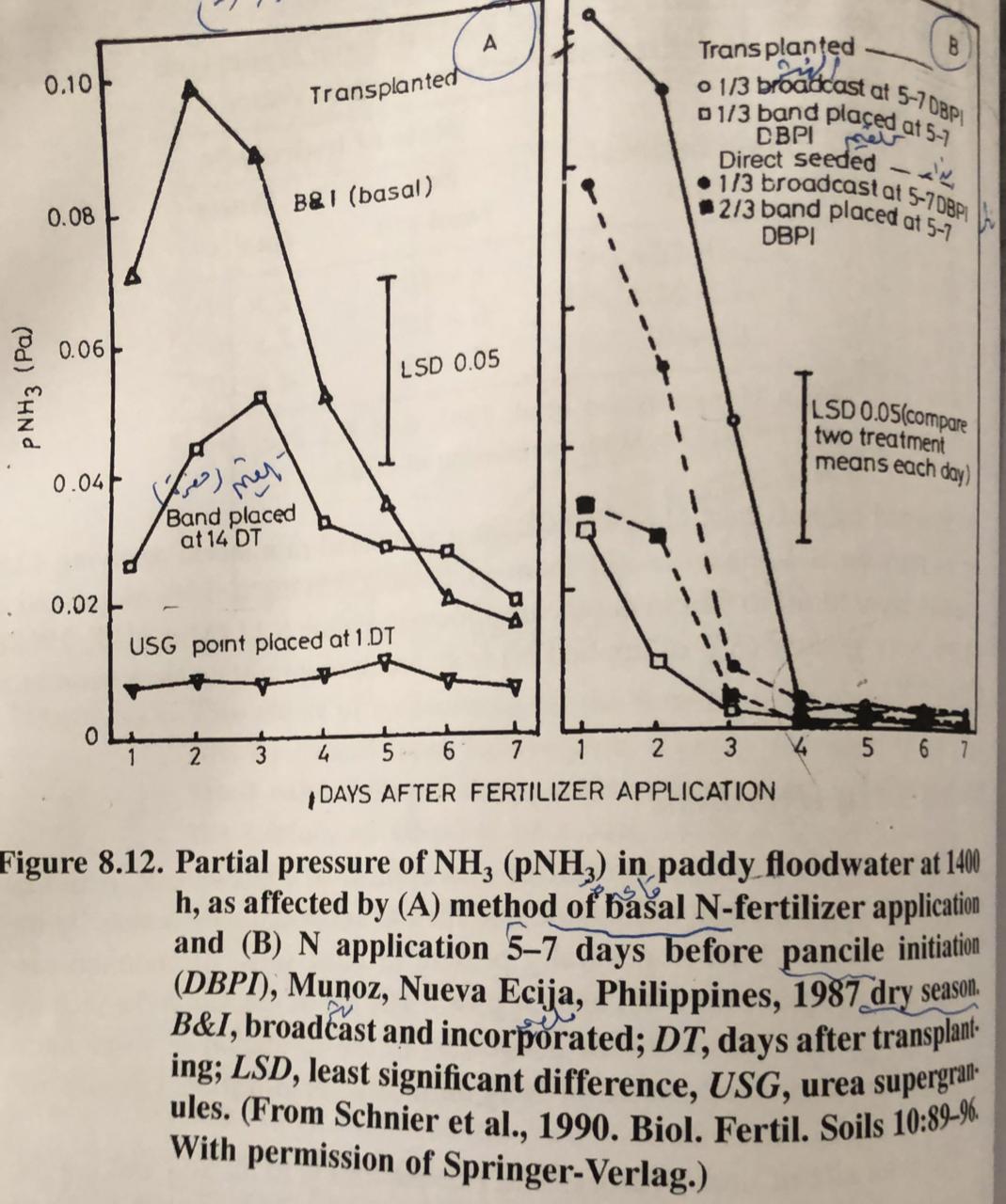
Data showed that N – recovery was greater with bromgrass at 55 than 110 kg h than corn crop due to better system root and biomass

For bromgrass .

(NH4)2SO4 and NH4NO3 were higher than Ca(NO3 )2 may refer to more ammomnia volatilization or leaching of nitrate fig. 8.10





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