

### **Topic 4: Self-Reliant Systems and Procedures**

### 4.1 Soil based Agriculture

### Developed By:





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# Objectives

### **Objective 01**

Understand the importance of soil nutrients for plant growth.

### **Objective 02**

Learn about nutrient cycles and their role in soil fertility.

### **Objective 03**

Explore the impact of soil pH on nutrient availability and plant health.

### **Objective 04**

Master effective soil sampling techniques.

### **Objective 05**

Recognize factors influencing sample collection.





# Objectives

### **Objective 06**

Familiarize with soil testing methods for nutrient analysis.

### **Objective 07**

Interpret soil test results to inform nutrient management decisions.

### **Objective 08**

Develop customized fertilization plans based on soil test data.

### **Objective 09**

Learn about the role and benefits as well as the evolution of Automated Fertilization Systems



# **Introduction to Soil Nutrients:**

**Overview of Essential Nutrients:** Soil serves as the primary medium for plant growth, providing essential nutrients necessary for their development.

### **Macronutrients:**

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S),

### **Micronutrients:**

- Iron (Fe)
- Manganese (Mn)
- Zinc (Zn)
- Copper (Cu)
- Boron (B)
- Molybdenum (Mo).









Each nutrient plays a unique role in various biochemical processes within plants, influencing their growth, development, and productivity.







# **Understanding Nutrient Cycles:**

Nutrients in the soil undergo cyclic processes known as nutrient cycles, involving interactions between soil, plants, and the environment. Key cycles include:

- Nitrogen cycle
- Phosphorus cycle
- Potassium cycle







# Nitrogen Cycle:

• Involves processes such as nitrogen fixation, nitrification, denitrification, and nitrogen mineralization, which collectively regulate the availability of nitrogen to plants.







# **Phosphorus Cycle:**

• Involves weathering of phosphorus-containing minerals, uptake by plants, and return to the soil through organic matter decomposition. Soil pH strongly influences phosphorus availability and cycling.







# **Potassium Cycle:**

 Involves the release of potassium from minerals, uptake by plants, and cycling through plant residues and soil organic matter. Soil texture and mineralogy influence potassium availability and cycling.







# **Understanding Nutrient Cycles:**

Understanding these cycles is crucial for maintaining soil fertility and preventing nutrient imbalances that can hinder plant growth.











# Importance of Soil pH:

Soil pH affects the amount of nutrients and chemicals that are soluble in soil water, and therefore the amount of nutrients available to plants. Some nutrients are more available under acid conditions while others are more available under alkaline conditions.







## Importance of Soil pH:









# Importance of Soil pH: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

### Acidic Soil (low pH)

At pH levels lower than 5.5, aluminum and manganese can become highly available to the point of being toxic. At similarly low pH levels, other elements like nitrogen, calcium, phosphorous, magnesium, and potassium become less available for absorption by plants.

### Slightly Acidic to Neutral Soil

Ideal soil conditions for most plants

### Alkaline Soil (high pH)

When the pH level of soil is above 7, elements like iron, zinc, copper, boron, phosphorous, and manganese also become less available for absorption by plants





# Importance of Soil pH:

- Most crops have specific pH preferences for optimal growth and nutrient uptake. For example, crops like potatoes and blueberries prefer acidic soils (pH 4.5-5.5), while others like alfalfa and peas thrive in neutral to slightly alkaline soils (pH 6.0-7.5).
- Soil pH influences nutrient availability by affecting chemical reactions and nutrient solubility. For instance, in acidic soils, aluminum and manganese toxicity may occur, limiting plant growth.
- Soil pH also influences microbial activity and soil structure, further impacting plant growth and soil health. Thus, maintaining the appropriate soil pH is essential for optimizing nutrient availability and promoting healthy plant growth.





# **Principles of Soil Sampling:**

- Effective soil sampling is essential for obtaining representative soil samples that accurately reflect the nutrient status of a field.
- Factors such as sampling depth, frequency, and location must be considered to ensure reliable results.
- Sampling depth typically ranges from 15-20cm for most crops, with multiple samples collected across the field to account for soil variability.









### **1.Composite Soil Sampling:**

- This method involves collecting soil samples from multiple locations within a specific area and combining them to create a composite sample representative of the entire area.
- Use a clean shovel or soil auger to collect soil samples from various spots across the area of interest.
- Collect samples at consistent depths (e.g., 6-8 inches for most crops) and avoid sampling from areas with obvious differences in soil type or management history.
- Mix the collected soil samples thoroughly in a clean bucket to create a composite sample.







### **1.Composite Soil Sampling:**

- Transfer a portion of the composite sample into a labeled plastic bag or container for submission to a soil testing laboratory or for on-site testing.
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- Locate spots randomly for drawing samples, by drowing "Z" or "N" shaped imaginary lines in the field.







### **1.Composite Soil Sampling:**

 Soils should not be collected from recently manured or fertilized/ limed fields.







- 2. Zigzag or W-shaped Sampling
- This method involves collecting soil samples in a zigzag or W-shaped pattern across the area of interest, ensuring thorough coverage and representation of the entire area.
- Begin at one corner of the area and collect soil samples at regular intervals along the zigzag or W-shaped path.
- Use a soil probe, auger, or hand trowel to collect samples at the desired depth.







- 2. Zigzag or W-shaped Sampling
- Combine the collected samples to create a composite sample, following the same procedure as described for composite soil sampling.
- This method provides good spatial coverage and is suitable for larger areas such as vegetable gardens or lawns.

















### 2. Zigzag or W-shaped Sampling









### 3. Grid Sampling

- Grid sampling involves dividing the area into a grid of equal-sized cells and collecting soil samples from each cell to assess spatial variability in soil properties.
- Determine the grid size based on the size of the area and the desired level of detail.
- Collect soil samples from the center of each grid cell at the specified depth using a soil probe or auger.







### 3. Grid Sampling

- Combine the collected samples to create a composite sample for each grid cell.
- Analyze the composite samples separately to evaluate spatial variations in soil properties across the area.









### 4. Depth-Based Sampling

- Soil properties can vary with depth, so collecting samples at different depths can provide valuable information about soil fertility and structure.
- Determine the desired sampling depths based on the root zone of the crops or plants of interest.
- Collect separate soil samples from each depth increment using a soil probe, auger, or hand trowel.
- Combine the samples from each depth increment to create composite samples for analysis.







### 4. Depth-Based Sampling

• Depth-based sampling is particularly useful for assessing nutrient distribution and root development in the soil profile.









### **Factors Influencing Sample Collection:**





Understanding these factors is crucial for determining the number of samples needed, as well as the spatial arrangement of sampling points to capture soil variability effectively.









**1.Understanding Nutrient Recommendations:** 

- Nutrient recommendations are guidelines that help farmers determine the optimal levels of essential elements required for plant growth and development.
- These recommendations are based on factors such as **soil type**, **crop** type, climate, and yield goals.
- Understanding these recommendations is essential for maximizing crop productivity while minimizing environmental impact.







### Soil Testing:

Soil tests provide valuable information about nutrient levels, pH, and other soil properties. This information guides nutrient recommendations tailored to specific soil conditions.

Different crops have varying nutrient requirements at different growth stages. Understanding the nutrient needs of specific crops is crucial for optimizing fertilizer applications.





### Crop Requirements:





### Yield Goals:





Desired crop yields influence nutrient recommendations. Higher yields often require increased nutrient inputs to meet the demands of the growing plants.

Nutrient recommendations should consider environmental factors such as leaching, runoff, and soil erosion to minimize nutrient losses and protect water quality.





### Environmental Considerations



### 2. Formulating Fertilization Plans:

- Formulating a fertilization plan involves selecting the right type and amount of fertilizers to meet crop nutrient requirements efficiently.
- A well-designed fertilization plan optimizes nutrient uptake, minimizes nutrient losses, and promotes sustainable farming practices.







**Steps in formulating a fertilization plan:** 





Monitor and Adjust 5

 $(\mathsf{pH})$ 









### **3. Integration of Organic Amendments**

- Organic amendments, such as compost, manure, and cover crops, play a vital role in improving soil health, enhancing nutrient availability, and promoting sustainable farming practices.
- Integrating organic amendments into nutrient management strategies helps reduce reliance on synthetic fertilizers, build soil organic matter, and support diverse microbial communities.









Effective nutrient management is essential for sustainable and productive agriculture. By understanding nutrient recommendations, formulating fertilization plans, and integrating organic amendments, farmers can optimize nutrient use efficiency, improve soil health, and support long-term agricultural sustainability.







Automated fertilization systems utilize technology such as:

- Soil sensors
- GPS
- Variable-rate technology to precisely apply fertilizers according to soil nutrient levels and crop requirements.

These systems can adjust application rates in real-time based on data collected from the field:

- Optimizing nutrient use efficiency
- Reducing the risk of over-application or under-application.









### Automated fertilization not only improves crop yields but also minimizes environmental pollution by reducing nutrient runoff and leaching.









### Role of Fertilization:

- Fertilization is a fundamental aspect of modern agriculture, vital for enhancing crop yield, quality, and overall productivity.
- By providing essential nutrients to plants, fertilization plays a crucial role in ensuring optimal growth, development, and resilience against environmental stresses.









### **Evolution of Fertilization:**

- Over the years, fertilization techniques have evolved significantly, transitioning from traditional manual methods to sophisticated automated systems.
- This evolution has been driven by advancements in technology, agricultural science, and the need for greater efficiency and sustainability in food production.









### **Benefits of Fertilization:**

- Automated fertilization systems offer numerous benefits compared to traditional approaches, including increased precision, efficiency, and resource utilization.
- Farmers can optimize fertilizer use, minimize wastage, and achieve better crop yields while reducing labor and operational costs.









# **Plant Nutrition and Fertilizers**

### Types of Fertilizers:

- **Organic:** Derived from natural sources, these fertilizers improve soil health and release nutrients slowly.
- **Inorganic:** Chemically manufactured, they provide immediate and precise nutrient availability for rapid plant growth.
- **Specialty blends:** Customized formulations that combine various components to meet specific plant and soil needs.







# **Plant Nutrition and Fertilizers**

- Each type has its unique composition, nutrient content, and release characteristics, making them suitable for different crops, soil types, and growth stages.
- Choosing the right fertilizer is essential for meeting plant nutrient requirements and optimizing crop performance.







# **Technologies for Automated Fertilization**

### **Technologies for Automated Fertilization**

### **Drip Irrigation Systems**:

- Deliver water and nutrients directly to the root zone of plants.
- Minimizing water wastage and nutrient runoff.
- Integrating fertilizers into drip systems allows for precise and uniform nutrient application.
- Improving fertilizer efficiency and plant uptake.







# **Technologies for Automated Fertilization**

### **Technologies for Automated Fertilization**

### **Fertigation Methods:**

- Involves the simultaneous application of water and fertilizers through irrigation systems.
- This method allows for precise control over nutrient delivery, enabling farmers to adjust fertilizer rates and compositions based on crop needs and growth stages.







# **Technologies for Automated Fertilization**

### **Technologies for Automated Fertilization**

### **Precision Agriculture Tools:**

- GPS-guided systems and remote sensing offer valuable insights into crop health and nutrient status.
- By mapping spatial variability in soil properties and plant health, these tools help optimize fertilization decisions and resource allocation, leading to more efficient and sustainable farming practices.







# Integration of Sensors and Control Systems

### **Role of Sensors**

• Sensors play a crucial role in automated fertilization systems by providing real-time data on soil conditions, nutrient levels, and crop performance.

Examples of Sensors used to monitor plant health and nutrient status, enabling timely adjustments to fertilization programs:

- Soil moisture sensors
- Nutrient probes
- Leaf sap analyzers









# Integration of Sensors and Control Systems

### **Actuators for Nutrient Delivery**

- Actuators control the flow and distribution of fertilizers in automated systems based on sensor inputs.
- Solenoid values, pumps, and injectors are commonly used actuators for adjusting fertilizer application rates and timings, ensuring accurate nutrient delivery while minimizing waste.







# Integration of Sensors and Control Systems

### **Control Algorithms**

- Control algorithms govern the operation of automated fertilization systems, optimizing nutrient delivery based on sensor feedback and predefined setpoints.
- They are employed to regulate fertilizer dosing, maintain desired nutrient concentrations, and adapt to changing environmental conditions: - PID controllers
  - -Fuzzy logic algorithms
  - -Machine learning techniques







# Implementation Strategies

### **System Selection:**

- Crop type
- Field size
- Soil characteristics
- Budget constraints



Drip irrigation systems, fertigation equipment, and precision agriculture tools should be chosen based on their suitability for specific farming contexts and objectives.





# Implementation Strategies

### **Fertilization Schedules:**

Developing customized fertilization schedules requires careful planning and monitoring of crop nutrient requirements.

- Soil testing
- Plant tissue analysis
- Sensor data are used to determine optimal fertilizer rates, timings, and formulations, ensuring efficient nutrient uptake and crop performance.







# Implementation Strategies

### **Troubleshooting:**

Troubleshooting skills are essential for identifying and resolving issues that may arise during the implementation of automated fertilization systems.

Common problems that can impact system performance and crop productivity:

- Clogged emitters
- Sensor malfunctions
- Calibration errors









# **Economic and Environmental Considerations**

- Cost-Benefit Analysis: Factors like initial investment, operational expenses, potential yield, and labor savings determine the return on investment and longterm profitability.
- Environmental Impact: Automated fertilization systems reduce nutrient leaching, fertilizer runoff, and greenhouse gas emissions, promoting sustainable agriculture and ecosystem conservation.
- Regulatory Compliance: Farmers must follow nutrient management plans, water quality regulations, and environmental permits to protect soil, water, and air quality.







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# THANK YOU

