BUILDING HEALTHY SOILS AND PLANTS

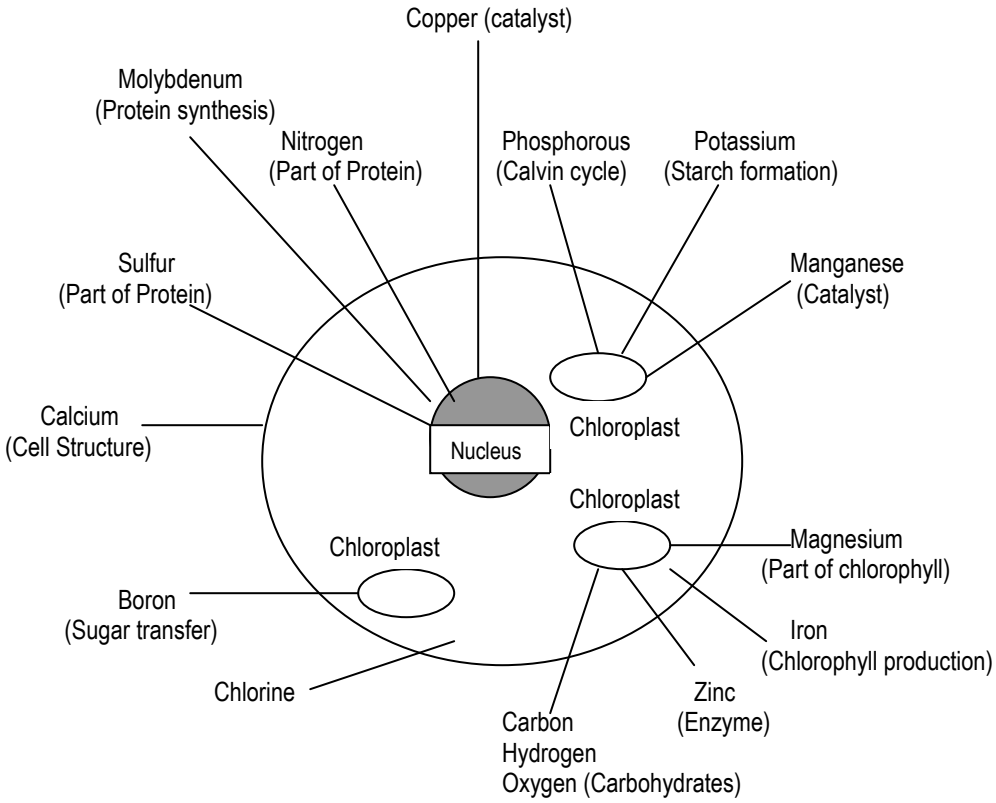
Summary

- All essential nutrients are needed to produce one plant cell.
- Productivity of soil is limited by the least available nutrient.
- Measurement of Soil Cation Exchange Capacity is needed for development of a fertilizer program to build healthy soil.
- Soil pH can only indicate acidity and alkalinity; it does not indicate how much lime or other nutrients to apply to achieve optimum soil fertility.
- Biological life in healthy soil can provide over 400 kg/ha/year of available Nitrogen.
- Pests are not attracted to healthy plants.
- Healthy soil produces quality feed and quality feed produces healthy animals.
- Excess Nitrogen fertilizer can cause animal health problems.

Building a Plant Cell

How many nutrients are needed to build a plant cell? The tag on most fertiliser bags emphasize N P K. These 3 elements are important, but a look at Figure 1 will show there is a lot more to plant nutrition. There are at least 16 essential elements needed to produce one plant cell. If any of these essential elements is missing, the cell cannot be built.

FIGURE 1



Building Soil Fertility

Productivity of soil is limited by the least available nutrient. Rebuilding soil fertility can be compared to repairing a chain. The chain will not be stronger until the weakest link is repaired, no matter how much work is done on repairing other weakened links.

Sometimes, no results are observed after applying nutrients that have been diagnosed as deficient. If the fertiliser recommendation does not include the most limiting nutrient, other deficient nutrients cannot be effective. Comparing the limited capacity of a wooden tub with broken slats to the capacity of a deficient or unbalanced soil will clarify this principle. (See illustration on last page)

Taking shortcuts with soil fertility, or relying on trial and error, can become very expensive via lost productivity and the cost of investing in the wrong fertilisers. It is important to start with the right information, i.e. a good soil analysis and an interpretation that identifies the soil limitations.

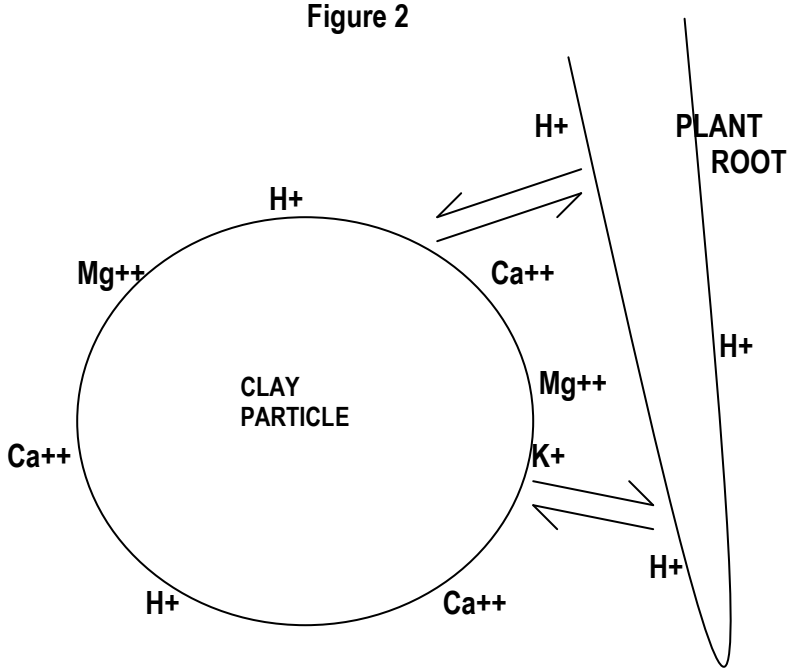
Soil Holding Capacity

Positively charged nutrients (cations) are held on the negatively charged surface of clay and humus particles in the soil (see Figure 2). Plant roots take these nutrients from the clay and humus surface and replace them with Hydrogen icons, i.e. Hydrogen is exchanged for nutrient cations.

This process is called Cation Exchange, and the amount of these cations the soil can hold is called Cation Exchange Capacity (CEC). CEC is used to identify the balance of cations in the soil, then a fertiliser program can be developed to bring the soil to the optimum balance.

Fertiliser recommendations that don't consider CEC have limited value for building healthy soil.

Figure 2



Cation Balance and The Meaning of pH

In Table 1, 'A' is a balanced, healthy, productive soil. This balance was identified after intensive research based on analysing soils that were naturally productive and healthy, and comparing them with unproductive soils. Calcium promotes good crumb structure in soil and is important for numerous other soil processes.

When Hydrogen occupies 12% of the CEC, soil pH is 6.2. If the soil fertility balance of soil 'A' is changed by replacing Calcium with Magnesium on 20% of the CEC, the result is oil 'B'. Excess Magnesium makes soils tight and hard when dry, and sticky when wet. This is a medium productivity soil that is difficult to manage. The Hydrogen % is unchanged so soil pH is still 6.2, but the soil is deficient in Calcium and needs Lime or Gypsum.

Removing Magnesium from 20% of the CEC of soil 'B' and replacing it with Sodium results in soil 'C'. This is an unproductive, saline soil. Hydrogen % remains unchanged so soil pH is still 6.2.

The pH measurement is important because many biological and chemical processes are affected by soil pH, but it can only be used to measure acidity and alkalinity, not identify which nutrients to add to bring pH and soil fertility to the optimum balance.

Table 1 shows that it is possible to have the same pH in healthy, productive soils and unproductive soils.
How accurate are lime recommendations based on pH alone?

TABLE 1

	Soil A	Soil B	Soil C
Nutrient		**Percent of CEC**	
Calcium (Ca++)	68	38	38
Magnesium (Mg++)	12	42	22
Potassium (K+)	5	5	5
Sodium (Na+)	1.5	1.5	21.5
Trace Elements	1.5	1.5	1.5
Hydrogen (H+)	12	12	12
TOTAL	100	100	100
pH	6.2	6.2	6.2

Nitrogen from Soil Organisms

One hectare of healthy, balanced soil can contain the following:-

1000 kg	of	Bacteria
1000 kg	of	Actinomycetes
1000 kg	of	Protozoa and Nematodes
1000 kg	of	Moulds and Fungi
2000 kg	of	Earthworms
7000 kg/ha		Total

These organisms are almost pure protein, which is usually 16% Nitrogen (N). If calculations are based on only 5% N and only 2% of this 5% N is available to plants, then:-

5% of 7000 kg	=	350 kg
2% of 350 kg	=	7 kg

The approximate life expectancy of these organisms is 7-70 hrs. If calculations are based on 70 hrs, there are 125 life cycles per year. Allowing for conditions to be unsuitable for 6 months of the year, Nitrogen release is calculated on only 62.5 life cycles.

7 kg x 52.5 cycles	=	437.5 kg/year

This is an indication of potential Nitrogen availability in a healthy soil. How much Nitrogen fertiliser do you really need if your soil is healthy? Are you investing your money in the right fertilisers?

Pest Resistance of Healthy Plants

Energy from the sun combines Carbon Dioxide (CO_2) from the air and Water (H_2O) taken up by the plant to produce Carbohydrates. This process takes place in the Chloroplasts in plant cells. This process is called the Calvin Cycle and can be simplified as:-

$(CO_2 + H_2O) \times 6$	=>	$C_6H_{12}O_6$ (SUGAR)
$C_6H_{12}O_6 - H_2O$	=>	$C_6H_{10}O_5$ (STARCH)

While the plant is stress-free, this process continues to produce Sugar which is then converted to starch and accumulated for later use. Sugar does not accumulate when the process is working efficiently.

If the plant is stressed by nutrient deficiency or imbalance, drought, heat etc., Starch production slows down but Sugar production continues while sunlight is available. This leads to an accumulation of Sugar.

Insects can digest simple sugars but their system cannot digest starch. While the plant is healthy, there is insufficient Sugar to sustain them, so they look elsewhere. A stressed plant with Sugar accumulation provides a banquet for insects.

Chemical control of pests treats the symptoms of the problem while the real cause is still attracting more pests. If the cause is corrected, the symptoms will disappear and chemical control won't be needed.

Soil Fertility and Animal Health

The saying "You are what you eat" applies to animals also. Soil fertility management directly affects cow health. Healthy soil produces quality feed; quality feed produces healthy animals. Fertiliser programs based on high Nitrogen rates produce bulk of feed, but it is often poor quality due to mineral imbalance.

High Nitrogen use on pastures can be detrimental to cow health. Excess Nitrates block the conversion of Carotene in plants to Vitamin A in animals, so cows can be Vitamin A deficient on seemingly good pasture.

Symptoms of Vitamin A deficiency include:-

poor adaptation to dark	eye infections
weak, thick bones	kidney degeneration
abortions	birth of weak calves
muscular incoordination	lameless in hock or knee joints
pneumonia	diarrhoea

High Nitrogen use also causes Copper deficiency which leads to weak hoof tissue, making cows more susceptible to footrot in wet weather. Photosensitization due to Iodine deficiency is another side effect of excess Nitrogen. The usual symptom is sunburn on light coloured patches and backs of udders.

The alternative is a balanced approach to soil fertility resulting in quality pasture and healthy animals.

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