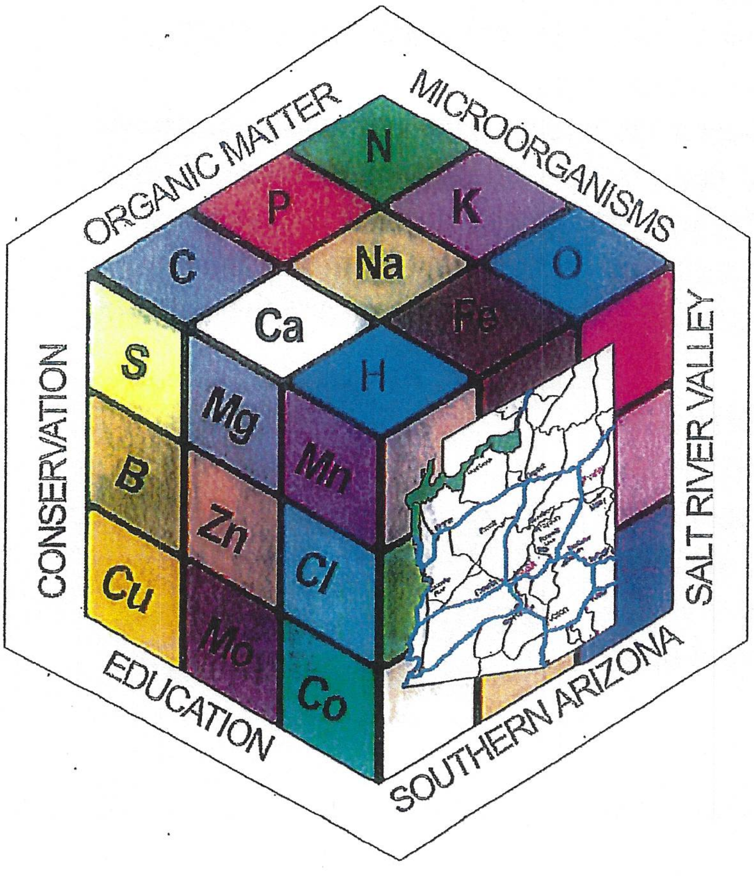
MESA-EAST VALLEY ROSE SOCIETY

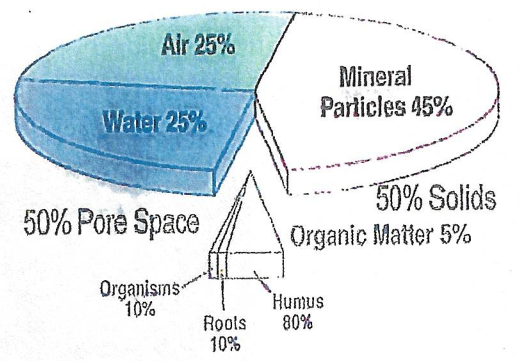
ALL ABOUT SOILS



A Clay Ridge Publication
By James D. Claridge

THE FOUR MAJOR COMPONENTS OF SOILS

Mineral soils are made of minerals, organic matter, water and air. A surface soil in good condition for plant growth contains approximately 50% solid material and 50% pore space. By volume the mineral portion is 45% to 50% – the organic material less than 5% - containing both plant and animal residues in a state of decomposition that must be renewed constantly with the addition of plant residues & mulch. The air & moisture in the soil (pore space) = 25% air - 25% water.



COMPOSITION of SOIL by VOLUME

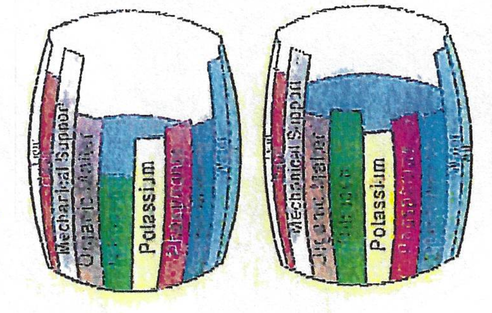
Most Arizona soils have less than 1% organic matter by weight due to the rapid rate of decomposition when warm soils are moistened. Tilling the soil increases the amount of air in the soil which increases the rate of organic matter decomposition, This 1% is a major soil source of phosphorus (P) and sulfur (S) and the greatest source of nitrogen (N). OM (organic matter) increases the amount of water the soil can hold and the portion of water that is available for plant growth. It is the main source of energy for soil microorganisms without which biochemical activity would be at a standstill.

The soil organic matter is classified into two categories, (1) original tissue (recognizable by the naked eye) and (2) humus (unrecognizable) which has a capacity to hold water and nutrients that greatly exceeds that of clay.

Both clay and humus exist in a colloidal state (small individual particles that have a large surface area per unit weight and carry surface charges that attract nutrients and water). They largely control the chemical and physical properties of the soil. Chemical reactions and nutrient exchanges occur round them and their surfaces attracting nutrients, protecting them from leaching below the root zone and then releasing them slowly for plant uptake.

SUPPLY & AVAILABILITY OF NUTRIENTS

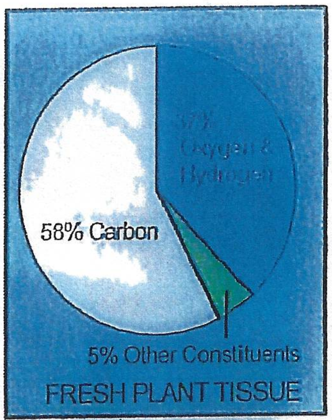
Six environmental factors control the growth of plant: (1) light, (2) mechanical support, (3) heat, (4) air, (5) water and (6) nutrients. With the exception of light, soil supplies all or part of these external factors. Plant growth is dependent upon



a favorable combination of these factors, if anyone is out of balance a reduction in plant growth occurs. The factor which is the least optimum determines the level of plant growth. The principle of limiting factor states, '***The level of crop production can be no greater than that allowed by the most limiting of the essential plant growth factors.***'

The water level in the barrels represents plant production. Left – Nitrogen the most limiting factor - other elements are adequate - production can be no higher than that allowed by the Nitrogen. Right – when nitrogen is added the level of production is raised until it is controlled by the next most limiting factor - potassium.

The Essential Elements



Certain elements that are essential for plant growth must be present in optimum concentrations and in usable forms for plant growth in a proper balance among the concentrations of the various soluble nutrients in the soil. The plant is made up of approximately 95%* CHO and 5% from the soil constituents - plant growth is dependent upon the nutrients in the soil. Seventeen elements are known to be essential for plant growth; they are listed below according to amount used in large or small amounts & from air & water or from the soil solids.

Elements used in Large Amounts						**Elements used in Small Amounts**			
From Air & Water		**From Soil Solids**				**From Soil Solids**			
Carbon	**C**	**Nitrogen**	**N**	**Calcium**	**Ca**	**Iron**	**Fe**	**Copper**	**Cu**
Hydrogen	**H**	**Phosphorus**	**P**	**Magnesium**	**Mg**	**Manganese**	**Mn**	**Zinc**	**Zn**
Oxygen	**O**	**Potassium**	**K**	**Sulfur**	**S**	**Boron**	**B**	**Chlorine**	**Cl**
						Molybdenum	**Mo**	**Cobalt**	**Co**

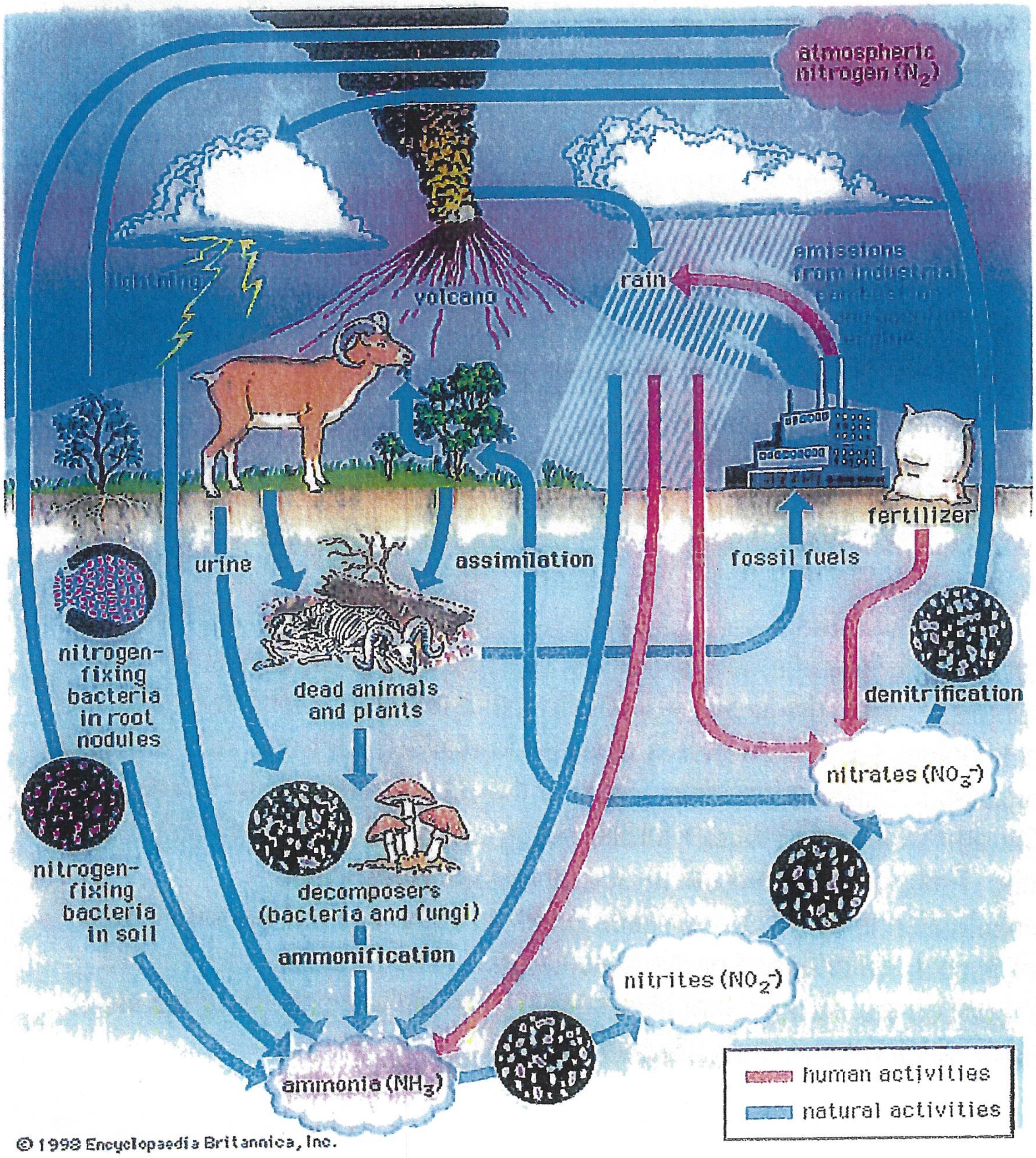
Nitrogen - Most of the nitrogen is found in the organic matter, it must be decomposed by soil microorganisms to make simple forms of nitrogen available to plants. It is first an ammonium salt (NH_4^+) that is oxidized to nitrite (NO_2^-) and then to nitrate (NO_3^-) - a process is called *nitrification*. Most of the nitrogen utilized by plants is absorbed in the ammonium and nitrate forms - large amounts of nitrite (NO_2^-) can be toxic to plants. This process is accomplished by microorganisms.

This transformation is by sensitive microorganisms in the soil that perform slowly when the soil is cold, waterlogged or excessively acid. The organisms are mobile and have first call on the nitrogen that allows them to multiply rapidly using the nitrogen themselves slowing down the nitrification process.

THE NITROGEN CYCLE

In soils there is intake and outgo of nitrogen during the year. The biochemical reactions of nitrogen in the soil are known as the *nitrogen cycle*. Nitrogen comes from commercial fertilizers, crop residues, green and farm manures and ammonium & nitrates in precipitation & the fixation of atmospheric nitrogen by microorganisms. The outgo is by crop removal, leaching and gaseous loss into the atmosphere. The atmosphere (air) contains 79% nitrogen gas N_2 – the rest is in the organic matter in the soil and living plants. Plants can only take up nitrogen in the ammonium ion (NH_4^+) and the nitrate ion (NO_3^-) forms.

For technical Nitrogen Cycle see page 20



IMMOBILIZATION - The process of tying up nitrogen in organic forms.

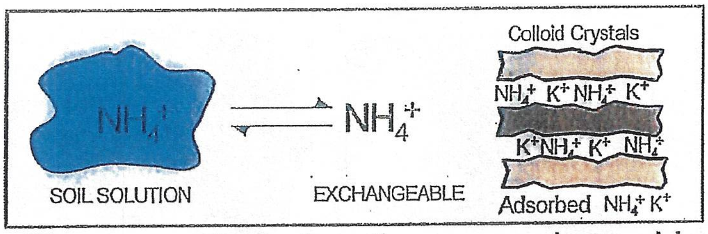
At any one time most of the nitrogen is soils is immobilized in organic combinations and is not available for plant growth, leaching or gaseous loss. During microbial decomposition of plant and animal residues much of the inorganic nitrogen is converted to organic forms.

MINERALIZATION – The slow release of nitrogen.

Only 2-3% of the immobilized nitrogen is mineralized annually for plant needs. The majority of nitrogen is biochemically fixed within the soil by specialized microorganisms breaking down plant tissue & organic matter incorporated into the soil or by the addition of Nitrogen fertilizers. As the microbial activity subsides, some of the immobilized nitrogen is mineralized to NO_3^- & NH_4^+ ions that appear in the soil solution & are usable plants.

Nitrification

Ammonium compounds are available to microorganisms or are subject to fixation by clay minerals and organic matter. They can be adsorbed onto the surfaces of clay particles due to their positive charge. These are released as they are exchanged by other compounds. Most of the ammonium is chemically altered by bacteria into nitrite (NO_2^-) and further modified by to nitrate (NO_3^-) called *nitrification*. The second transformation follows closely to prevent any accumulation of nitrite that is toxic to plants. Under ideal conditions, nitrification will produce daily rates of 6 – 22 lbs. of nitrogen per acre furrow slice (2,000,000# of soil) when 100# of nitrogen is added in the form of ammonium. Nitrate is very soluble and is easily lost from the soil by leaching.



Denitrification

Anaerobic bacteria in the absence oxygen - convert nitrates and nitrites into nitrogen (N_2) or nitrous oxide (N_2O) gas that diffuses into the atmosphere readily.

Nitrogen fixation

Free-living nitrogen-fixing bacteria live in close contact with legume plants. They form nodules on the roots - taking free nitrogen from the soil air - changing it into usable forms that are absorbed by the plant. The seed is inoculated with the bacteria.

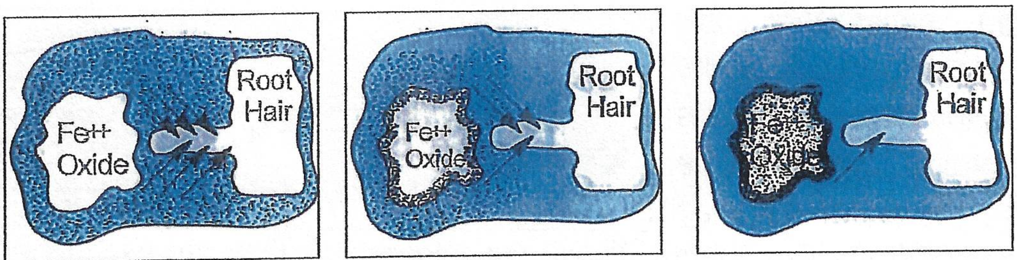
Almost all of the nitrogen found in the soil originally came from the atmosphere. Significant amounts enter the soil in rainfall or through the effects of lightning.

Phosphorus

Phosphorus has no microbial aid for fixation like nitrogen – it must come from (1) commercial fertilizer, (2) barnyard manure or (3) plant residues and native compounds – organic & inorganic already present in the soil.

Soil phosphorus held in organic combinations becomes available during organic decomposition. Mineral phosphorus is usually found in small quantities that is water soluble. Even when plant rootlets are aided by plant exudates and CO_2 and are in intimate contact with the mineral, the rate of solubility is slow.

Soluble fertilizer compounds may be changed to insoluble calcium phosphates or other iron and aluminum combinations when they come into contact with the soil. Since phosphorus is so readily tied up in the soil – it does not leach out but becomes slowly available over the years.



Application of Soluble P | P on colloid still available | P is tied up on colloid

Next to nitrogen, phosphorus is the next critical element in plant nutrition – its lack may prevent other nutrients from being acquired by plants.

Phosphorus is mainly for root development, flowering, fruiting & seed formation. The total amount of phosphorus in the soil compares with that of nitrogen - its removal by plants is low compared to nitrogen and potassium, only ¼ to ⅓ of these elements. Apply phosphorus in bands or clumps to avoid a lot of surface area contact with the soil around the fertilizer. The recovery of 15% by plants of added phosphates in a given season is due to soil fixation. The utilization of phosphorus in combination with barn-yard manure shows the importance of organic matter in increasing the availability of this element.

Potassium

Arizona soils have a tremendous reserve of potassium in the soil which makes its slow release adequate for plant growth. Most soils are high in total potassium, as much as 40,000#/AFS of K_2O of which 1–2% is readily available to plants.

Under normal conditions with adequate supply, potassium removal by plants is 3 – 4 times higher than phosphorus and almost equaling nitrogen. Plants tend to take up soluble potassium far in excess of their needs if large quantities are present. This tendency is termed ***luxury consumption***; it does not increase the growing capacity of the plant to any extent.

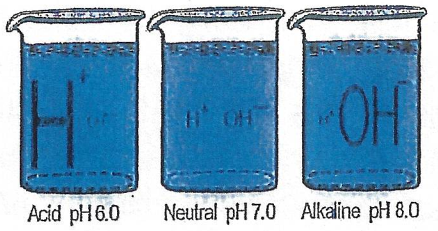
Potassium has no microbial aid for fixation - sources are (1) commercial fertilizer, (2) barnyard manure, (3) plant residues and native compounds – organic & inorganic already present in the soil. Its role in the plant is disease resistance, strong root systems, prevention of 'lodging', delays maturity & balances nitrogen & phosphorus.

Micronutrients for plants:

There are eight nutrients essential to plant growth and health that are only present in very small quantities. These are magnesium, sulfur, manganese, boron, copper, iron, chlorine, cobalt, molybdenum, and zinc. Though these are present in only small quantities, they are all necessary.

Soil Solution

Because there are large and small pore spaces in the soil, the soil solution is not always continuous. Water cannot move freely, but as the moisture content is reduced by evaporation the concentration of soluble salts in the soil solution rises. In arid regions with very little rainfall and restricted drainage, the salt concentration interferes with the growth of plants.

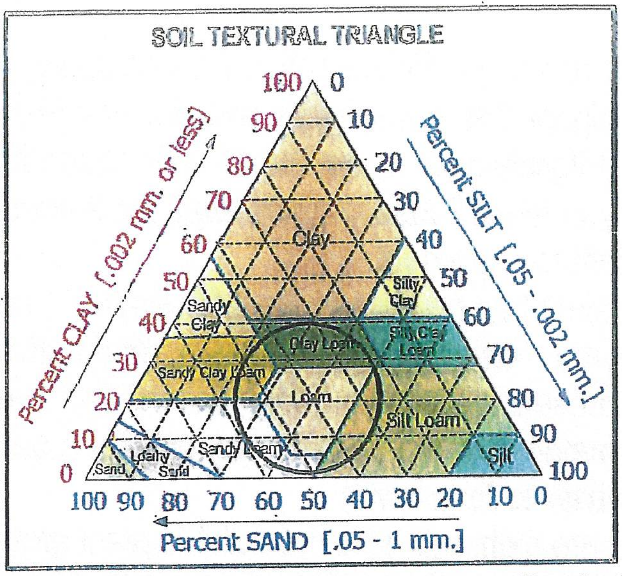


At pH 6.0 - 100 times more H ions than OH ions in solution.
At pH 8.0 - 100 times more OH ions than H ions in solution.

The important property of the soil solution is its reaction – pH. When H^+ ions predominate in the soil solution, an acid condition prevails. When OH^- ions are in large quantities, it is an alkaline condition.

The soil pH influences the nutrient absorption and plant growth through the direct effect of the H ion or its influence on nutrient availability.

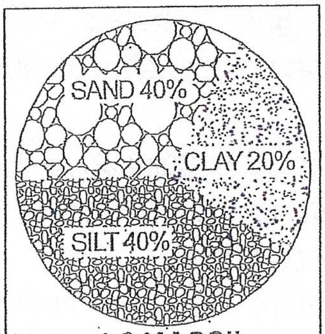
A pH scale measures the level of the acidity or the alkalinity of the soil. Plants grow at different pH levels but the middle of the pH scale gives the optimum plant nutrient availability.



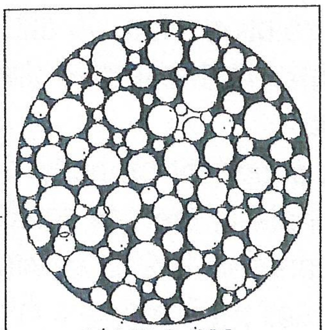
Soil texture refers to sand, silt and clay in combination with gravel and larger-material content. Sand and silt is the product of physical weathering while clay is the product of chemical weathering. The texture influences the physical behavior of the soil - available water holding & nutrient capacity which increases with the silt and clay content. Plant growth favors medium-textured soils, such as loam and sandy loam. The balance in air and water-handling characteristics in the medium-textured soils accounts for this.

Soil is a mixture of sand, silt & clay in varying amounts of each. By finding the percent of each component, a name and characteristic of how that soil will react when growing plants can be determined. Settling out the soil separates in a soil sample, the following Textural Triangle can be used to determine the soil name.

The soil separates determine the physical and chemical characteristics exhibited by the soil. 20% Clay, 40% Silt and 40% Sand falls in the Loam Soil. A loam soil has good nutrient & water-holding capacity, aeration, and is easy to work with equipment - the ideal soil.

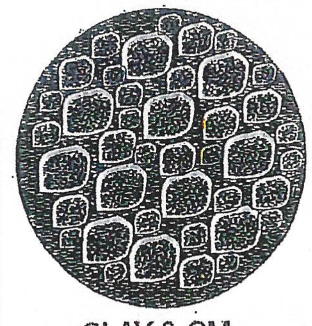


LOAM SOIL

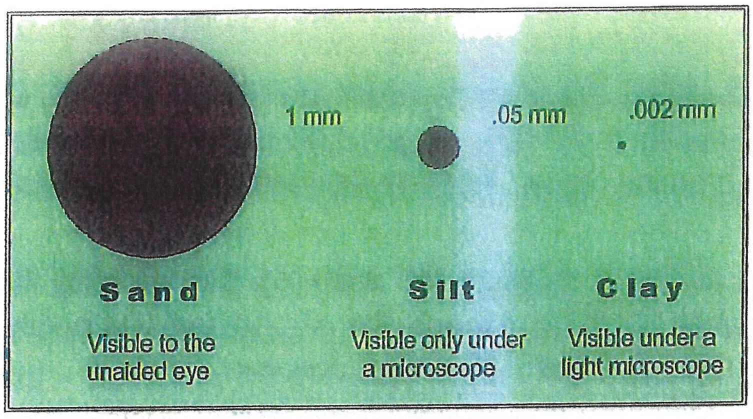

SAND & OM

To give a sandy soil the characteristics of a loam soil, add organic matter. The organic matter lies between the sand particles and slows down the movement of water and nutrients and has a high water and nutrient holding capacity. Organic matter holds sand particles together giving it stability and makes it is easy to work with.

To change a clay soil to act like loam, add organic matter - it binds the clay particles together forming aggregates that act similarly to sand giving the mixture aeration, water movement and adds to the nutrient holding capacity.


CLAY & OM

Size relationship



Fertilizers are compounds given to plants either via the soil, for uptake by plant roots, or by foliar feeding for uptake through leaves. Fertilizers can be organic (composed of organic matter or carbon based), or inorganic (containing simple, inorganic chemicals). They can be naturally-occurring compounds such as peat or mineral deposits, or manufactured through natural processes like composting.

Fertilizers typically provide the three 'primary macronutrients' NPK (nitrogen (N), phosphorus (P), potassium (K)), the 'secondary macronutrients' - calcium (Ca), sulfur (S), magnesium (Mg), boron (B), chlorine (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu) and molybdenum (Mo) are trace elements (or micronutrients) added by specialized fertilizers.

A 10-10-10 fertilizer has 10% nitrogen as N, 10% phosphorus as P_2O_5, and 10% potassium as K_2O - the other 70% is filler and has no value to the plants. If nitrogen is the main element, they are often described as **nitrogen fertilizers**.

FERTILIZERS N P-K

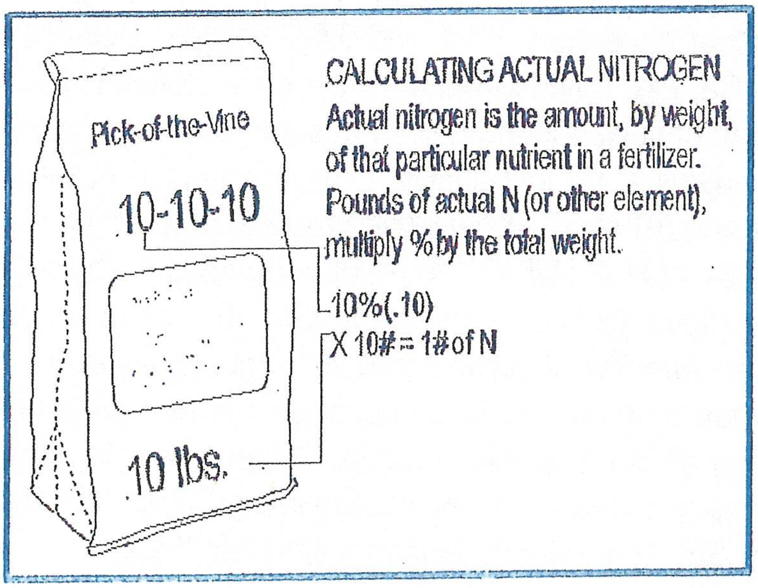
The three main fertilizer elements needed by plants;

[N] - green growth of the plant – breaks down organic matter in the soil

[P] - root development & flowering

[K] - disease resistance & general health of the plant

The numbers on a bag of fertilizer represent the percent (%) of N, P & K in the bag. This is the fertilizer guarantee.



The higher the organic matter content in the soil, the more nutrient & water holding capacity in the soil. Organic additives worked into the soil help to hold it together & produce higher yields. Mulch added to the garden already contains 10% Nitrogen.

When adding manure to the soil - do the following to minimize burning of the plants - when tilled into the soil, the microorganisms begin to break it down tying up the N. They have first call on the Nitrogen in the soil - this decomposition gives off heat that may burn new seedlings or growing plants. When manure is added to the garden, (3 cu. ft. bags/100 sq. ft.) allow 3 to 4 weeks of decomposition to take place before planting. When adding manure, it is a good idea to add 2#/100 sq. ft. of single super phosphate at the same time. If you want to plant sooner, add 3# of 21-0-0/100 sq. ft. and till in with the manure and phosphate. Wait at least one week before planting – two weeks if manure is not well rotted.

Organic fertilizers

- Naturally occurring organic fertilizers include manure, worm castings, peat, seaweed and guano. Green manure crops are grown to add nutrients to the soil. Naturally occurring minerals such as mine rock phosphate, sulfate of potash and limestone are also considered Organic Fertilizers.
- Manufactured organic fertilizers are compost, blood meal & seaweed extracts.

Green manure - a cover crop, plowed or turned under & incorporated into the soil. Green manures perform multiple functions - soil improvement and soil protection:

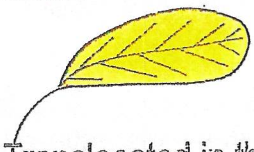
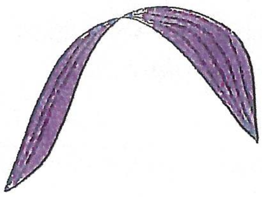
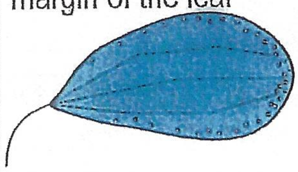
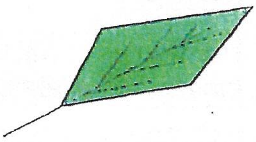
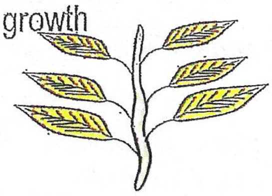
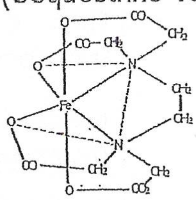
Farm manure refers to the refuse from all animals on the farm but most is mainly from cattle. The average farm manure ready for application contains 0.5% nitrogen, 0.25% of phosphoric acid, and 0.5% potash. Besides N, P & K, farm manure contains Ca, Mg, S and a little of all the trace elements that helps to maintain a balanced nutrient condition in the soil. It has the following characteristics: (1) moist condition, (2) variability, (3) low analysis, (4) unbalanced nutrient condition, (5) residual influence and (6) rapid fermentative process. It is a low analysis fertilizer giving only 10# of N, 5# of P & 10# of K for each ton added to the soil. To obtain high amounts of these elements it is necessary to add 10 – 15 tons per acre. For each ton of farm manure add 50# of fertilizer with 20% phosphoric acid.

When farm manure is incorporated into the soil the microorganisms break it down utilizing all the available nitrogen. Where possible, wait a minimum of 2 weeks after application to plant. When planting immediately, add 15# of ammonium sulfate (21-0-0) per 500# of well-rotted manure tilled into the soil.

FERTILIZER ELEMENTS

ELEMENT	ACTION IN THE PLANT	SYMPTOM
Nitrogen N NO_3^-, NH_4^+	Gives dark green color, induces rapid growth, increases protein content, gives crisp leaf quality	Yellowing or firing of older leaves, few lateral shoots, small leaves, bent stems, stunted growth
Phosphorus P_2O_5 $HPO_4^=$, $H_2PO_4^-$	Promotes root, flowering & seed formation, hastens maturity, energy bond	Purpling of leaves, delayed maturity, leaves dark green tips dying, early defoliation
Potassium K K^+, K_2O	Increased vigor & disease resistance, increased grain plumpness, stiff stalks	Mottling or curling of leaves & firing of margins, midrib green, plants lodge easily
Calcium Ca Ca^{++}	Promotes early root formation & growth, improves plant vigor	Death of terminal bud, leaves have wrinkled appearance along margins
Sulfur S $SO_4^=$	Protein formation, promotes root growth, stimulates seed production	Young leaves general yellowing but not along midrib, stalks short & slender
Iron Fe Fe^{++}	Essential to chlorophyll production & protein synthesis, electron carrier	Chlorosis in young leaves, principal veins remain green, stalks short & tender
Magnesium Mg Mg^{++}	Component of chlorophyll, aids translocation of 'P'	Older leaves light green, mottled with dead spots
Zinc Zn Zn^{++}	Part of enzyme system, formation of growth hormones	Mottled leaves, interveinal chlorosis, white bud
Manganese Mn Mn^{++}	Functions in enzyme systems & certain 'N' transformations	Dead spots scattered over leaf, small veins green
Boron B BO_3^+	Rate of H_2O absorption & sugar translocation	Rosetting effect or death of terminal bus
Copper Cu Cu^{++}	Involved in plant respiration & utilization of 'Fe', vitamin A	Permanent wilting of young leaves, weak stalks
Molybdenum Mo $MoO_4^=$	Required for 'N' fixation, activation of enzymes, reduces nitrates	Interveinal chlorosis, plants become stunted
Chlorine Cl Cl^-	Necessary for osmosis & ionic balance, role in photosynthesis	
Cobalt Co	Component of vitamin B-12	

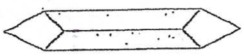
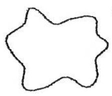
MACRO – NUTRIENTS for PLANT GROWTH

NUTRIENT	USE IN THE PLANT	DEF. SYMPTOM	FERT. CARRIER
NITROGEN – **N** FORM TAKEN UP Ammonium NH_4^+ Nitrate NO_3^- pH 3 – 8.5 Held on the colloids Volatilizes & leaches	**Green Growth** **Chlorophyll, Amino Acids, & Proteins**	Yellowing of older leaves  Translocated in the plant	Ammonium Sulfate 21 – 0 – 0 Ammonium Nitrate 33.5 – 0 – 0 Urea 45 – 0 – 0
PHOSPHORUS – **P** FORM TAKEN UP Phosphate HPO_4^- Phosphate PO_4^- pH 6 – 7 Does not leach Combines with Ca^{++}	Energy Source ATP & ADP Part of DNA inheritance RNA protein synthesis Root development & Flowering	Purpling or reddening of the leaves 	Single Super Phosphate 0 – 20 – 0 Treble Super Phosphate 0 – 46 – 0 Ammonium Phosphate 16 – 20 – 0 11 – 48 – 0
POTASSIUM – **K** FORM TAKEN UP Potassium K^+ pH 6.2 – 9 Held between colloid plates - Leaches	Does not enter into any building blocks Catalysts for other reactions Cell turgidity Disease resistance Luxury consumption	Mottling – dead spots around the outside margin of the leaf 	Potassium Chloride 0 – 0 – 50 Mixed Fertilizers 10 – 10 – 10
IRON – **Fe** FORM TAKEN UP Ferric Sulfate $FeSO_4$ Iron Chelate pH 4 – 6 Slight Leaching	Chlorophyll – Green color Protein formation 	Yellowing of new growth 	Iron Chelate (Sequestrine 138) 

NITRIFICATION: $NH_3 \longrightarrow NH_4^+ \longrightarrow NO_2^= \longrightarrow NO_3^-$ Leaching

DENITRIFICATION: $NO3^- \longrightarrow NO_2^= \longrightarrow NO^- \longrightarrow N_2O \longrightarrow N_2$ Volatilization

NUMBERS ON A FERTILIZER BAG ARE THE % OF **N P K**

Crystal  Prill  Granule 

KEY TO ELEMENT DEFICIENCY SYMPTOMS

A. Older or lower leaves of plant mostly affected; effects localized or generalized.

B. Effects mostly generalized over whole plant; more or less drying or firing of lower leaves; plant light or dark green.

C. Plant light green; lower leaves yellow, drying to light-brown color; stalks short and slender if element is deficient in later stages of growth. ------ Nitrogen

CC. Plant dark green, often developing red and purple colors; lower leaves sometimes yellow, drying to greenish brown or black color; stalks short & slender if element is deficient in later stages of growth. ------------ Phosphorus

BB. Effects mostly localized; mottling or chlorosis with or without spots dead tissue on lower leaves; little or no drying u of lower leaves

C. Mottled or chlorotic leaves typically may redden, sometimes with dead spots; tips and margins turned or cupped upward; stalks slender. ---- Magnesium

CC. Mottled or chlorotic leaves with large or small spots of dead tissue.

D. Spots of dead tissue small, usually at tips & between veins, more marked at margins of leaves; stalks slender ------------------ Potassium

DD. Spots generalized, rapidly enlarging, generally involving areas between veins & eventually involving secondary & primary veins; leaves thick; stalks with shortened internodes. --------------- Zinc

AA. Newer or bud leaves affected; symptoms localized.

B. Terminal bud dies, appearance of distortions at tips of young leaves.

C. Young leaves of terminal bud at first typically hooked, finally dying back at tips and margins, so that later growth is characterized by a cut-out appearance at these points; stalk finally dies at terminal bud. - Calcium

CC. Young leaves of terminal bud light green at bases, final breakdown in later growth, leaves become twisted; stalk dies back at terminal but. - Boron

BB. Terminal bud commonly remains alive; wilting or chlorosis of younger or bud leaves with or without spots of dead tissue; veins light or dark green.

C. Young leaves permanently wilted (wither-tip effect) without spotting or marked chlorosis; twig or stalk just below tip & seed head often unable to stand erect in later stages when shortage is acute. ---------- Copper

CC. Young leaves not wilted; chlorosis present with or without spots of dead tissue scattered over the leaf.

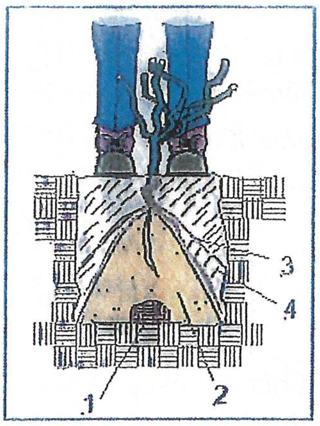
D. Spots of dead tissue scattered over the leaf; smallest veins tend to remain green, producing a checkered or reticulating effect. ------- Manganese

DD. Dead spots not commonly present; chlorosis may or may not involve veins, making them light or dark green in color.

E. Young leaves with veins & tissue between veins light green in color. Sulfur

EE. Young leaves chlorotic, principal veins typically green; stalks short and slender. Iron

ROSES

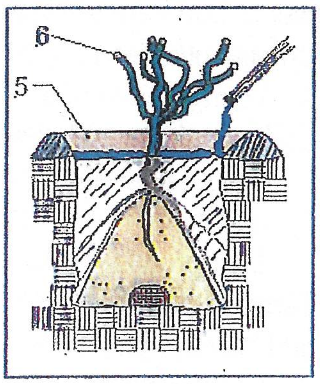


Roses grow best in full sun. Avoid planting roses close to the south or west wall of a building due to the reflected heat in the summer that will damage the plants. Locate roses away from large trees and shrubs to avoid root competition and unfavorable shade.

Plant roses 4-5 weeks prior to buds starting to grow, this allows roots to become established before top growth starts. Plant roses Dec. 15 through the end of February

Planting: Dig the hole 15-18" deep and as wide to allow the roots to spread to their normal position.

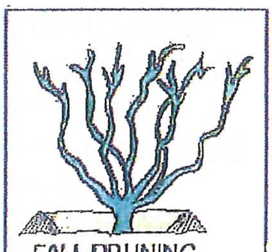
1. Place 2-4 cups - treble or single super phosphate - in the bottom of the hole. Do not mix fertilizer with soil. This assures adequate phosphorus for life of the plant.
2. Build a cone of soil & mulch mix over the fertilizer. Make the cone tall enough to allow the rose bush to fit into the hole at the same level it was originally grown.
3. Remove the sawdust from the bare root plant and prune any dead or damaged roots. Place the crown of the plant on top of the cone and spread the roots down the sides.
4. Fill in around the roots with a 50-50 mix of soil and mulch. Cover each layer of roots as you fill the hole, firm the soil around each layer with your foot until the hole is filled.
5. Form a basin around the plant and water deeply.
6. Prune to 4 or 6 canes about 8" long. Cut to strong outside buds - new growth will not crowd the center. Remove low spreading, crossing, weak or straggly canes.



Fall Pruning - Remove spent flowers - cut back all canes 4-6" to initiate new growth. Remove lone water sprouts not needed for the spring structure building of the plant.

Winter Pruning January – February

1. Clean out dead & weak growth, old wood that has bloomed for two years or more should be removed. Remove old wood that is dark in color and has general unhealthy appearance.
2. Remove about two thirds of the previous year's growth to an outside bud. If a bouquet rose is desired, remove three fourths of the previous year's growth.



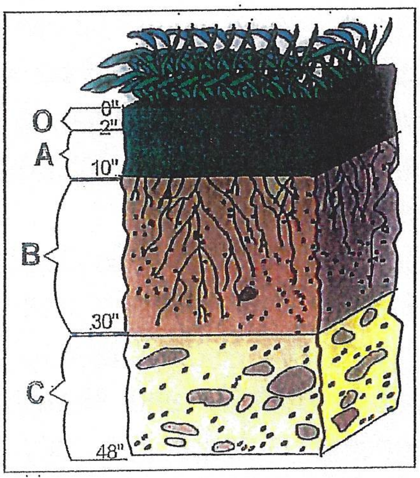
ORGANIC MATTER

All of the properties of a highly productive soil are dependent upon the presence of organic matter:

- **Soil fertility:** Organic matter adds plant nutrients as it breaks down & provides sites for nutrients to bind to, holding them in upper soil layers for plants to use.
- **Soil structure:** The slimes and microbial gums produced by decomposing organic matter bind soil particles. The result is a stronger, granular, more permeable and workable soil.
- **Soil water holding capacity:** A soil with good structure is more permeable and porous. Water infiltrates more easily and is held in small soil pores.
- **Soil pH:** Organic matter additions reduce the pH of excessively alkaline soils. The decomposition process releases hydrogen ions, increasing soil acidity.

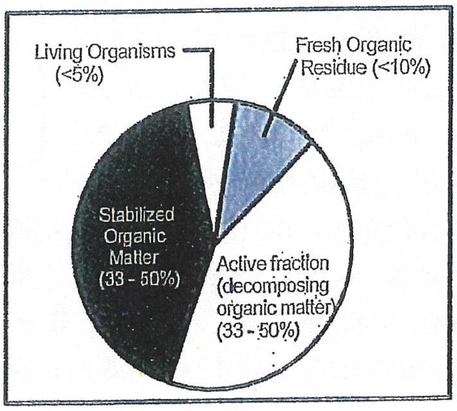
Without regular organic matter addition, soils become drained of essential plant nutrients and unable to absorb or retain water. As their structure is weakened, soils are much more susceptible to the forces of wind and water erosion.

What is Organic Matter?



We think of organic matter as the plant and animal residues we incorporate into the soil - a pile of leaves, manure or plant parts. A lot of organic material added to the soil is not organic matter.

The difference between organic material and organic matter - anything that was alive and is now in or on the soil is organic material. For it to become organic matter, it must be decomposed into humus by micro-organisms to a resistant state of decomposition. Organic material is unstable in the soil, changing form and mass readily as it decomposes. As much as 90% disappears quickly because of decomposition.



Organic matter is stable in the soil when it has been decomposed to a resistant state. Usually, only about 5% of it mineralizes yearly. That rate increases if temperature, oxygen, and moisture conditions become favorable for decomposition, which often occurs with excessive tillage. It is the stable organic matter that is analyzed in the soil test.

Organic matter was originally created by plants, microbes, and other organisms - **stabilized organic matter** (highly decomposed and stable) - **active fraction** which is being actively used and transformed by living plants, animals, and microbes.

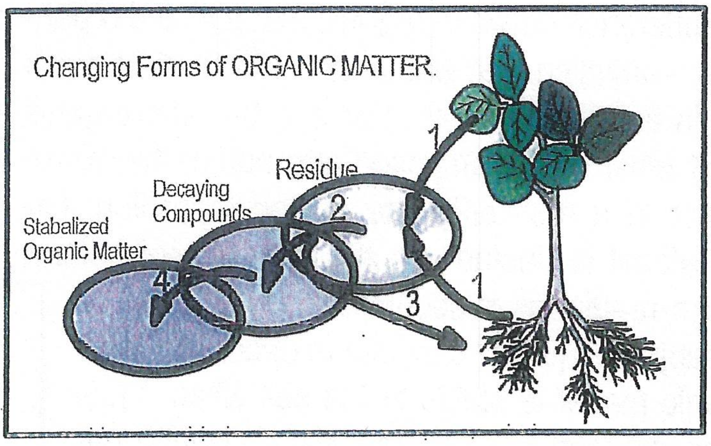
Stabilized organic matter

As soil organisms decompose plant and animal tissues over the years or decades - complex compounds are formed that few microbes can degrade and other compounds become bound inside soil aggregates where microbes cannot reach. The hard-to-decompose stabilized materials make up a third to a half of soil organic matter. Much of the stabilized matter originated from plants that centuries old and are bound to clay gluing together tiny aggregates of soil particles. They act like a sponge and can absorb six times its weight in water. In sandy soils, water held by organic matter will make the difference between crop failure and success during a dry year.

Organic compounds in soil

This pie chart represents organic matter in soil before cultivation. After land has been cultivated for one or two decades, much of the active fraction is lost and stabilized organic matter makes up more than half of the soil organic matter. Both **organic and clay particles can hold on to nutrients** electrochemically - organic matter can hold five times as much nutrients for plants to use. The amount of clay cannot be changed but you can easily increase the amount of organic matter in the soil.

The active fraction



Up to 15% of soil organic matter is fresh organic material and living organisms. Another third to one half is partially and slowly decomposing material that may last decades. This decomposing material is the active fraction of soil organic matter. Many of the nutrients used by plants are held in organic matter until soil organisms decompose the material and release them as plant-available nutrients (nitrogen, phosphorus, sulfur, and iron). A soil with 1% organic matter contains about 135 pounds of nitrogen per 2000 sq. ft. - depending on the rate of decomposition, 1-2# may become available to plants in a year.

Changing Forms - Soil Organic Matter

1. Additions – roots & leaves die, they become part of the soil organic matter.
2. Transformations – organisms create by-products, wastes & cell tissue.
3. Microbes – release wastes that are used by the plant
4. Stabilization – compounds become stabilized & resistant to further changes.

Organic matter affects nutrient cycles by chelating (chemically holding on to) nutrients, and preventing them from becoming insoluble or unavailable to plants.

How Much Organic Matter Is in the Soil?

An acre of soil measured to a depth of 6 inches weighs approximately 2,000,000 pounds, which means that 1 percent organic matter in the soil would weigh about 20,000 pounds per acre. Remember that it takes at least 10 pounds of organic material to decompose to 1 pound of organic matter, so it takes at least 200,000 pounds (100 tons) of organic material applied or returned to the soil to add 1 percent stable organic matter under favorable conditions. Most of the organic matter is located in the top 10" of the soil profile. This is mainly where the plant gets most of it nutrients.

Nutrient Supply

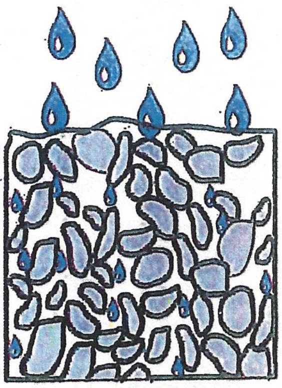
Organic matter is a reservoir of nutrients that can be released to the soil. Each percent of organic matter in the soil releases 20 to 30 pounds of nitrogen, 4.5 to 6.6 pounds of P_2O_5, and 2 to 3 pounds of sulfur per year. The nutrient release occurs predominantly in the spring and summer, so summer crops benefit more from organic-matter mineralization than winter crops.

Water-Holding Capacity

Organic matter behaves somewhat like a sponge, with the ability to absorb and hold up to 90% of its weight in water. A great advantage of the water-holding capacity of organic matter is that the matter will release most of the water that it absorbs to plants. In contrast, clay holds great quantities of water, but much of it is unavailable to plants.

Soil Structure Aggregation

Organic matter causes soil to clump and form soil aggregates, which improves soil structure. With better soil structure, permeability (infiltration of water through the soil) improves, in turn improving the soil's ability to take up and hold water.



Soil with good structure has stable pore spaces that allow root growth, earthwrom movement and air storage.

Soil structure and compaction - arrangement of particles within the soil. The most desirable is a granular structure – small pebbles or crumbs of soil. With a stable granular structure soils are easy to dig, accept water readily and make a good seedbed – ideal condition called 'good tilth'.

Good soil structure means the pore spaces are stable. A productive soil is made up of many species of fungi, bacteria, insects & mites. These depend on organic matter as food and a fuel source. Together with earth worms and plants – these organisms provide the 'glue' that holds the soil together and gives it structure.

Estimating the volume of organic amendment needed.

Depth of amendment desired (in.)	Area of garden (sq. ft.)* 200	500	1000	2000
	Organic material to add (cu. yd.)			
1	0.6	1.5	3.1	6.2
2	1.2	3.1	6.2	12.3
3	1.9	4.6	9.3	18.5
4	2.5	6.2	12.3	24.7

*To estimate square footage - multiply length by width (in feet).

The soil structure is damaged by action that compact the soil – machinery or foot traffic which hinders the penetration of air, water & root growth. Tilling the soil damages the structure & increases the rate of organic matter loss through decomposition.

Decomposition is desirable because it releases nutrients and feeds soil organisms. But if decomposition is faster than the rate at which organic matter is added, soil organic matter levels will decrease.

Regular additions of organic matter are important as food for microorganisms, insects, worms, and other organisms. Organic matter can cause the nitrogen tie-up - temporary nitrogen deficiency for plants if the organic matter is low in nitrogen.

Carbon: Nitrogen Ratios & Nitrogen Fertilizer Requirements

Material	C:N	#N/200#	# 21-0-0	#46-0-0
Sewage Sludge	12:1	-	-	-
Alfalfa	13:1	-	-	-
Green Manure	20:1	-	-	-
Compost (Fine)	20:1	-	-	-
Manure	30:1	3.87	5.75	2.63
Compost (Course)	35:1	3.31	8.38	3.83
Horse Manure	50:1	2.32	13:12	5.99
Straw (yellow)	70:1	1.66	16.27	7.43
Straw (blackish)	90:1	1.29	18.02	8.23
Sawdust	400:1	.29	22.78	10.40

C:N less than 23:1 will not result in immobilization of soil nitrogen. This calculation assumes and average of 58% carbon. 21-0-0 is ammonium sulfate - $(NH_4)_2SO_4$. - 46-0-0 is urea - $CO(NH_2)_2$. Animal manure is assumed to be dry – contain no bedding material.

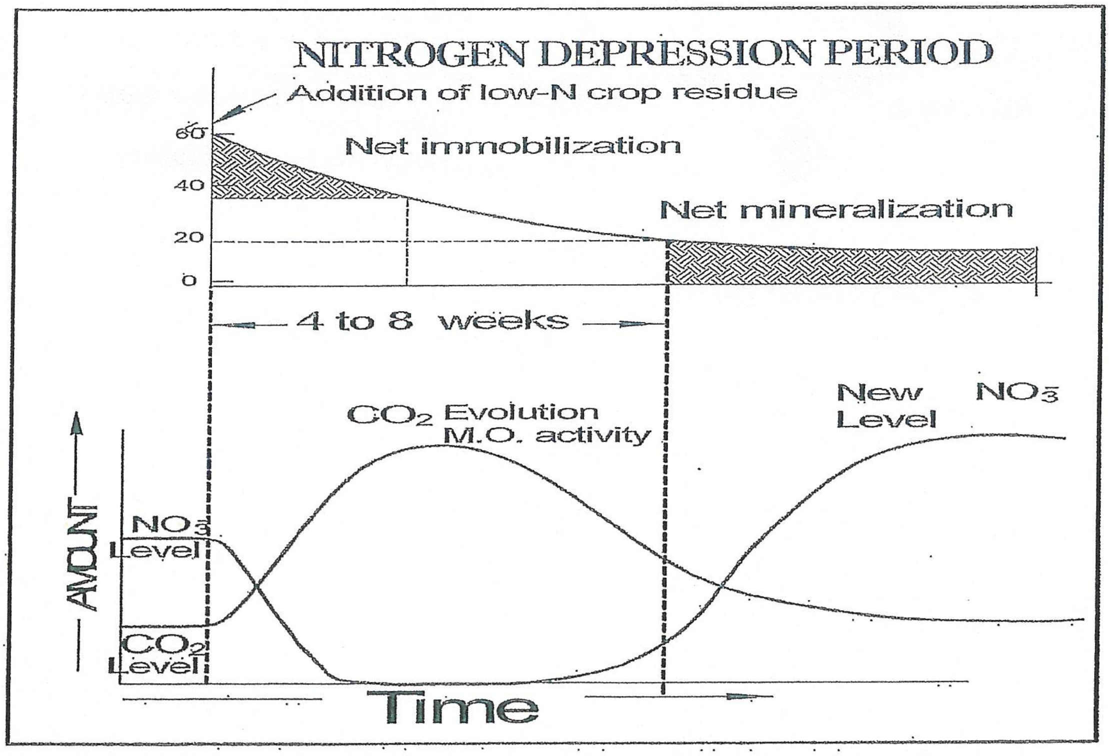
(The above amount of N calculation)

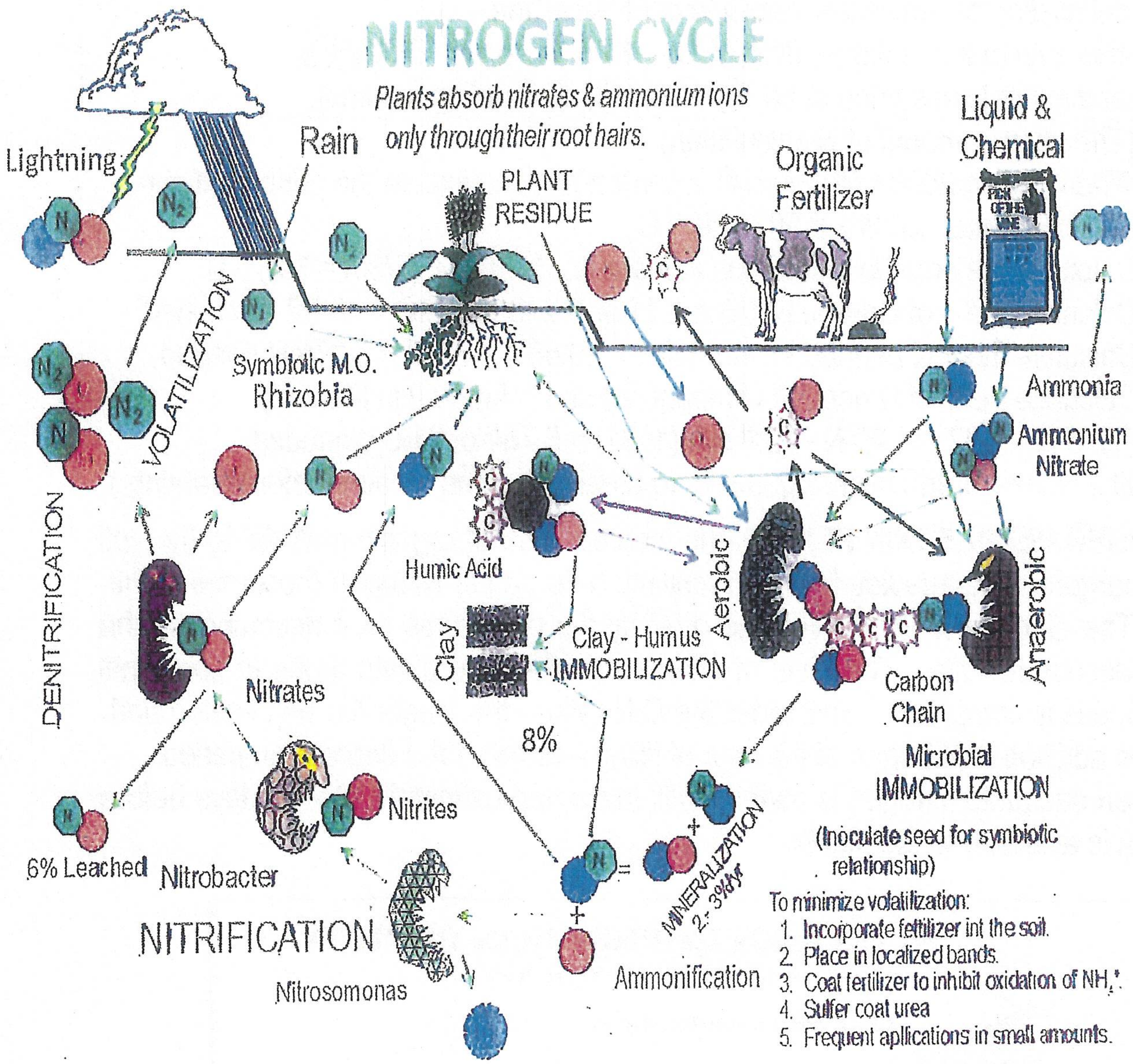
- When adding 200# of Manure to a garden plot - Calculate the pounds of carbon in manure: 200# x 0.58 = 116# C.
- Calculate the pounds of nitrogen in manure: 116# C x (1/30) = 3.87# N
- Calculate the # of Carbon Retained 116# C x .35 by MO = 40.6# C retained
- Calculate the # N needed for C retained 40.6# C x (1/8) = 5.07# N needed
- Calculate the # of N needed (Amount needed – Amount in Manure)
  5.07# N – 3.87 = 1.2# N - 1.2# N x (1/.21) = 5.75# of 21-0-0 needed.

(Wait 2 weeks for the microorganisms to break down the manure before planting.)

NITROGEN DEPRESSION PERIOD The incorporation of organic material to the soil – microorganisms immediately began multiply & tie up the Nitrogen (becomes immobile). The nitrogen is used over and over by the organisms as it decomposes the carbonaceous residue. The level of nitrogen available to plants drops to zero until this process is completed. The wider the C:N ratio – the longer the depression period. The addition of Nitrogen at the time of tilling – reduces the depression period.

When adequate nitrogen is added it still takes approximately 10 – 14 days before nitrogen is available to the plants.




NITROGEN CYCLE
Plants absorb nitrates & ammonium ions only through their root hairs.
Lightning
Rain
PLANT RESIDUE
Organic Fertilizer
Liquid & Chemical
Ammonia
Ammonium Nitrate
Symbiotic M.O. Rhizobia
VOLATILIZATION
DENITRIFICATION
Humic Acid
Clay
Clay - Humus IMMOBILIZATION
8%
Aerobic
Anaerobic
Carbon Chain
Microbial IMMOBILIZATION
(Inoculate seed for symbiotic relationship)
Nitrates
Nitrites
6% Leached
Nitrobacter
NITRIFICATION
Nitrosomonas
MINERALIZATION 2 - 3%/yr
Ammonification
To minimize volatilization:
1. Incorporate fettilizer int the soil.
2. Place in localized bands.
3. Coat fertilizer to inhibit oxidation of NH4+.
4. Sulfer coat urea
5. Frequent aplications in small amounts.