# THE ROLE OF FERTILIZER

## Why fertilize

Soils need fertility maintenance. Soil is a natural body of finely divided rocks,minerals and organic matter. Sand, silt, clay and organic matter help provide tilth, necessary aeration and favorable water intake rates, but they seldom maintain adequate plant food to sustain continuous healthy plant growth.

## What is fertilizer?

There are 17 elements that are known to be essential for plant growth and development. Fertilizers (also called plant food elements) materials produced to supply these elements in a readily available form for plant use.

| Source | | |
|---|---|---|
| **Air and Water** | **Soil &Fertilizer** | |
| Carbon | Nitrogen | Magnesium |
| Hydrogen | Phosphorus | Manganese |
| Oxygen | Potassium | Molybdenum |
| | Sulfur | Copper |
| | Zinc | Calcium |
| | Iron | Chlorine |
| | Boron | Nickle |

Three of the 17 essential elements, carbon, hydrogen and oxygen, are taken primarily from the air and water. Oxygen and hydrogen are obtained by plants from water. Carbon and hydrogen are taken in by the leaves from the air. The other 14 elements utilized by the plant must come from the soil or from added fertilizer materials.

Crop removal of these elements, plus leaching, volatilization and erosion causes the soil fertility to be continually reduced. Turf and landscape plants will have poor color (yellow-green to yellow), poor plant density allowing weed invasion and low plant vigor which increases plants susceptibilities to disease and insect damage.

Soil productivity can be maintained by well managed, scheduled applications of multiple element fertilizers.

## Why doesn't fertilizer have 100% plant food?

A fertilizer 16-6-8 analysis adds up to 30% plant food or 30 pounds per hundred pounds of material. What is the other 70%? It is not a filler; it is the way the plant food is chemically compounded so plants can utilize it.

Plants can't use elemental nitrogen (N), they only take up nitrogen when it is in the $NO_3$ or $NH_4$ form. This means that for each part of nitrogen you have three parts of oxygen with ($NO_3$) or four parts of hydrogen with ($NH_4$). When nitrogen is in a compound which is available to plants, nitrogen is only part of the compound. The same is true with phosphorus and the other elements. Phosphorus is absorbed by plants as $H_2PO_4-$, $HPO_4 =$ or $PO_4 =$ depending upon soil pH.

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If fertilizers were in the elemental form, they would be difficult to handle:

- Elemental **nitrogen (N)** – a colorless inert gas that could drift off into the air.
- Elemental **phosphorus (P)** – catches fire spontaneously when exposed to the air. It is actually poisonous to plants in concentrated forms.
- Elemental **potassium (K)** – placed in contact with water it will catch fire, explode and decompose into a strong caustic solution.

## Functions of the 14 elements obtained from the soil and added fertilizer

### A. Primary Plant Food Elements

**Nitrogen | Phosphorus | Potassium**

Plants rapidly utilize these elements and unfertilized soils normally cannot provide them in quantities needed for best plant growth.

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**Nitrogen (N)**

1. Promotes rapid vegetative growth (leaf and stems) hastening recovery after mowing and imparting vigor to the turf.
2. A vital element in the formation and function of chlorophyll, the key ingredient imparting dark green color.
3. Synthesizes amino acids which in turn form protein.
4. Regulates the uptake of other nutrients.
5. Basic ingredient of vital compounds – Nucleic acid and enzymes.

**Phosphorus (P)**

1. Stimulates early root formation and growth – gets plants off to a good start and forms a root filter system in the soil to efficiently pick up the other available plant nutrients and water. Improves the strength and stamina of the plant.
2. Hastens maturity (conversion of starch to sugar).
3. Stimulates blooming and seed development.
4. Causes energy transformation and conversion processes in which sugars are converted to hormones, protein and energy to grow new leaves and fruit.
5. Forms nucleic acids (DNA and RNA).
6. Vital for photosynthesis (greening for plants).
7. Essential for cell division.

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**Potassium (K)**

1. Aids in the development of stems and leaves.
2. Increases disease resistance and hardiness which helps wearability.
3. Strengthens cell walls, causing grass to stand up and reduces lodging.
4. Affects water intake by plant cells–plants with inadequate potassium may wilt in the presence of ample moisture.
5. Acts as a catalyst in Iron uptake.
6. Essential to the formation and translocation of protein, starches, sugar and oil–improving the size and quality of fruit, grains and tubers.

**Phosphorus fertilizer**

## B. Secondary Plant Food Elements

### Calcium | Magnesium | Sulfur

They are used in somewhat less quantities than the primary elements, but they are just as essential for plant growth and quality.

### Calcium (Ca)

1. Calcium is an essential part of cell wall structure and must be present for the formation of new cells.
2. Deficiency of calcium causes weakened stems and premature shedding of blossoms and buds.

### Magnesium (Mg)

1. Essential for photosynthesis (greening of plant).
2. Activator for many plant enzymes required in growth process.

### Sulfur (S)

1. A constituent of three amino acids and is therefore essential in the formation of protein.
2. Helps maintain green color in plants.
3. Improves alkaline soils.
4. Helps compacted soils–making them loose and allowing better water penetration.

Sulfur Note –There are commonly two types of sulfur applied to plants and soils: sulfate sulfur ≠ ($SO_4$); elemental sulfur (S)

**Sulfur**

### Sulfate Sulfur ($SO_4$)

Sulfate sulfur ($SO_4$) is the form taken up for plant food. Many plants require as much sulfur as phosphate in their growth processes.

Sulfate Sulfur ($SO_4$) is contained in gypsum ($CaSO_4$) and other sulfate fertilizers–ammonium sulfate, ammonium phosphate sulfate and many turf fertilizers.

Gypsum ($CaSO_4$) will help reclaim alkali soils and make them loose and friable. Alkali soils contain sodium which causes soil to disperse, puddle and seal up. The free calcium from gypsum will replace the sodium on the clay particle and allow the sodium to be leached out of the soil.

It also causes the small soil particles to flocculate (join together in small crumbs), leaving space between them for air and water movement.

### Elemental Sulfur (S)

Elemental sulfur (S) will convert to sulfate sulfur in the soil. This reaction can be slow, depending upon the sulfur particle size and the soil conditions. Once it has converted to sulfate sulfur ($SO_4$), it is available to the plant. If the soil contains calcium, it can form gypsum in the soil and be used for reclamation of alkaline soils.

Elemental sulfur will lower the pH of the soil at the location of the pellet as it converts to sulfate. (See the article on turf and sulfur).

## C. Micronutrients

### Iron | Zinc | Manganese

Even though micronutrients are used by plants in very small amounts, they are just as essential for plant growth as large amounts of primary and secondary nutrients. They must be maintained in balance in order for all nutrients and water to be used efficiently.

On turf grass there are three micronutrients that are particularly important in order to maintain green color and plant vigor :

### Iron (Fe)

Yellowing of grass (iron chlorosis) is often due to iron deficiency. Iron is required for the formation of chlorophyll in the plant cell (causes turf to maintain a healthy green color). It serves as a catalyst for biological processes such as respiration, symbiotic fixation of nitrogen and photosynthesis.

Applications of iron can correct iron deficiency, but it may be temporary in high pH soils, due to tie up with calcium. This may require acidification of the soil with elemental sulfur or the use of ammonium forms of nitrogen or some other acidification agents. As ammonium converts to nitrate in the soil, it has an acidifying effect. This acidifying effect makes iron and many other elements more available in high pH soils.

### Zinc (Zn)

Zinc is an essential component of several plant enzymes. It is a part of auxins and controls the synthesis of indoleacetic acid which regulates growth compounds. Zinc also affects the intake and efficient use of water by plants.

### Manganese (Mn)

Manganese serves as an activator for enzymes in plants. Without manganese, the plants cannot use the iron which they have absorbed. It assists the iron in chlorophyll formation which causes yellowish turf to green up.

**Manganese**

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# TURF & SULFUR

Sulfur has been recognized as one of the many elements required for plant growth for nearly 130 years. Deficiencies of this plant nutrient were identified as early as 1900 on certain soils in the Pacific North-western states. In Canada, this deficiency was first discovered in 1927 on some soils in Alberta. In spite of these early records of the need for sulfur, it has received only limited attention until quite recently.

Interest in sulfur as a plant nutrient has increased greatly in the past few years, partly because reports of sulfur deficiency throughout the world are becoming more frequent and extensive. The main reasons for greater occurrence of sulfur deficiencies are:

1. Increased use of high analysis, essentially sulfur-free fertilizers.
2. Decreased use of sulfur as a fungicide and insecticide.
3. Increased crop yields which require larger amounts of all of the essential plant nutrients.
4. Increased consumption of low sulfur fuels and increased emphasis on control of air pollution.
5. Increased ability to identify soils low in sulfur.

**Sulfur's role in the plant.**

Sulfur is required by the plant for:

1. The synthesis of the amino acids, cystine, cysteine, methionine and hence for protein elaboration.
2. The activation of certain proteolytic enzymes such as the papainases.
3. The synthesis of certain vitamins (biotin and thiamin or vitamin B1), glutathione and of coenzyme A.
4. The formation of the glucoside oils found in onions, garlic and cruciferous plants.
5. The formation of certain disulphide linkages which are associated with the structural characteristics of protoplasm. The concentration of phydril. (-SH) groups in plant tissues has also been shown to be related to increased cold resistance in some species.

   Sulfur was recently shown to be present in the nitrogenase enzyme system which is involved in the fixation of nitrogen by micro-organisms.

   In certain situations free-living nitrogen-fixing organisms in the soil and the nodule bacteria in legumes will make significant contributions to the nitrogen supply soils.

Nitrogen and sulfur requirements are closely linked because both are required for protein synthesis. Plant protein contains about 1% S and 17% N. The need for sulfur fertilization often depends upon the supply of N and other nutrients and fertilization at high rates with these elements may induce a sulfur deficiency.

## Why is sulfur important?

### Greening of Turf

In the absence of sulfur, turfgrass exhibits a chlorosis that frequently occurs as an intense yellow color. In mild cases one may think of nitrogen deficiency or even iron deficiency.

On the positive side, we find that sulfur enhances color, density and growth. Sulfur helps nitrogen (N) to be used efficiently. There seems to be a direct relationship with nitrogen. The turfgrass fertilized with the higher quantities of nitrogen show increased response to sulfur. It has been reported that when 12 pounds of nitrogen are used, there is a requirement for 8 pounds of potassium oxide and 3.45 pounds of sulfur.

The net effects of adequate sulfur in combination with N, P and K are several:

1. Better decomposition of residues (thatch).
2. Stimulation of soil microorganisms.
3. Improved color, density and composition of turfgrass.
4. Greater drought tolerance.
5. Improved winter hardiness.

## Sulfur reduces disease in turf.

Well-documented studies by Goss, Gould and others in the Pacific Northwest reveal some very convincing reasons for applying sulfur along with nitrogen, phosphorus and potassium. Adequate sulfur reduced *Fusarium* patch in turfgrass by 86%.

This property of controlling disease really should cause no great surprise because we have known this about sulfur for a long time. The surprising thing is that so many of us have forgotten it or have not put the knowledge to use.

Another turfgrass disease that has been checked and controlled to a large degree with sulfur is *Ophiobolus* patch.

When Merion Kentucky Bluegrass is short of sulfur, it is much more susceptible to powdery mildew.

Dollarspot fungus in warm-season grasses in Florida was reduced by the use of sulfur in fertilizers. This may be a bit hard for many to believe, but data from the Pacific N.W. shows that adequate sulfur prevented *Poa annua* from infesting bentgrass turf. At the same time the blue-green algae was reduced significantly.

Perhaps some of the advantages found in using adequate sulfur come from the fact that turf is rendered more vigorous, an obvious sign of healthier grass. Healthy turf resists injuries and recovers faster when injury occurs.

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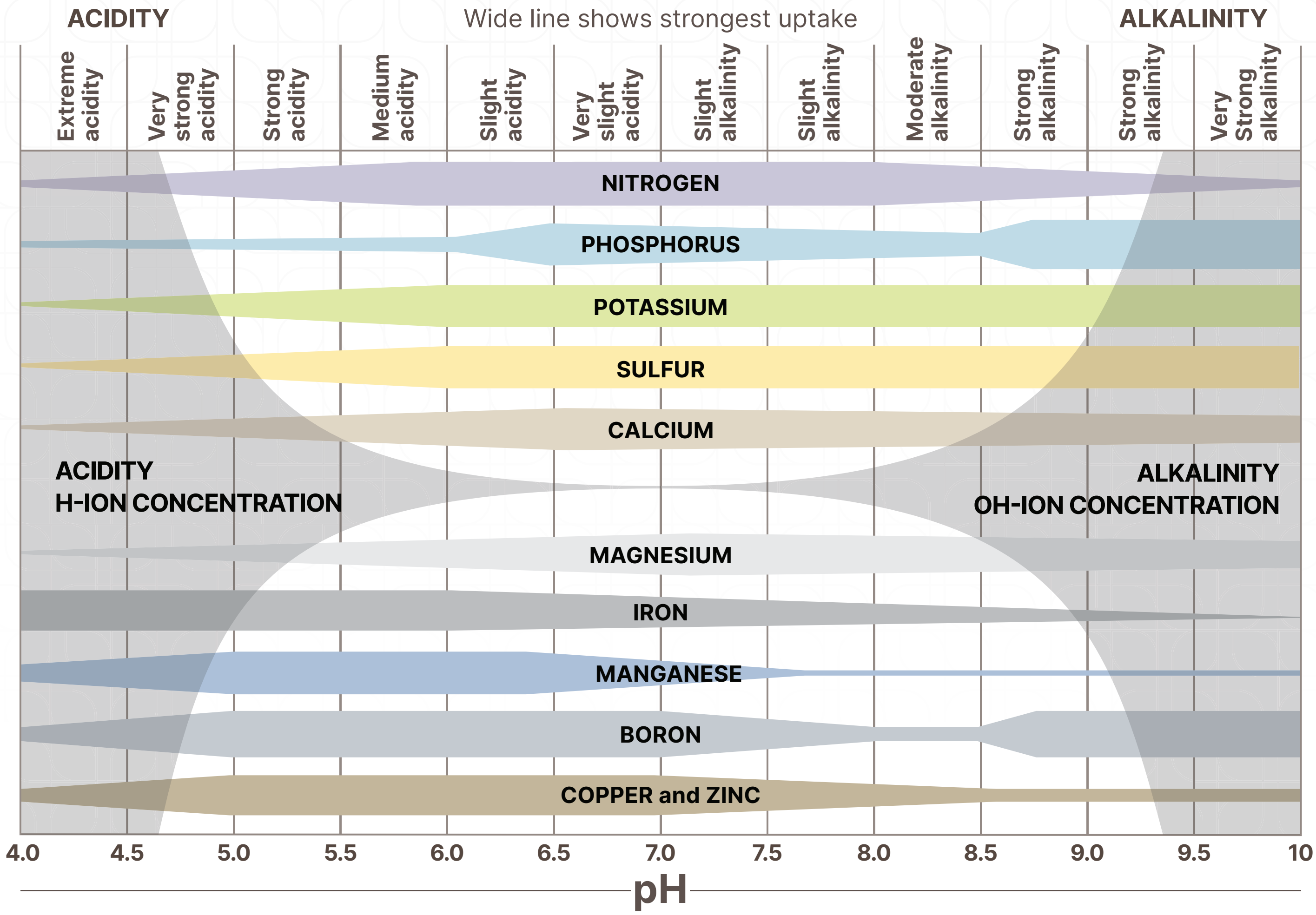
# SOIL UPTAKE OF NUTRIENTS

In relations to acidity or alkalinity




## MATERIALS USED FOR CORRECTING ALKALI

| Material | Chemical Formula | Active Ingredients % | Combined Sulfur% | Lbs. necessary to equal 1Lb. of sulfur |
|---|---|---|---|---|
| Gypsum | $CaSO_4$ $2H_2O$ | 65-95 | 18.6 | 5.38 |
| Soil Sulfur | S | 99 | 99 | 1 |
| Sulfuric Acid | $H_2SO_4$ | 95 | 31 | 3.2 |
| Lime Sulfur Solution | CaSx | 29 | 22 | 4.54 |

## MATERIALS USED FOR CORRECTING ACIDITY

| Material | Chemical | Equivalent $CaCO_3$ | Source |
|---|---|---|---|
| Limestone | $CaCO_3$ | 95% | Natural limestone deposits |
| Hydrated Lime | $Ca(OH)_2$ | 120% | Limestone burned with steam |
| Burned Lime | CaO | 150% | Limestone burned in kiln |
| Dolomite | $CaCO_3MgCO_3$ | 110% | Natural mineral deposit |

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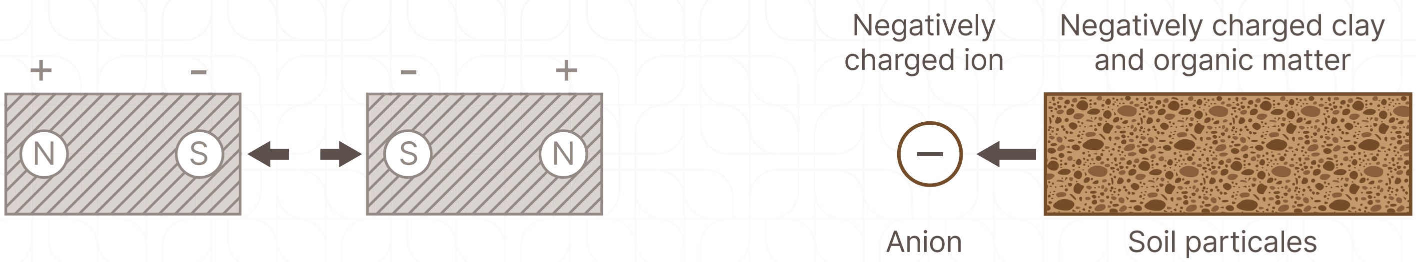
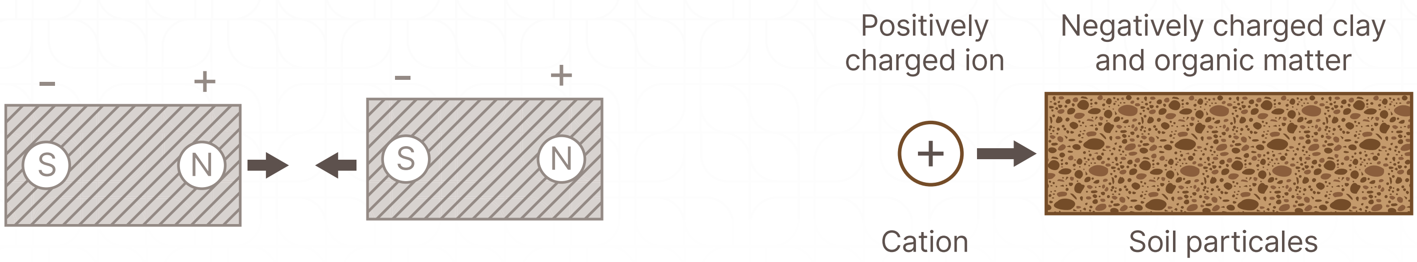
# HOW SOIL HOLDS and SUPPLIES NUTRIENTS to PLANTS




**1. Like poles** of magnets **repel** each **other**

Similarly

Ions and soil particles with **like charges repel** each other

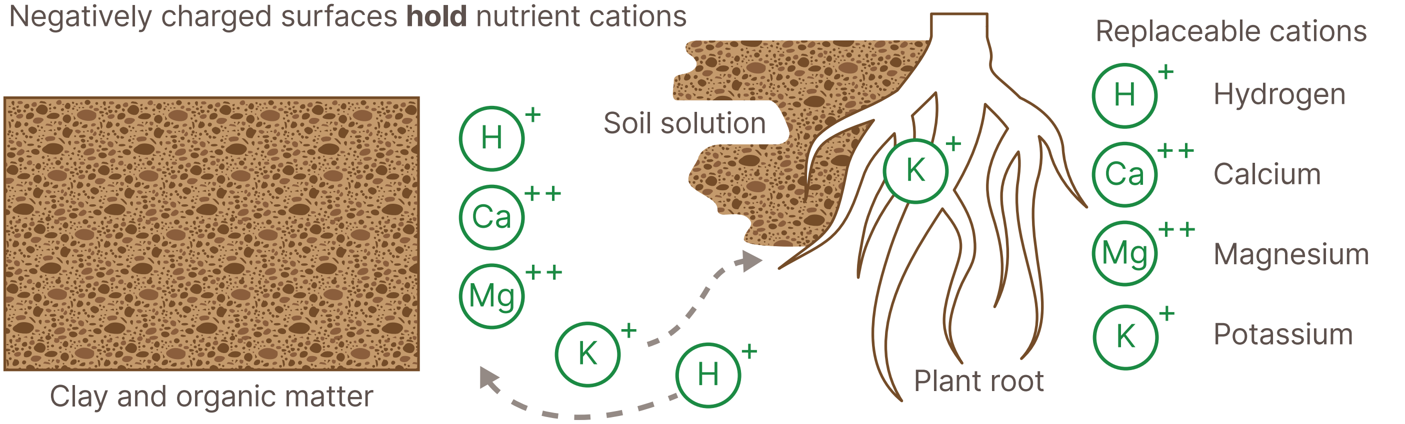



**2. Unlike poles** of magnets **attract** each other

Similarly

Ions and soil particles with **unlike charges attract** each other

**3.** Negatively charged surfaces **hold** nutrient cations




The nutrient ions held in replaceable form or absorbed on clay and organic matter soil particles are a major source of plant nutrients. They are replaced or exchanged to the soil solution and taken up by plants...soil minerals contain a reserve of nutrients. These nutrients become slowly available to plants.

Idea from "Profitable Soil Management" Soil Fertility Services, No.3, University of Wisconsin.

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# INDUCED NITROGEN DEFICIENCY

**Soil amendments:**

Straw, bark, peat moss, wood fiber mulch and manure (with a heavy mixture of bedding straw) can induce a nitrogen deficiency on plants. These materials are high in carbon content. By adding them into the soil we tend to raise the carbon to nitrogen ratio.

The carbon to nitrogen ratio is the amount of carbon in relation to the amount of nitrogen in the soil. The carbon to nitrogen ratio should be 10:1 or lower. When the soil has ten parts of carbon , it should have at least one part of nitrogen or the plants will not be able to obtain the nitrogen they need. When we add the carbonatious material, we raise the amount of carbon. Micro-organisms in the soil attempt to break down the carbonatious material and in this process they use some of the nitrogen from the soil. The micro-organisms have the ability to take the nitrogen before the plant can, so often times adding soil amendments induces a nitrogen deficiency for the plant.

It is good practice to add some nitrogen with these amendments to bring the carbon to nitrogen ratio back to a 10:1, so both the plant and the micro-organisms requirements are satisfied.

**Liquid fertilizers tend to volatize more than dry fertilizer on turf.**

Part of the liquid fertilizer sticks to the grass leaf when applied to turf. When temperatures and climatic conditions are right, particularly if urea nitrogen is used, urease enzymes can convert part of the nitrogen to gases that can volatize off into the air.

Dry pelleted fertilizers tend to filter down through the grass to the mat or soil surface, where it can readily be dissolved and moved into the root zone.

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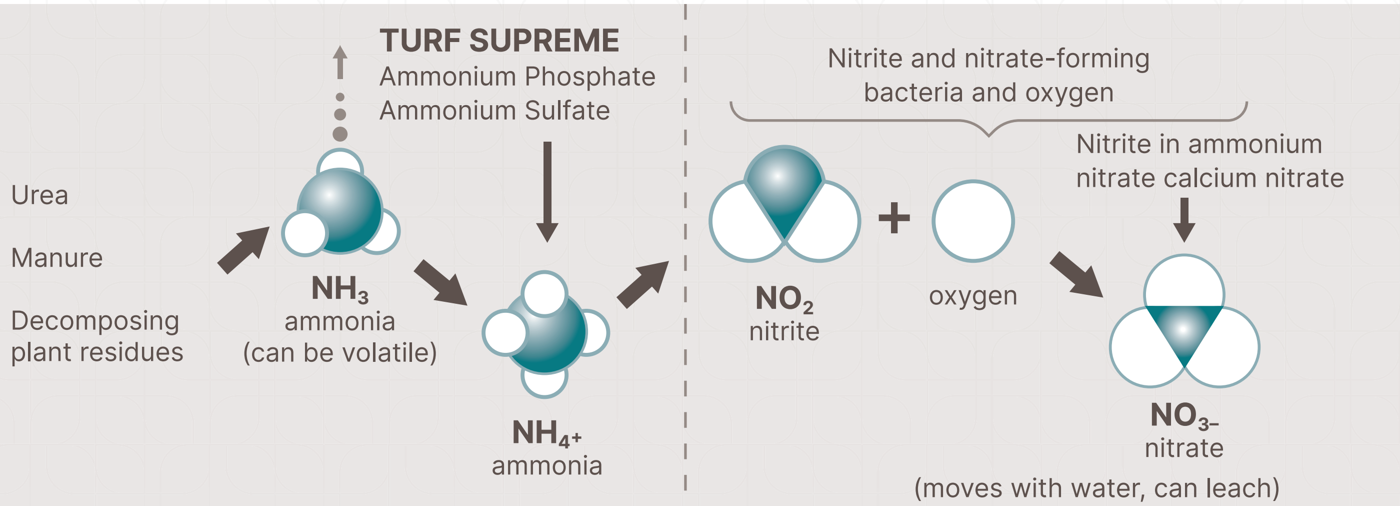
# NITRIFICATION vs DENITRIFICATION

## Nitrification

Conversion of nitrogen containing
Materials to a plant useable form

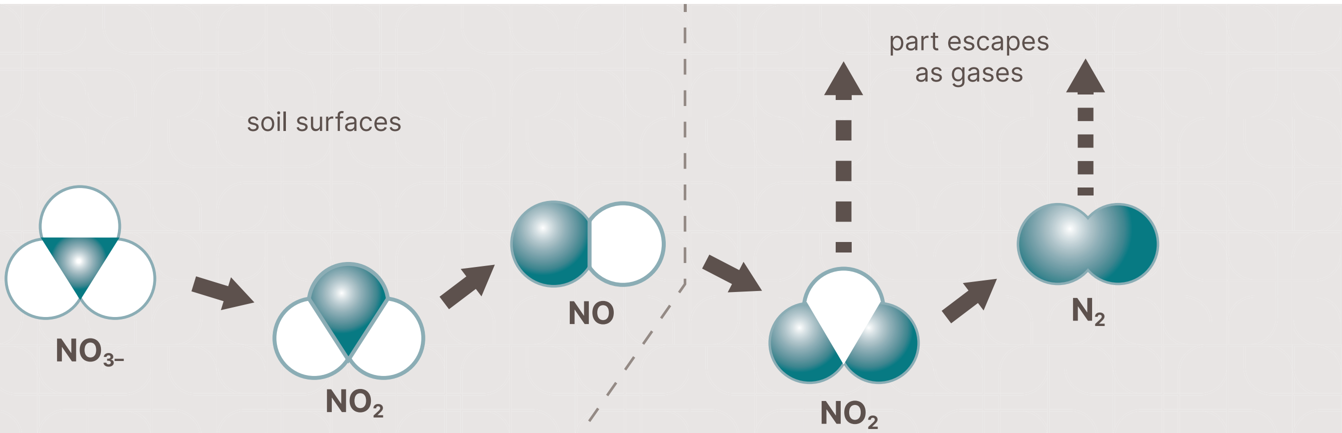



These steps do not require oxygen and so can take place even in very wet soil.

These steps require oxygen and take place even in a very wet soil hence a nitrogen deficiency ofter show in wet areas.

## Denitrification

Loss of plant useable
Nitrogen to the atmosphere




**Caused by** soil orgarnisms that live without air in a wet soil and get their oxygen (O) by taking it from nitrate ($NO_3$).

**Conditions favoring** warm, wet soil with large amounts of plant residues. (The soil orgarnisms that rot the reisidues rapidly uuse up the free oxygen supply, and then denitrifying organisms begin to multiply).

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