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Nitrogen: An Essential Element in Plant Nutrition and Growth

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Nitrogen is one of the most crucial basic non-metal nutrients that plants need in vast quantities for growth and nourishment. It is the element found in nature that is most broadly spread. The hydrosphere, lithosphere, and atmosphere are where it happens. Lithospheric nitrogen is mainly derived from the soil, and only a very small portion of this nitrogen is directly available to plants. The two main forms of nitrogen found in soils are nitrate (NO_3) and ammonium (NH_4) ions. It is well known that nitrogen is a highly mobile element that is exchanged by living things, the soil, and the atmosphere. However, the N-turnover is influenced by a few variables and processes i.e. physio-chemical and other are biological (Das, 2022).

Most of the soil nitrogen is found in organic soil combinations. The soil's moisture regime determines how these organic forms of nitrogen decompose into inorganic ammonical (NH_4) forms. The rate of transformation from organic to NH forms is extremely sluggish in saturated or waterlogged soil. Only when the organic form has been transformed into the inorganic form may rice potentially use organic nitrogen forms as a reserve. However, higher plants cannot use nitrogen in its elemental form. Numerous procedures, such as the fixation of nitrogen by cyanobacteria, ammonia, nitrate, and other soil microorganisms such as Rhizobia and Azospirillum, and the fixation of nitrogen because of various industrial operations during the creation of synthetic nitrogenous fertilizers, etc (Das, 2022).

Table 1: Properties of Nitrogen

Symbol	N
Block	p-block
Electron Configuration	[He] $2s^2$ $2p^3$
Atomic Number	7
Atomic Mass	14.01 g/mol
Constitution in Earth's Atmosphere	78%
Melting Point	62.23 K (N_2)
Boiling Point	77.355 K (N_2)
Density	1.2506 g/L at 0°C

Role of Nitrogen in Plant Growth

- It is a necessary part of protoplasm, proteins, and chlorophyll.
- It is a component of co-enzymes, pyrimidines, purines, and porphyrines.
- Enhances the plant's ability to convert sunlight into energy through photosynthesis.
- Supports symbiotic relationships with nitrogen-fixing bacteria in the soil.
- It is essential for carbohydrates utilization within plants.
- It promotes the development and expansion of roots.

- Supports rapid cell division and tissue growth, essential for plant development.
- Crucial for overall plant metabolism and health.
- It promotes above-ground vegetative growth and gives the leaves a rich green hue.
- Involved in ATP production, which provides energy for various cellular activities.
- It controls the utilization of phosphorus, potassium, and other elements to a significant extent.
- It results in succulence, a desirable feature that is especially present in leafy crops including beets, radishes, lettuce, and spinach (Singh, 2020).

Table 2: Demand for Nitrogen in various Crops

Crops with high demand for Nitrogen	Crops with low demand for Nitrogen
✓ **Cereal Crops:** Maize, Rice, Wheat ✓ **Leafy Vegetables:** Cabbage, Kale, Lettuce, Spinach ✓ **Root Vegetables:** Potato, Carrot, Beet.	✓ **Legume crops:** Peas, Lentils, Beans, etc. ✓ **Bulbs:** Onion and Garlic.

Transformation of Nitrogen in Soils

The nitrogen in fertilizer and soil can vary through several mechanisms. Numerous processes, including nitrogen fixation, immobilization, and mineralization (Das, 2022).

Nitrogen Fixation: The atmospheric nitrogen (N_2O) is transformed into molecules that plants may utilise, such as ammonia (NH_3) or similar compounds. This can happen abiotically through industrial processes like the Haber-Bosch process and lightning, or biologically through nitrogen-fixing bacteria like Rhizobium in legume root nodules.

Mineralization: Microorganisms convert organic nitrogen from dead plants, animals, or animal waste (such as manure) into ammonium (NH_4). Nitrogen is released by this process in a form that the soil can further change or absorb by plants.

Nitrification: Ammonium oxidation: Nitrifying bacteria, including Nitrosomonas, oxidize ammonium (NH_4) to nitrite (NO_2). Nitrite Oxidation: Bacteria such as Nitrobacter further oxidize nitrite to produce nitrate (NO_3), a form that plants can readily absorb.

Assimilation: Nitrate (NO_3) and ammonium (NH_4) are absorbed by plants from the soil and utilized for the synthesis of proteins, nucleic acids, and other nitrogen-containing molecules that are essential for growth.

Denitrification: Certain bacteria, such as Pseudomonas, can convert nitrate (NO_3) back into nitrogen gas (N_2) or nitrous oxide (N_2O), which are then discharged into the atmosphere when anaerobic conditions (low oxygen settings) are met. By returning nitrogen to the atmosphere, this mechanism decreases the amount of nitrogen that is available in the soil yet completes the nitrogen cycle.

Volatilization: Particularly in alkaline soils, ammonium in the soil has the potential to be transformed into ammonia gas and released into the atmosphere.

Leaching: Rainwater can remove nitrate (NO_3) from the soil, particularly in sandy soils. This can result in nitrogen loss and possible water contamination.

Immobilization: By absorbing nitrogen into their own

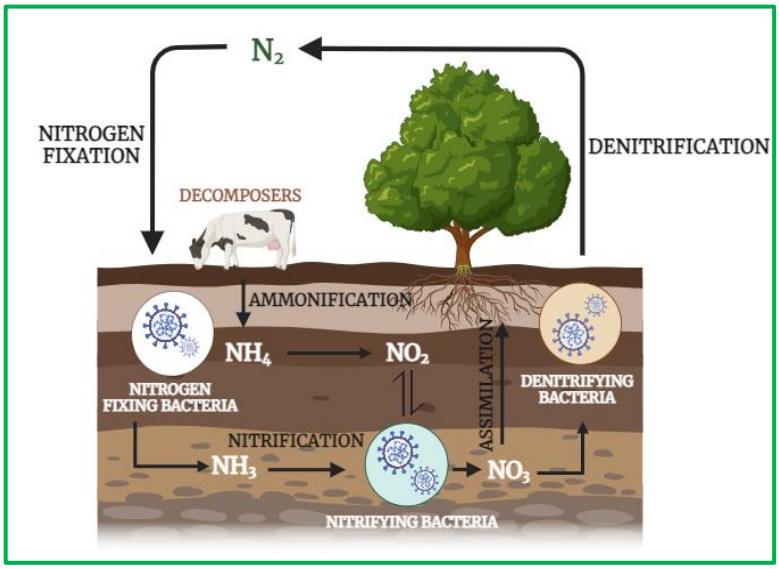

Figure 1: Nitrogen Cycle

biomass, soil microorganisms can "lock up" nitrogen temporarily, preventing plants from absorbing it until the bacteria perish and break down.

Deficiency Symptoms of Nitrogen in Plants

- Yellowing of older leaves (chlorosis) due to insufficient chlorophyll.
- Stunted growth and weak stems.
- Reduced leaf size and pale green color in the entire plant.
- It promotes abundant vegetative growth while delaying reproductive growth. Frequently, the flower bud becomes pale and sheds too soon.
- A plant that is nitrogen-starved ripens too soon and produces a low-yield crop; cereal kernels and other crops' seeds do not grow to their full size but instead become thin and light in weight.
- Root development is negatively impacted (Singh, 2020).

Conclusion

Nitrogen is an essential nutrient for the growth and nourishment of plants, and it is involved in many biological processes. Nitrogen is a key component of amino acids and is required for the creation of proteins, which are vital for the structure and operation of cells. Furthermore, it is a component of chlorophyll, a pigment that helps plants absorb sunlight for photosynthesis. This mechanism, which enables plants to grow and develop, is essential to the creation of energy. Nitrogen is necessary for the synthesis of nucleic acids, such as DNA and RNA, which facilitate the transfer of genetic information and cell division. Additionally, it is a part of ATP, or adenosine triphosphate, which is a cellular energy currency that facilitates the transmission of energy during metabolic activities. Sufficient nitrogen encourages rapid vegetative growth, particularly in the leaves and stems, improving the general health and productivity of the plant. On the other hand, a lack of nitrogen causes weak stems, stunted growth, limited flowering and fruiting, and chlorosis, or the yellowing of older leaves. Nitrogen is normally absorbed by plants as nitrate (NO_3^+) or ammonium (NH_4^+), but excess nitrogen needs to be controlled to avoid nutrient leaching, contaminated water, or even harm to the health of the plants. Because of its vital significance, nitrogen is a key component of agriculture and sustained crop production.

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