

Nutrient Use Efficiency for Sustainable Agriculture

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Introduction

Sustainable agriculture aims to produce enough food for a growing population while protecting natural resources and the environment. One of the most important aspects of sustainable farming is Nutrient Use Efficiency (NUE), which refers to the ability of crops to absorb and utilize nutrients effectively for growth and yield. Improving nutrient use efficiency helps farmers increase productivity, reduce production costs, and minimize environmental pollution.

What is Nutrient Use Efficiency?

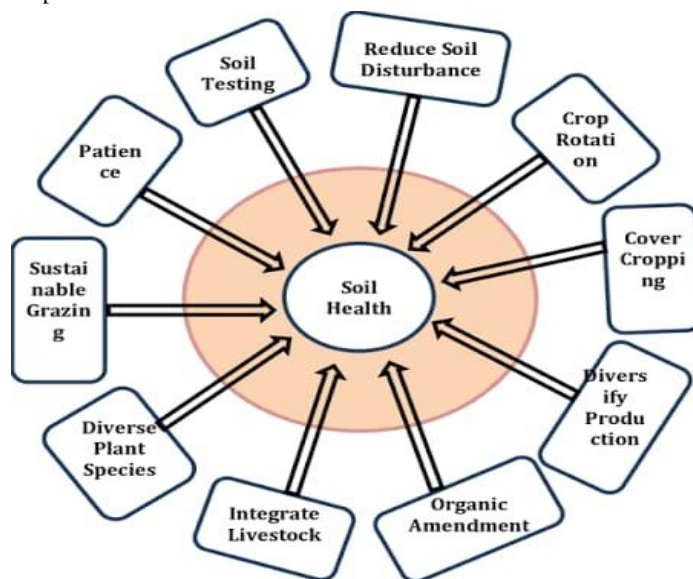
Nutrient Use Efficiency is the measure of how effectively plants take up nutrients such as nitrogen (N), phosphorus (P), and potassium (K) from the soil and convert them into biomass and crop yield. Higher NUE means that more of the applied nutrients are used by the crop, while less is lost through leaching, runoff, volatilization, or soil erosion.



Nutrient Efficiency Ratio

Nutrient efficiency ratio (NER) is a useful tool for assessing the overall nutrient use efficiency of crops, as it takes into account the interactions between multiple nutrients and the impact of nutrient imbalances on plant growth. NER is a measure of how efficiently plants use multiple nutrients simultaneously to produce biomass. Calculating NER involves dividing the dry matter yield of a plant by the sum of the amounts of multiple nutrients taken up by the plant, such as nitrogen, phosphorus, and potassium. A higher NER indicates that the plant is using nutrients more efficiently to produce biomass, while a lower NER suggests that the plant is not using the nutrients

efficiently and may be limited by one or more nutrients. The nutrient efficiency ratio can be used to evaluate the effectiveness of nutrient management practices and to identify opportunities for improving nutrient use efficiency in plants.



Components of Nutrient Use Efficiency:

1. **Uptake Efficiency (Uptake NUE):** The proportion of nutrients taken up by the plant from the soil compared to the total amount available in the soil. Efficient root systems, soil health, and appropriate nutrient management contribute to higher uptake efficiency.
2. **Internal Efficiency (Internal NUE):** The efficiency with which the plant utilizes the absorbed nutrients for growth and yield. It is the ratio of the plant's biomass or yield to the amount of nutrient absorbed.
3. **External Efficiency (External NUE):** The efficiency of nutrient utilization from external sources such as fertilizers. It considers the proportion of applied nutrients that are effectively taken up by plants and contribute to yield.

Importance of Nutrient Use Efficiency

Improving nutrient use efficiency offers several benefits:

- Increases crop yield and quality.
- Reduces fertilizer costs for farmers.

- Minimizes nutrient losses to the environment.
- Prevents water pollution caused by nutrient runoff.
- Reduces greenhouse gas emissions from excessive fertilizer use.
- Maintains long-term soil fertility and health.
- Supports sustainable agricultural production.

Benefits of Nutrient Use Efficiency (NUE) in Agriculture

1. **Higher Crop Yields** -Plants absorb and utilize nutrients more effectively, leading to increased productivity.
2. **Reduced Fertilizer Costs** -Efficient nutrient use means less fertilizer is needed to achieve the same or better yields, lowering production costs.
3. **Improved Crop Quality** Produces healthier crops with better size, color, nutritional value, and market value.
4. **Enhanced Soil Health** Prevents nutrient buildup and helps maintain balanced soil fertility over time.
5. **Lower Environmental Pollution** Reduces nutrient losses through leaching, runoff, and greenhouse gas emissions, protecting water and air quality.
6. **Better Water Use Efficiency** Well-nourished plants use water more effectively and tolerate drought conditions better.
7. **Increased Resistance to Stress** Crops with balanced nutrition are more resilient to pests, diseases, and environmental stresses.
8. **Higher Farmer Profitability** Combines lower input costs with higher yields and better-quality produce, increasing net income.
9. **Sustainable Agriculture** Conserves natural resources and supports long-term agricultural productivity.
10. **Reduced Nutrient Losses** Minimizes nitrogen volatilization, phosphorus fixation, and nutrient leaching, improving fertilizer effectiveness.

Practices to Improve Nutrient Use Efficiency

- Apply the **4R Nutrient Stewardship** principles:
 - Right source
 - Right rate
 - Right time
 - Right place
- Conduct regular soil testing.
- Use precision agriculture technologies.
- Apply organic manures and biofertilizers where appropriate.

- Use controlled-release fertilizers or fertigation.
- Select high nutrient-efficient crop varieties.

Practices to Improve Nutrient Use Efficiency

1. **Soil Testing:** Analyzing soil nutrient status helps apply fertilizers according to crop needs.
2. **Balanced Fertilization:** Supplying the correct proportion of essential nutrients ensures healthy crop growth.
3. **Integrated Nutrient Management (INM):** Combining organic manures, compost, crop residues, biofertilizers, and chemical fertilizers improves nutrient availability.
4. **The 4R Nutrient Stewardship:** Applying the right source of fertilizer, at the right rate, at the right time, and in the right place.
5. **Precision Agriculture:** Using GPS, sensors, drones, and smart technologies to apply nutrients accurately.
6. **Crop Rotation and Legumes:** Including leguminous crops helps fix atmospheric nitrogen and improves soil fertility.
7. **Efficient Irrigation:** Proper water management enhances nutrient uptake and reduces nutrient losses.
8. **Use of Enhanced-Efficiency Fertilizers:** Slow-release and controlled-release fertilizers provide nutrients gradually, improving crop utilization.

Challenges

Despite its benefits, improving nutrient use efficiency faces several challenges, including:

- Imbalanced fertilizer application.
- Poor soil health.
- Limited farmer awareness and training.
- Climate change affecting nutrient availability.
- High cost of advanced technologies.

Conclusion

Nutrient Use Efficiency is a key component of sustainable agriculture. By adopting scientific nutrient management practices, farmers can produce higher yields while conserving natural resources and protecting the environment. Improving nutrient use efficiency not only benefits farmers economically but also contribute to food security, environmental sustainability, and the well-being of future generations. Governments, researchers, and farmers must work together to promote efficient nutrient management for a more sustainable agricultural system.
