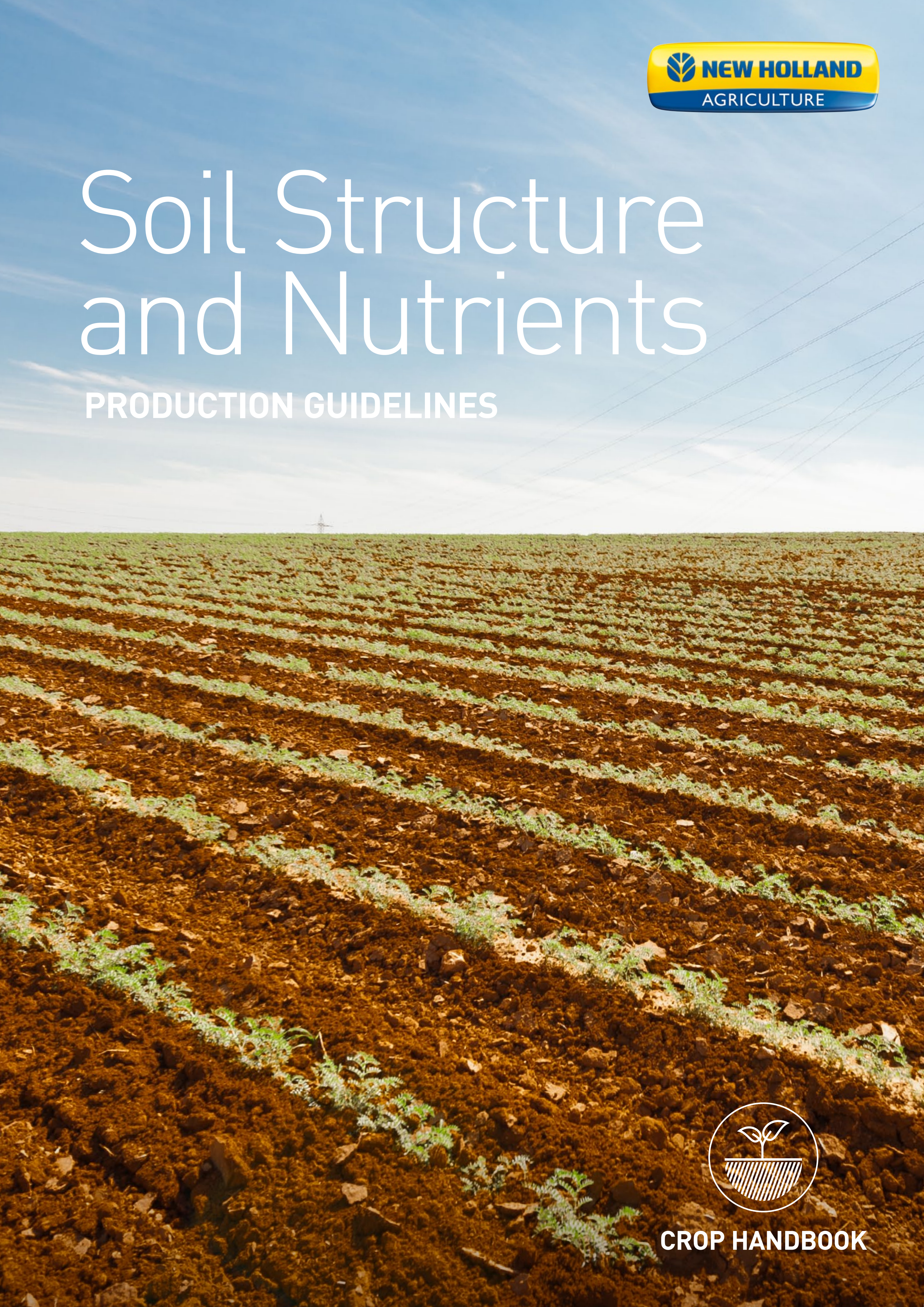
NEW HOLLAND AGRICULTURE

Soil Structure and Nutrients

PRODUCTION GUIDELINES



CROP HANDBOOK

Soil Structure and Nutrients

CROP HANDBOOK

Introduction to Soil Composition

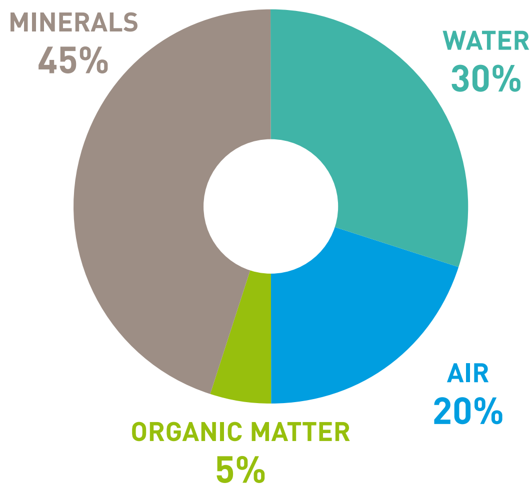
Soils are important because they are the most common base for bulk food production. Knowledge of soils is necessary to estimate soil's suitability for agricultural use.

Generally, Soil is comprised of 4 components

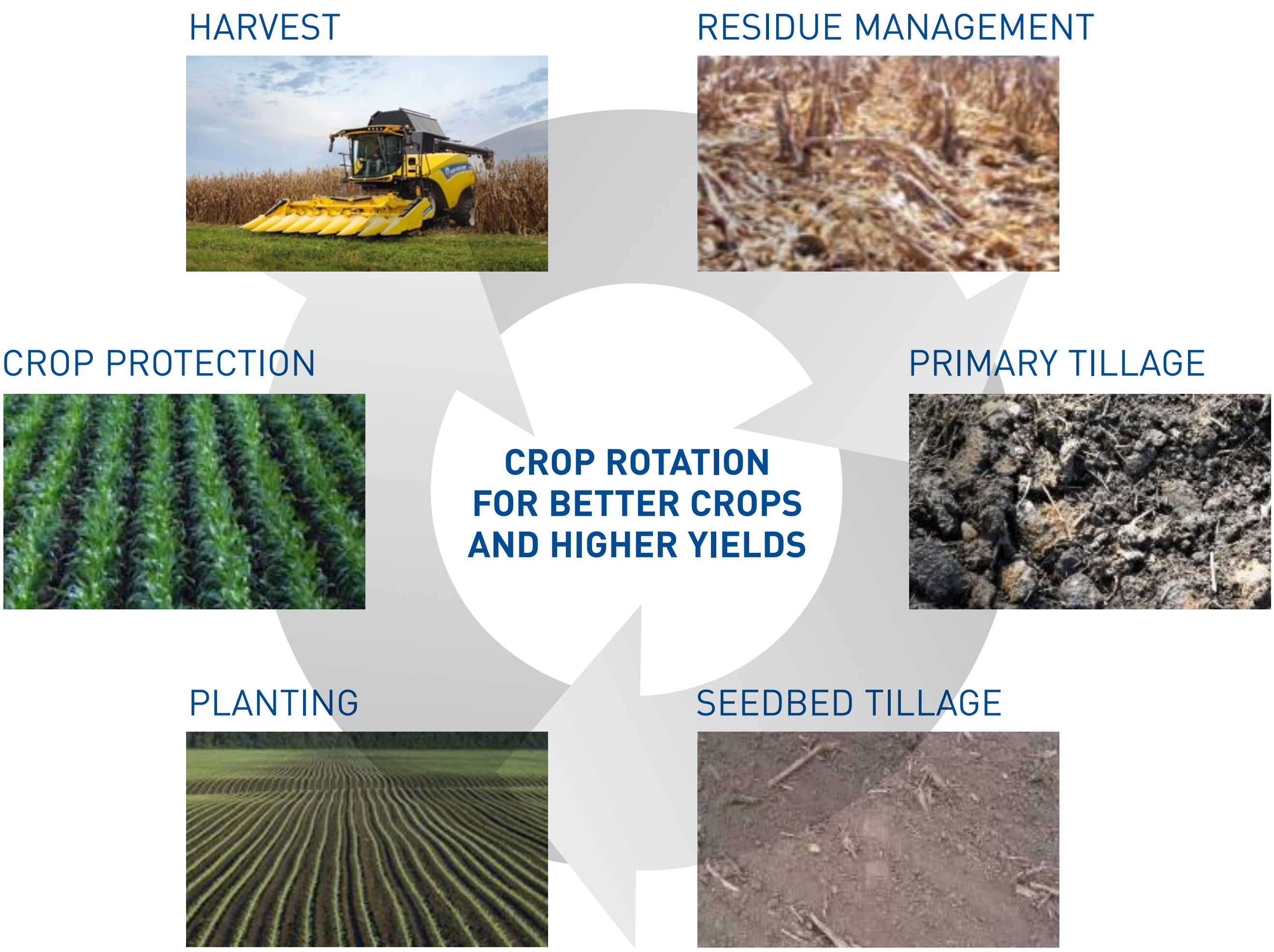
- Water (actually a solution of salts)
- Air and other gases
- Organic Matter (residue from plants, animals, bacteria and other)
- Minerals / Nutrients

Soil Organic Matter (OM) provides essential nutrients to the plant and bonds the soil together.

- Too little OM and plants will not be able to access the necessary nutrients for growth (ex: Stoney Ground or Sandy Desert)
- Too much OM and there is risk of ground water contamination and disease from excess nutrients



A SYSTEM BASED ON AGRONOMY



Soil Analysis

- Soil analysis are the right tool to determined the state of soil nutrition and make decisions about fertilizing. As showed below, soil is a complicated system, but some parameter are basic for such decision. In average fertile soils, sampling should be carried on each 4 years.
- Very many parameters can be determined analysis. However, most important and useful are:

1. Water pH

2. Content in Phosphorus (P)

3. Content in Potassium (K)

4. Content in Organic Matter (OM)

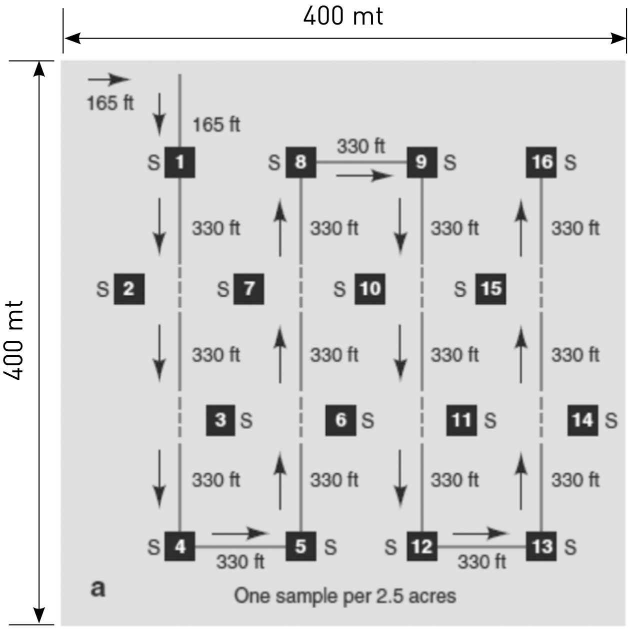
5. Total Nitrogen content and C/N ratio

6. Cation Exchange Capacity (CEC)

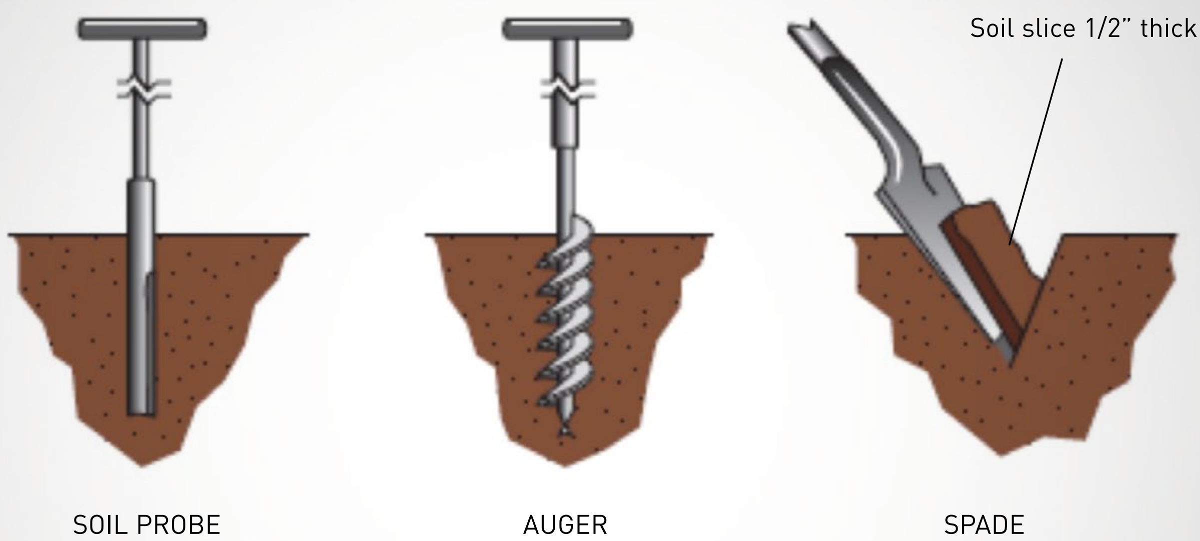
7. Soil texture

8. Content in Calcium (Ca)

9. Content in Magnesium (Mg)



40 Acres = 16 Hectares
S = Sample
1 Sample per 2.5 acres = 1 sample per Hectare

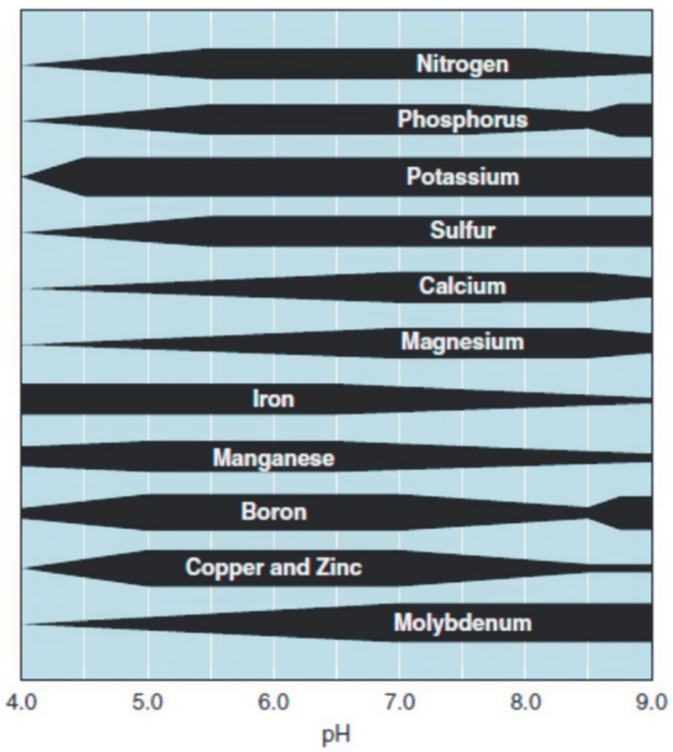


How to take soil samples with a soil probe, an auger, and a spade (Illinois University)

Soil pH (acidity and alkalinity)

- pH is a measurement of acidity. Concerning soil analysis, pH measures the acidity of soil solution (content in H+). Scale goes from 1 to 14 and the higher is the digit, the less acidic is the soil. Soil pH is a measure of the acidity or alkalinity of soil. Since pH is measured using a logarithmic scale, a decrease of 1 unit of pH means that the acidity increases by a factor of 10, so small changes in pH values can have important consequences. Soil acidification is a concern, as acidity is created by removal of bases (mainly Ca and K) by harvested crops, leaching, and an acid residual left in the soil from N fertilizers. If surface soil pH is too high or too low, the efficacy of some herbicides and other chemical reactions may be affected. Also, soil acidity affects plant growth in several ways. Whenever soil pH is low (and acidity is high), several situations may exist:
- The concentration of soluble metals, especially Al and Mn, may be toxic.
- Populations and the activity of the organisms responsible to transform N, S, and P to plant-available forms may be reduced.
- Calcium may be deficient. Usually this occurs only when the Cationic Exchange Capacity of the soil is extremely low.
- Symbiotic N fixation in legume crops is greatly impaired. The symbiotic relationship requires a narrower range of soil reaction than does the growth of plants not relying on N fixation.
- Acidic soils – particularly those low in organic matter – are poorly aggregated and have poor tilth. They are mostly unstructured (see above).
- The availability of mineral elements to plants may be affected. Figure below shows the relationship between soil pH and nutrient availability (the wider the dark bar, the greater the nutrient availability). For example, the availability of P is greatest in the pH range between 5.5 and 7.5, dropping off below 5.5. In other words, for a given soil, if P is applied at pH 6, there will be more of it available than if the same amount is applied when the soil pH is below 5.5.
- Because the activity of OM is increased greatly as soil acidity is decreased, OM deficiencies usually can be corrected by liming.

AVAILABILITY OF NUTRIENTS IN RELATION TO PH



SUGGESTED PH GOALS

- A soil test every 4 years is the best way to check pH levels. For cash grain systems and pasture grasses (not alfalfa or clover), maintaining a pH of at least 6.0 is a realistic goal. If the soil test shows that the pH is 6.0 or less, apply limestone.
  After the initial investment, it costs little more to maintain a pH at 6.5 than at 6.0. The profit over 10 years will be little affected because the increased yield will approximately offset the cost of the extra limestone plus interest. In contrast, a profitable yield response from raising the pH above 6.5 in cash grain systems is unlikely.
- For applications rates of limestone in order to correct pH, see Ca.
- Mechanism of acidity neutralization by Ca compounds:

$$CaO + 2H^{+} = Ca^{++} + H_2O$$

Phosphorus (P)

- P is an essential component of Nucleic acids, phospholipids and other chemical substances responsible for, among other, energy transfer in cells.
- Presence of available P is particularly critical in first stages of plants' growth, particularly in wet weather conditions and when temperatures are low.
- Fertilizers' producers show the content in P as "P_2O_5" (phosphorus pentoxide).
- Content of available P in soil is carried out by several different methods as Olsen, Bray & Kurtz, Mehlich3. Consequently, the quantity of P or P_2O_5 is given in different units as mg per kg, parts per millions, lbs. per acre.
- For equivalence of P and P_2O_5 content when using different analysis methods, see charts below.

SOIL CONTENT	OLSEN TEST	BRAY & KURTZ TEST
Insufficient	<10 ppm P	<20 ppm P
Average	10-20	20-40
Good	>20	>40

1 ppm= 1 mg/kg

TRANSFORMATION FACTOR

P → P_2O_5: X 2,29

P_2O_5 → P: X 0,44

Potassium (K)

- K is also an essential component of cells matrix, and intervenes in metabolic processes at the plants growth points. K is essential for water pressure balance inside the cells and sugar metabolism.
- Presence of available K is not so critical in first stages of plants' developments: however this becomes critical in later stages.
- As a rule, in soils available K quantities are bigger than P.
- Fertilizers' producers show the content in K as "K_2O" (potassium oxide). Potash is the common name for different fertilizers based on K.
- Content of available K in soil is carried out by different methods as ammonium acetate (NH_4 acetate) and barium chloride (Ba Cl_2). The quantity of K or K_2O is given in different units as mg per kg, ppm, lbs. per acre, K meq/100gr.
- For equivalence of K and K_2O content when using different analysis methods, see charts below.

SOIL CONTENT	AMMONIUM ACETATE TEST
Insufficient	<100 ppm K
Average	100-150
Good	>150

1 ppm= 1 mg/kg

TRANSFORMATION FACTOR

K_2O → K: X 0,83

K → K_2O: X 1,20

TRANSFORMATION FACTOR

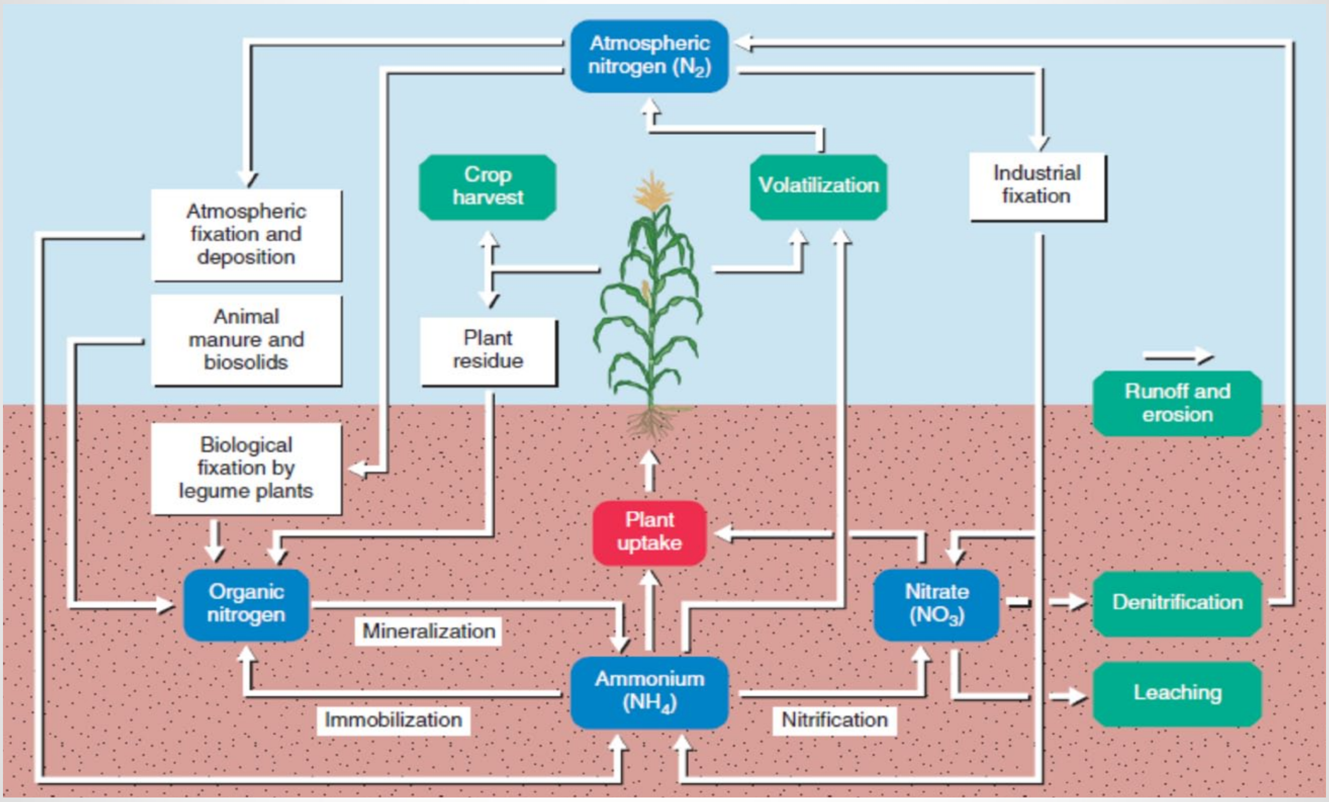
Kmeq/100gr → K ppm: X 390

K ppm → Kmeq/100gr: X 0,00256

Organic Matter (OM) and Nitrogen (N)

- OM in soil derives from decay of animal and vegetal tissue or byproducts. OM is an essential component of healthy soils, because influences both chemical and physical fertility.
- A content between 2 and 5% of OM is considered good.
- About 5% of OM is made by N: about 2% of N becomes available for plants every year. This process (mineralization of N) depends on many factors, so these digit are only a rough estimate. N content in soil as determined by analysis is a useful parameter, but is not the base for fertilizers' rates.
- N fertilization rates are rather calculated on the basis of removals by the crops with the yield (grain, forage etc...)
- OM improve the Cationic Exchange Capacity of soils. This means that nutrients under form of ions are exchanged between soil matrix (mostly OM and clay) and soil solution, hus becoming mobile and available for plants.

THE NITROGEN CYCLE



(University of Illinois)

NITROGEN (N)

- Approximately 78% of the air above an hectare of land is nitrogen (N). Unfortunately, grain crops such as corn and wheat cannot use this N because it is in N_2 form, which is very inert. This means that grain crops need to get their N from sources such as manure and fertilizer, in which the N is in forms that the plants can take up and use.
- Because plants have more N than any other element besides those that come from the air or water (Carbon, Hydrogen, and Oxygen), Nitrogen is the most limiting element in grain crop growth under most natural (unfarmed) agriculture. N is part of proteins and nucleic acids, which are the very essence of life.
- As showed above, N is tight bound with the OM dynamics in soil. This dynamics depend on many factors, as weather, temperature, moisture, symbiotic activity, microbes: thus, it is impossible measuring the quantity of N produced by OM every year: only estimate is possible.
- When grasses depend fully on N content in soils, legumes can extract N from the air through symbiosis with Azotobacter strains which settle in the roots of such plants as clover, soybean and alfalfa.
- Lack of N can occur at all stages of plants' life.
- Fertilizers' producer show the content of N as "N", so no transformation factors are needed in order to calculate the application rates of N fertilizers.
- When P and K are not very mobile into soil and do not evaporate, N does. This means that losses of N via leaching or evaporation can be important. There are several types of N fertilizers, so a choice is possible in order to avoid or minimize losses when applying N.
- Needs for N in crops are estimated on the basis of N removal with the products and by products of a given crop per year, plus estimated losses of N from soil per year.
- Protein in vegetal = 6,38 x Total Kjeldhal Nitrogen.

Carbon/Nitrogen ratio (C/N ratio)

- C/N ratio is a measure of processes (mineralization and immobilization) by which:
  1. organic N is converted to NH_4, thus becoming available for plants and
  2. mineral N is fixed in OM and microbes, thus becoming not available for plants.
     C/N ratio depends on many factors, as microbial life in soil, pH, matrix of soil and so on.
- Ideally, C/N equals 10, which is typical for stabilized humus.
- When C/N >11, microbes will need much Nitrogen to attack C in OM and grow; thus N content in soil available for plants decreases. This is a typical situation when high quantities of residues are incorporated into the soil and no N fertilizers are applied.
- When C/N <9, at the contrary, mineral forms of N can be lost.

CLASSIFICATION OF SOILS ON THE BASE OF C/N RATIO
OM AND N DYNAMICS

C/N RATIO	SOIL	ORGANIC MATTER CONTENT	N
<9	mineralized	decreases	available for crops, partially lost
about 10	humus content and composition is ideal	steady	steady
>11	humified	steady-decreases	fixed in microbes

Cationic Exchange Capacity (CEC)

A MEASUREMENT OF CHEMICAL ACTIVITY OF SOILS

- CEC is the capacity of the surface of soil matrix to exchange cations with the solution moving into the soil. Chemical elements exist in solution as cations (positively charged ions) or anions (negatively charged ions). In the soil solution, the plant nutrients hydrogen (H^+), Ca^{++}, Mg^{++}, K^+, ammonium (NH_4^+), Fe^{++}, Mn^{++}, Zn^{++}, and Cu^{++} exist as cations. The same is true for non-plant nutrients such as sodium (Na^+), barium (Ba^{++}), and metals of environmental concern, including mercury (Hg), cadmium (Cd), chromium (Cr), and others. Cation exchange capacity (CEC) is a measure of the amount of attraction for the soil with these chemical elements.
- OM and clay are important, among other, because they determine the CEC.
- In soil, a high CEC is desirable, but not necessary, for high crop yields, as it is not a direct determining factor for yield. CEC facilitates retention of positively charged chemical elements from leaching, yet it gives nutrients to a growing plant root by an exchange of H^+. Cation exchange capacity in soil increases when negatively charged electrostatic charges in minerals (mostly clay) and organic matter (OM) are present.
- The CEC of organic residues is low but increases as the residues convert to humus, which requires from 5 years to centuries. Thus, farming practices that reduce soil erosion and maintain soil humus favor the maintenance of CEC. It is influenced very little by fertilization, slightly decreased with soil acidification, and slightly increased with liming.
- Depending on the amount of clay and humus, soil types have the following characteristic amounts of Cation exchange (in units of mill equivalent per 100 grams of soil):

1. **Sandy soils** → less than 4
2. **Light-colored silt-loam soils** → 8 to 12
3. **Dark-colored silt-loam soils** → 15 to 22
4. **Clay soils** → 18 to 30
5. **Evaluation of CEC** → <10 scarce; 10-20 average; >20 good.

Soil Structure and Types

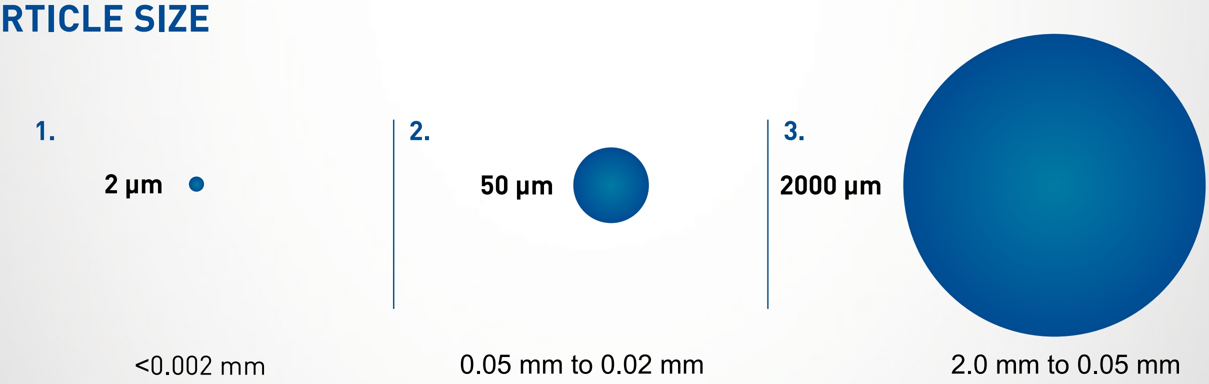
The particles in soil aggregate in different ways.

- When they aggregate in globular structures, there is room for air and soil solution (water plus nutrients). The soil is structured and in good conditions for plant growth. This conditions depends on many factors, mainly minerals' composition, OM, Ca, and tillage practices.
- When minerals do not aggregate, soil is unstructured. Causes are many, mainly poor content in OM, poor content in Ca, mineral composition, bad tillage practices bringing to compaction. In this conditions, there is less or no room for water and air. Plants growth is difficult, because nutrients can not be absorbed by roots.
- Farmers can intervene in improving soil structure by adding OM (residue, manure and similar), adding Ca (liming) and choosing the proper tillage system. Changing mineral composition is too much expensive in common farming.

SOIL TEXTURE

- Soil texture is defined as the relative abundance of the 3 particle size classes:
  1. **Clay** – Fine particles → 0-2 µm
  2. **Silt** – Medium size particles → 2-50 µm*
  3. **Sand** – Coarse size particles → 50-2000 µm*
- "Ideal" soil texture is comprised of a mixture of these three types of particle sizes (ClLo): ideal density is 1,3-1,4 (grams per cubic mm).
- * Different countries have varying upper limits for silt particle size. For this demonstration, we have chosen to use FAO/USDA for commonality.

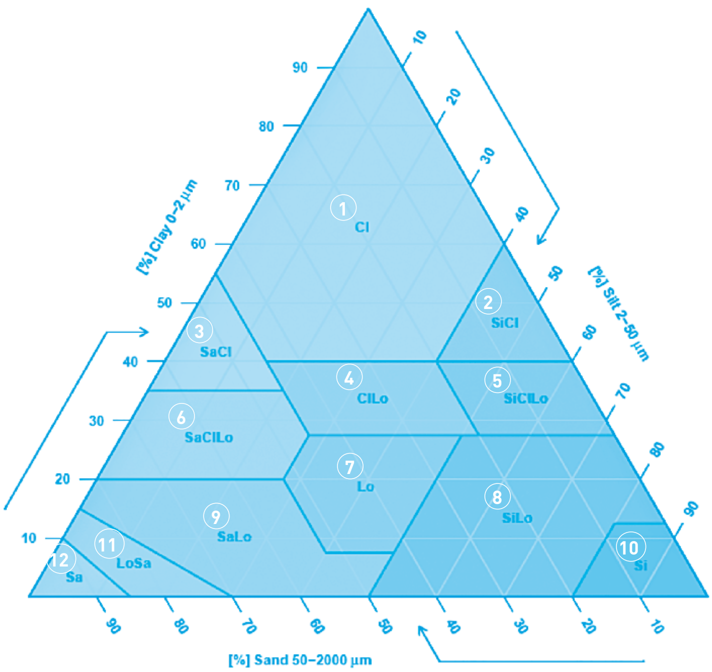
PARTICLE SIZE



USDA SOIL TEXTURE CLASSIFICATIONS

- Soil texture is rarely only one particle size, but is instead a mixture of all three.
- Based on the mixture, the FAO/USDA have created 12 soil classifications:

Name	Abbreviation
1. Clay	Cl
2. Silty clay	SiCl
3. Sandy clay	SaCl
4. Clay loam	ClLo
5. Silty clay loam	SiClLo
6. Sandy clay loam	SaClLo
7. Loam	Lo
8. Silty loam	SiLo
9. Sandy loam	SaLo
10. Silt	Si
11. Loamy sand	LoSa
12. Sand	Sa



RELATIONSHIPS AMONG SOIL COMPONENTS

This chart is broadly used for determining what type of soil we are dealing with. It is possible to estimate texture of soil "on the field" (Portland Cement Association. 1962. PCA Soil Primer)

Sand: Individual grains can be seen and felt readily. Squeezed in the hand when dry, this soil will fall apart when the pressure is released. Squeezed when moist, it will form a cast that will hold its shape when the pressure is released but will crumble when touched.

Sandy loam: Consists largely of sand, but has enough silt and clay present to give it a small amount of stability. Individual sand grains can be seen and felt readily. Squeezed in the hand when dry, this soil will fall apart when the pressure is released. Squeezed when moist, it forms a cast that will not only hold its shape when the pressure is released but will withstand careful handling without breaking. The stability of the moist cast differentiates this soil from sand.

Loam: Consists of an even mixture of the different sizes of sand and of silt and clay. It is easily crumbled when dry and has a slightly gritty, yet fairly smooth feel. It is slightly plastic. Squeezed in the hand when dry, it will form a cast that will withstand careful handling. The cast formed of moist soil can be handled freely without breaking.

Silt loam: Consists of a moderate amount of fine grades of sand, a small amount of clay, and a large quantity of silt particles. Lumps in a dry, undisturbed state appear quite cloddy but they can be pulverized readily; the soil then feels soft and floury. When wet, silt loam runs together and puddles. Either dry or moist casts can be handled freely without breaking. When a ball of moist soil is pressed between thumb and finger, it will not press out into a smooth, unbroken ribbon but will have a broken appearance.

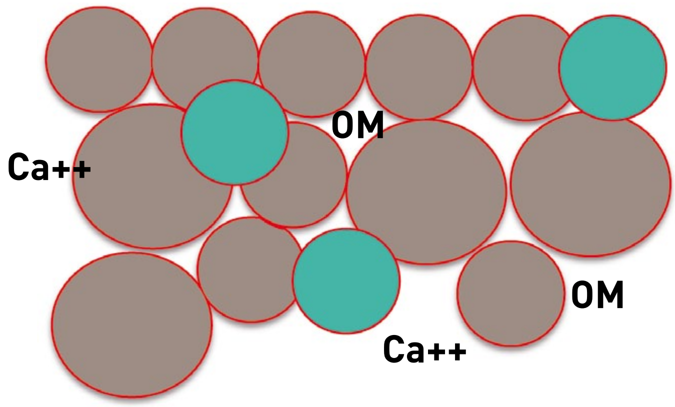
Clay loam: A fine-textured soil which breaks into clods or lumps that are hard when dry. When a ball of moist soil is pressed between the thumb and finger, it will form a thin ribbon that will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will withstand considerable handling.

Clay: A fine-textured soil that breaks into very hard clods or lumps when dry, and is plastic and unusually sticky when wet. When a ball of moist soil is pressed between the thumb and finger, it will form a long ribbon.

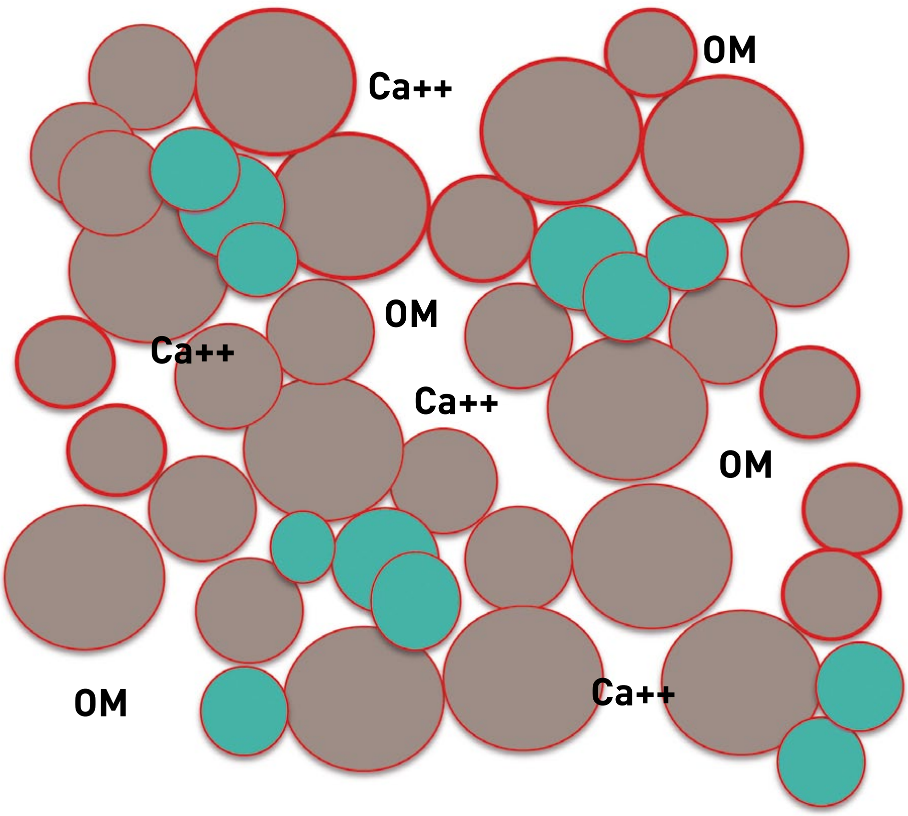
Concerning texture, agricultural use of soils has limit only for sand and loamy sand soils. Of course, other limits exist depending on factors as slope, permeability, climate, rock presence and others.

PARTICLES AGGREGATION

UNSTRUCTURED



STRUCTURED



Ca++ = Calcium Cations
OM = Organic matter

Water **Minerals** **Air** **Cationic Exchange Capacity (CEC)**

Structure of soils depends on texture, which means the way the particles the soil is made of aggregate. Structure is the result of this aggregation. A structured soil has particles aggregate in bigger formations that allows for air and water to penetrate: it means that roots can growth in a favourable environment and crops develop well. Tillage operations, performed with right timing and proper tools, improve the structure of soils. Poor timing and compaction damage the structure of soil with mostly loam or clay loam textures.

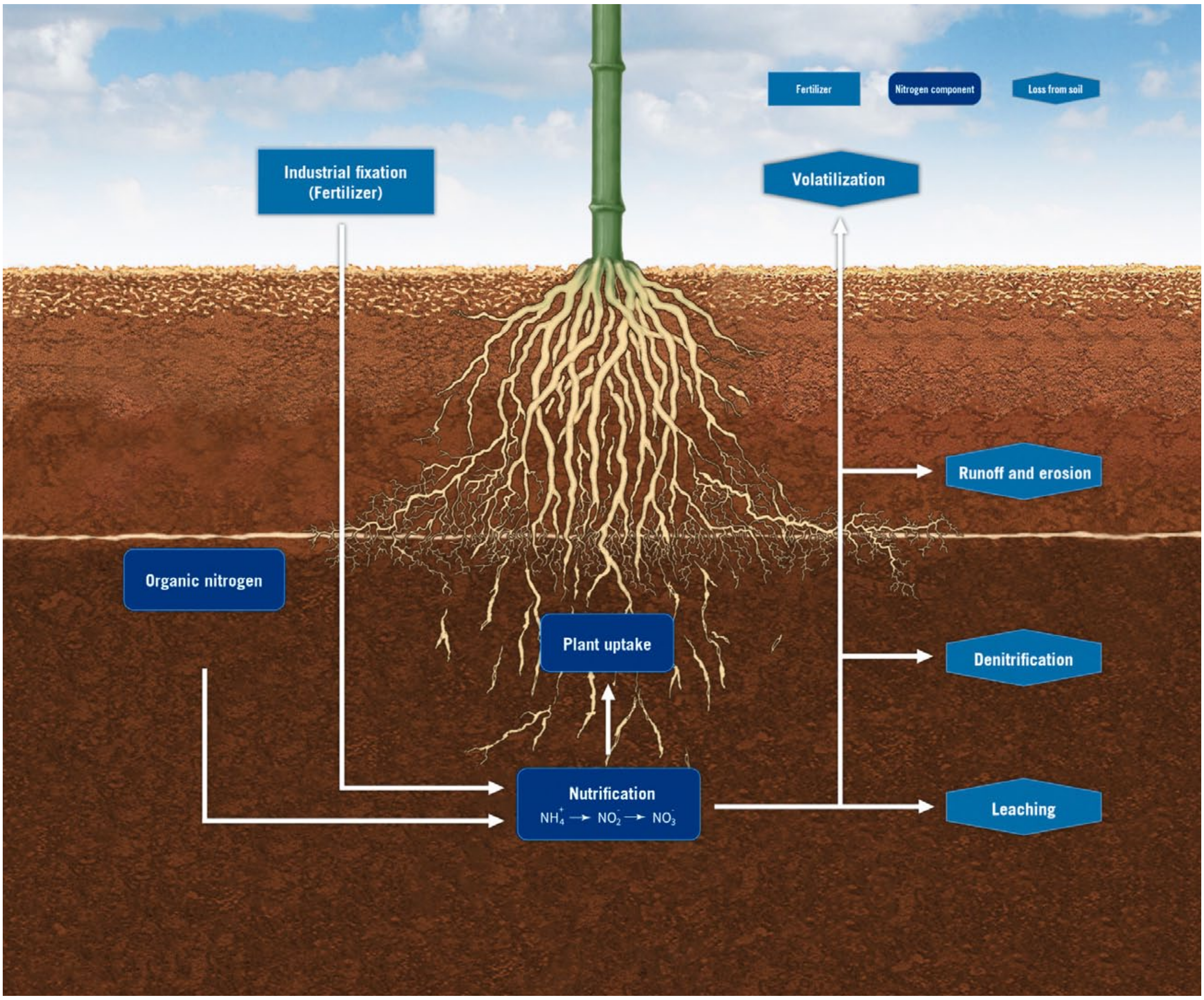
Calcium and Magnesium (Ca and Mg)

- Ca and Mg are defined as "minor macronutrients" because they are absorbed by crops in lesser quantities than P and K, but they are present in soils in larger quantities (as a rule).
- Ca plays a great role in determining soils' pH. Only in very acidic and leached soils deficiency of Ca and Mg is alike (see pH).
- A content of available Ca <2000m ppm is considered low.
- A content of available Mg <100 ppm is considered low.
- Liming is a mean to increase Ca content in soils and to correct pH.

CA COMPOUNDS QUANTITIES (TON/HA) NEEDED FOR INCREASING PH OF ONE UNITY

TYPE OF SOIL	CaO	$Ca(OH)_2$	$CaMg(CO_3)_2$	$CaCo_3$
Sandy	1-2	1.3-2.6	1.6-3.3	1.8-3.6
Silty loam (20% clay)	2-3	2.6-3.9	3.3-4.9	3.6-5.4
Clay or high OM	3-5	3.9-6.6	4.9-8.2	5.4-9

(Demolon & Giardini)



Machinery

IMPLEMENTING YOUR GROWTH PROJECTS

Crop producers know that their soil is the most precious natural resource, and better soil conditions mean higher crop yields. New Holland knows that every individual plant counts towards your bottom line and that's why we design our equipment specifically to help you maximize yield potential.

NEW HOLLAND TRACTORS

In manufacturing tractors, New Holland has always a care in choosing tires to minimize compaction of soil. This aspect becomes even more important in T7, T8 and T9 series, because the weight of machines is heavier. Not only large section tire are chosen, but also dual, trial and track options are available. The ultimate goal is to transfer the power to the ground for high traction, without damaging soil structure with compaction.




All New Holland harvesting combines series CR, CX, TC are equipped with wide tires to minimize compaction. A very important feature is the straw chopper, which chops and spreads straw and chaff on the whole width of the header. Comparative test has shown that New Holland chopper are the most performing on the market.


The outstanding results are:
1. Perfectly spread and chopped residue, which will not hinder following operations and will give organic matter to soil, thus improving structure.
2. Field where compaction has been minimized and thus ready for whatever crop and tillage system is planned.

New Holland proposes not only tractors and combine designed for less soil structure damage, but also seeding and tillage implements, as chisel plough ST 830, air carts, hoe and disk drills series P2060, P2070 and P2080. These implements are designed for minimum and no tillage cropping patterns. It means less traffic on fields, less compaction, improving soil structure. Air carts and ground engaging tools are very accurate in applying fertilizers and Ca compounds where they are needed, thus improving soils' chemical fertility and structure, in the meanwhile avoiding pollution. The result is a sustainable agriculture and a better natural environment.


AT YOUR OWN DEALER

APAC

Visit our website: **www.newholland.com**
Send us an e-mail: **international@newholland.com**

New Holland prefers AMBRA lubricants

The data indicated in this folder are approximate. The models described here can be subjected to modifications without any notice by the manufacturer. The drawings and photos may refer to equipment that is either optional or intended for other countries. Please apply to our Sales Network for any further information. Published by CNHI INTERNATIONAL SA. Brand Marketing and Communication. Bts Adv. - 09/16 - (Turin) - **AP6724N/INB**