Soil Fertility Management

SS 2101 Soil Plant Relations and Nutrient Management

Dr. S. Rajika Amarasinghe

Module 1.4: Soil fertility management

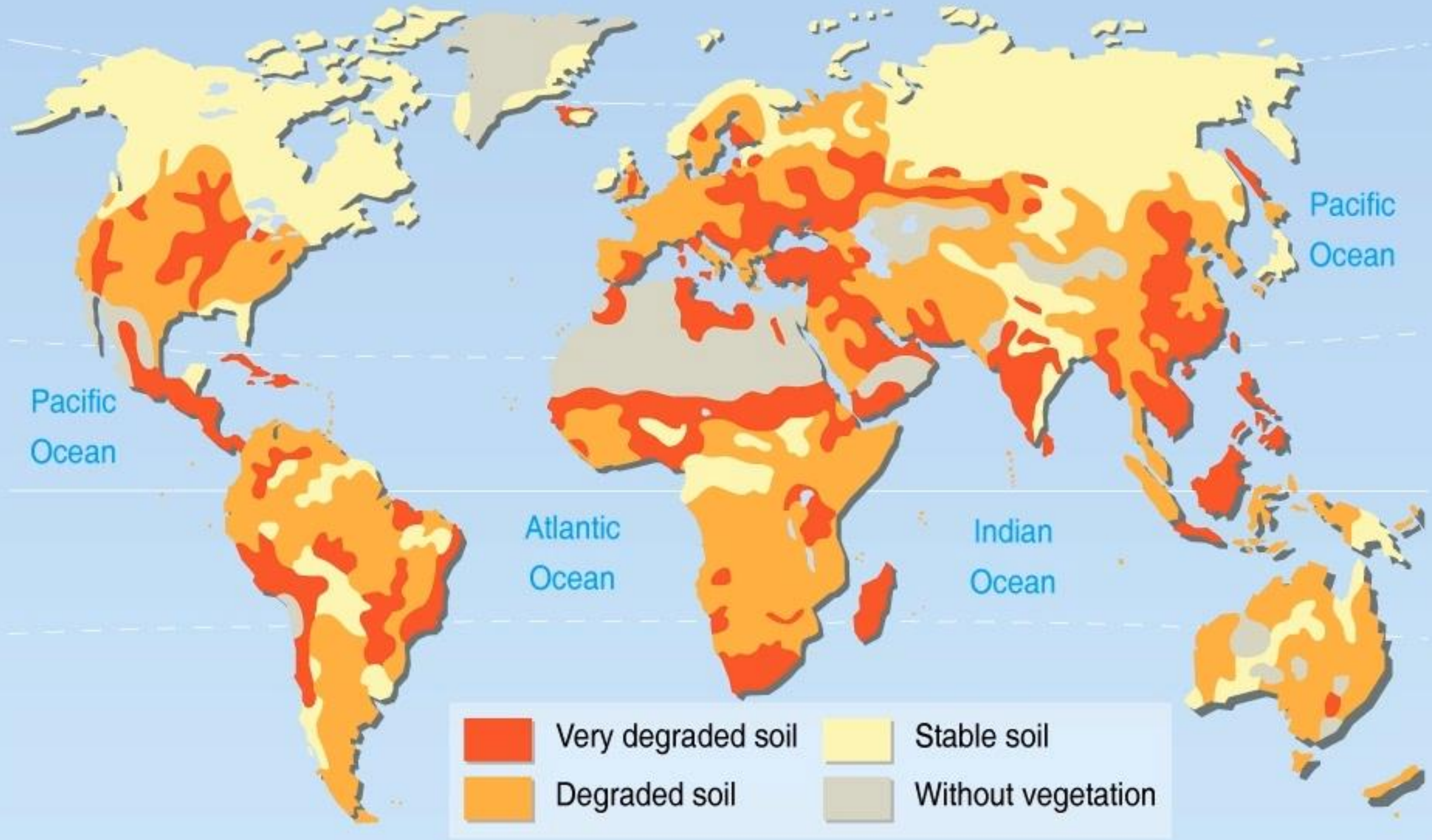
- **Topic 1.4.1: Nutrient resources and conservation**
  - **Lesson1.4.1.1:** Nutrient resources (renewable/recyclable/reusable)
  - **Lesson 1.4.1.2:** Nutrient resource management & conservation
- **Topic 1.4.2: Soil fertility evaluation**
  - **Lesson 1.4.2.1:** Plant deficiency symptoms and field observations
  - **Lesson 1.4.2.2:** Plant and soil analyses
- **Topic 1.4.3: Inorganic commercial fertilizers**
  - **Lesson 1.4.3.1:** Fertilizer materials-nitrogen, phosphorus and potassium
  - **Lesson 1.4.3.2**: Fate of fertilizer materials and the concept of limiting factor
  - **Lesson 1.4.3.3** Timing and application of fertilizers
- **Topic 1.4.4: Application of organic amendments**
  - **Lesson 1.4.4.1**: Crops residue/waste, manure, composts
  - **Lesson 1.4.4.2:** Advantages of applying Organic amendments
  - **Lesson 1.4.4.2:** Digestion methods of organic matter

Aims

- should be able to identify, categorize plant nutrients and outline the roles of them.
- should be able to identify the plant nutrient deficiencies and how it can be analyze through soil-plant analytical methods.
- should be able to understand the role of inorganic and organic fertilizers and differentiate the disadvantages and advantages of each fertilizer application methods

Sustainable Cultivation???

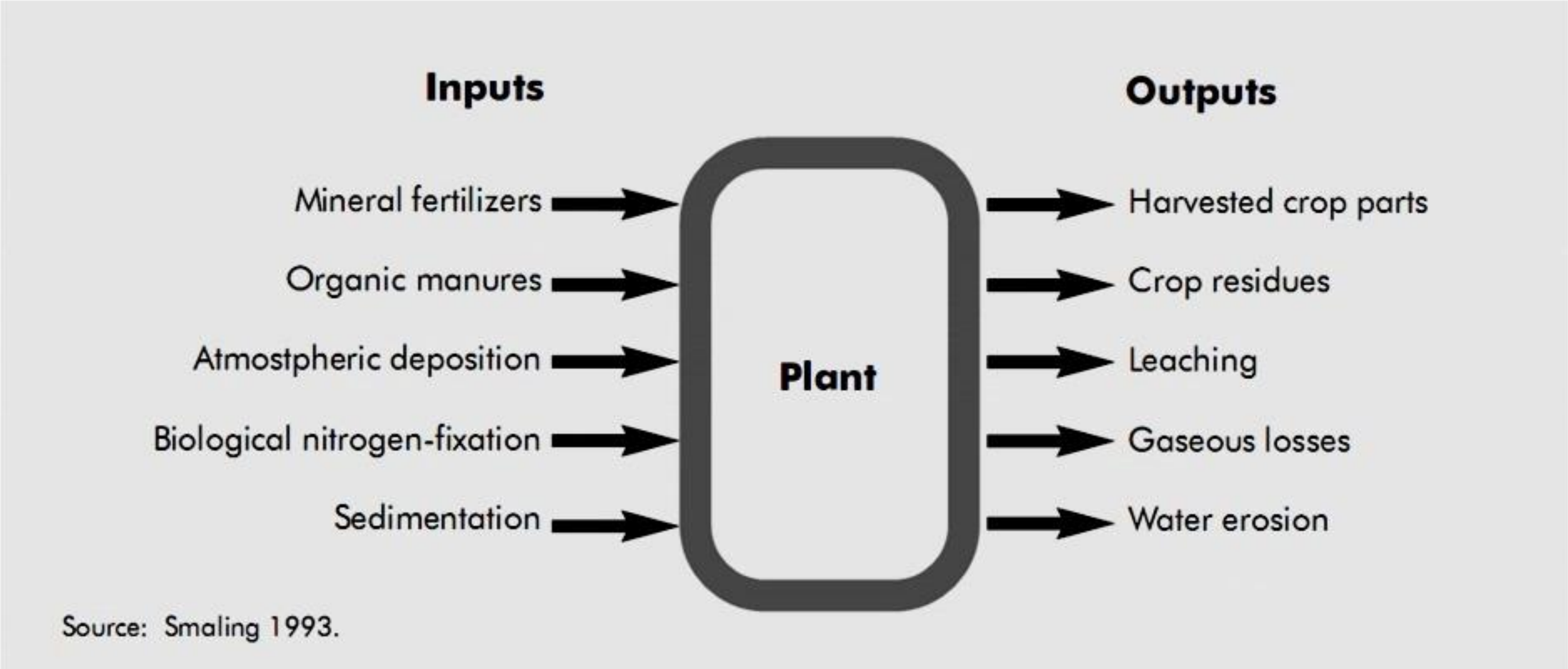
Soil degradation



Source: UNEP, International Soil Reference and Information Centre (ISRIC), World Atlas of Desertification, 1997.

Philippe Rekacewicz, UNEP/GRID-Arendal

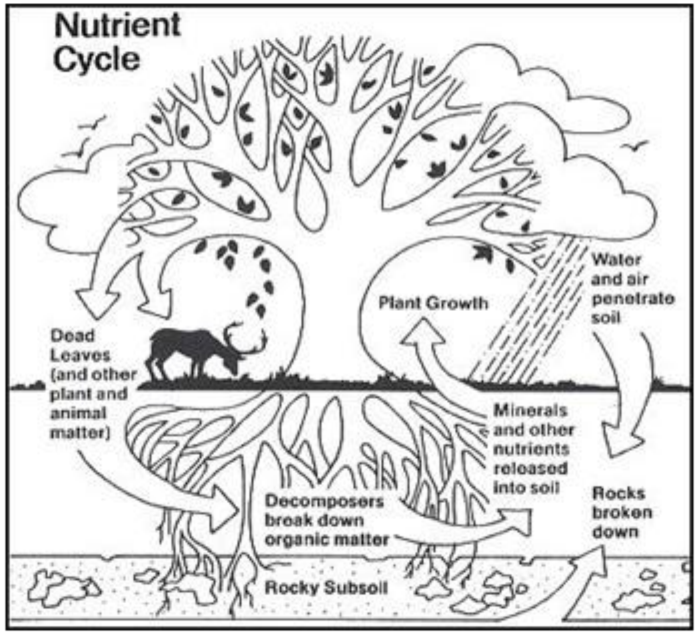
Conservation of soil nutrients and nutrient resources



Plant nutrient balance system

Goals of nutrient management

- Cost effective production by high quality/ healthy plants
- Efficient use and conservation of nutrient resources
- Maintain or enhance the soil quality (physical, chemical, and biological condition of soil)
- Reduce the environmental pollution (surface and ground water resources, soil..etc).
- Continuous supply of plant nutrients.



refers to the sustainable use of a resource at a rate slower than that at which the resource is regenerated

Conservation of nutrient resources

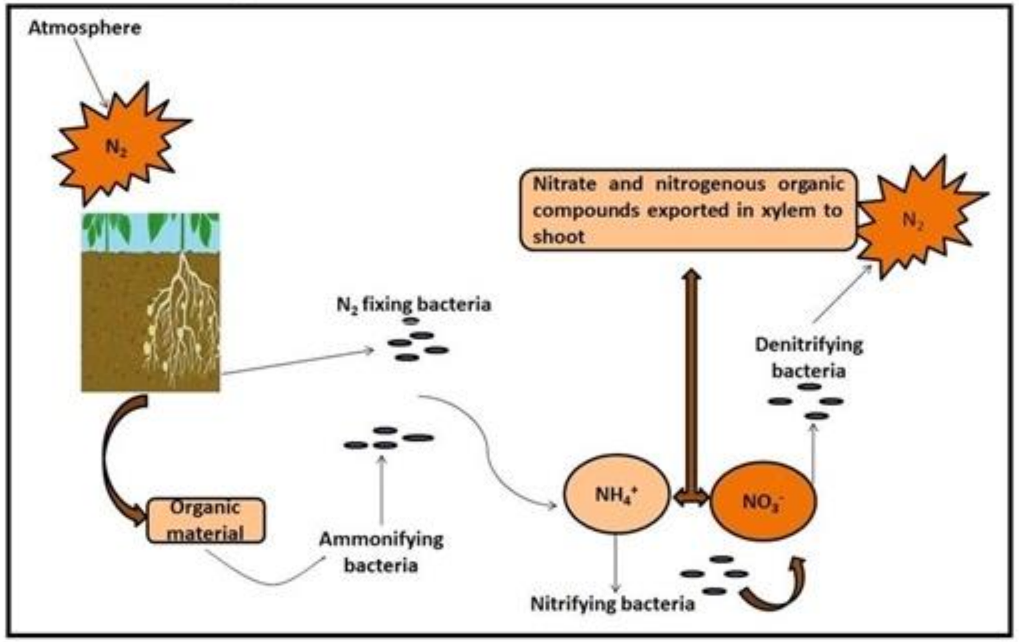
1. Recycling/reuse of resources

recycled refers to the sustainable use of a non-renewable resource by using it in a cyclical way.

- maure, compost, crop residues/mulching , Bio Char

2. Renewable resources

- crop rotations
- BNF (Biological Nitrogen Fixation)



Integrated Plant Nutrient Management (IPNM)

What is IPNM?

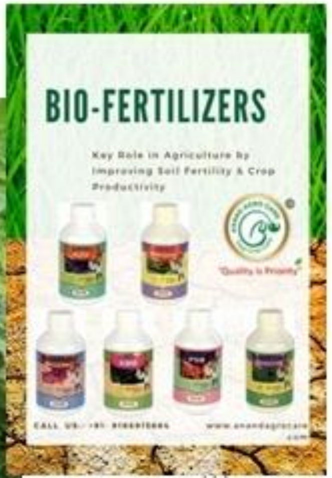
IPNM is the adjustment of plant nutrient supply to an optimum level for sustainable crop production.

It involves proper combination of chemical fertilizers and organic fertilizers, and bio-fertilizers (inoculum) suitable to the system of land use and ecological, social and economic conditions

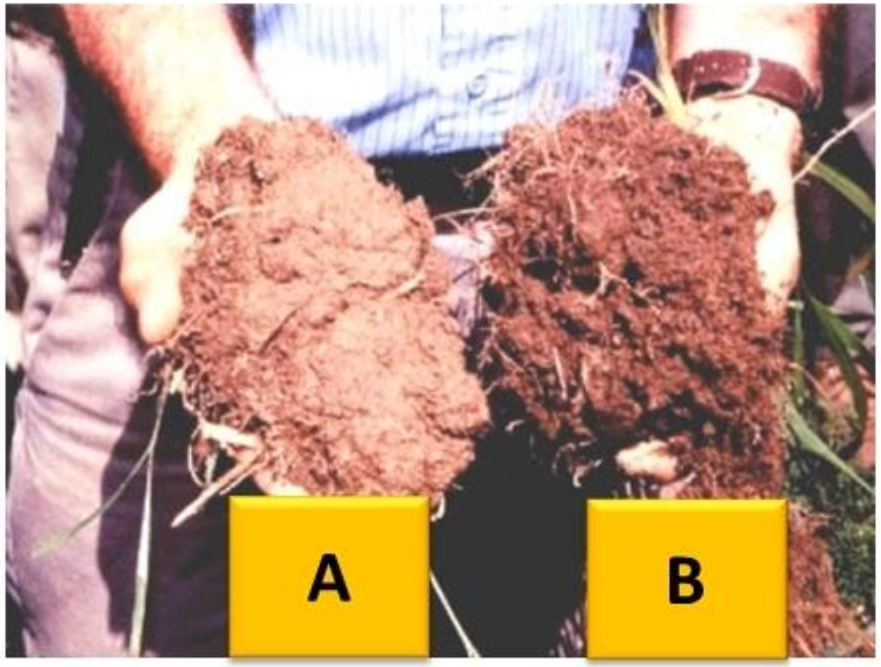
Inorganic Fertilizers

Organic Fertilizers

Green manures



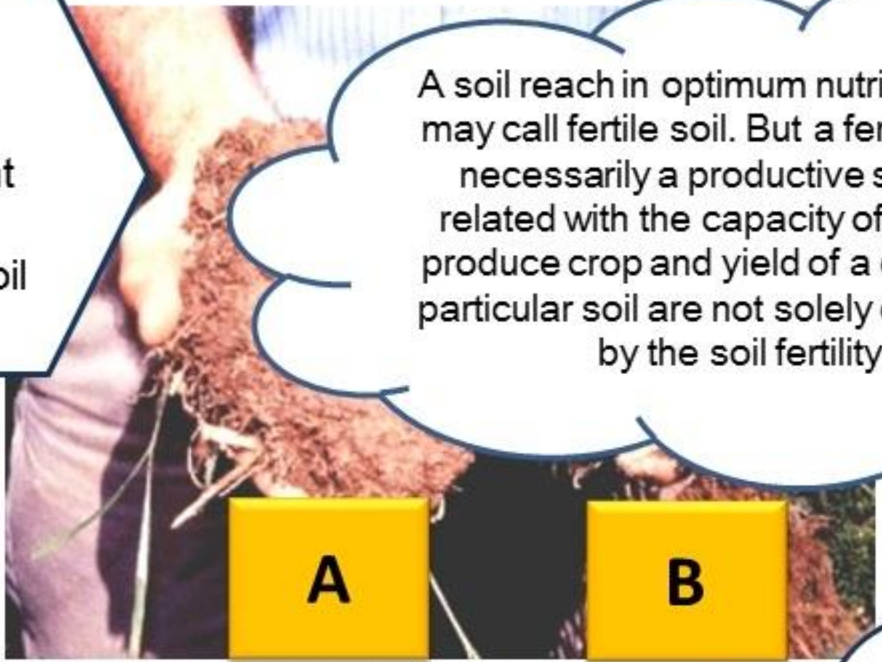
Fertility vs Productivity



Fertility vs Productivity

Soil fertility is related with inherent plant available nutrient status of soil determined by soil testing.

A soil reach in optimum nutrient content may call fertile soil. But a fertile soil **not** necessarily a productive soil which related with the capacity of the soil to produce crop and yield of a crop from a particular soil are not solely determined by the soil fertility.



To convert a fertile soil to a productive soil we must understand the factors that promote or degrade productivity and how we can mange theses factors to ensure the soil remains productive

With sound agronomic practices we can make the soil both fertile and productive

Besides soil fertility , drainage condition, drought exposure, flood prone, recurring pest problem, weeds, biological properties of a soil climate are also important factors

Soil fertility evaluation

- **Soil Fertility:**

  It is the capacity of soil to supply essential nutrients to plants in adequate amounts and in a balanced proportion

Soil fertility is related with inherent plant available nutrient status of soil determined by soil testing.

Evaluation of soil fertility are based on

- – Visual observation (Qualitative)
- – Soil and plant testing (Quantitative)

The major techniques used to evaluate soil fertility

1. Plant defficiency symptoms and field observations
2. Analysis of the nutrient content of the plant tissue
3. Soil analysis for the amount of variable nutrient

Qualitative Test

Quantitative Test

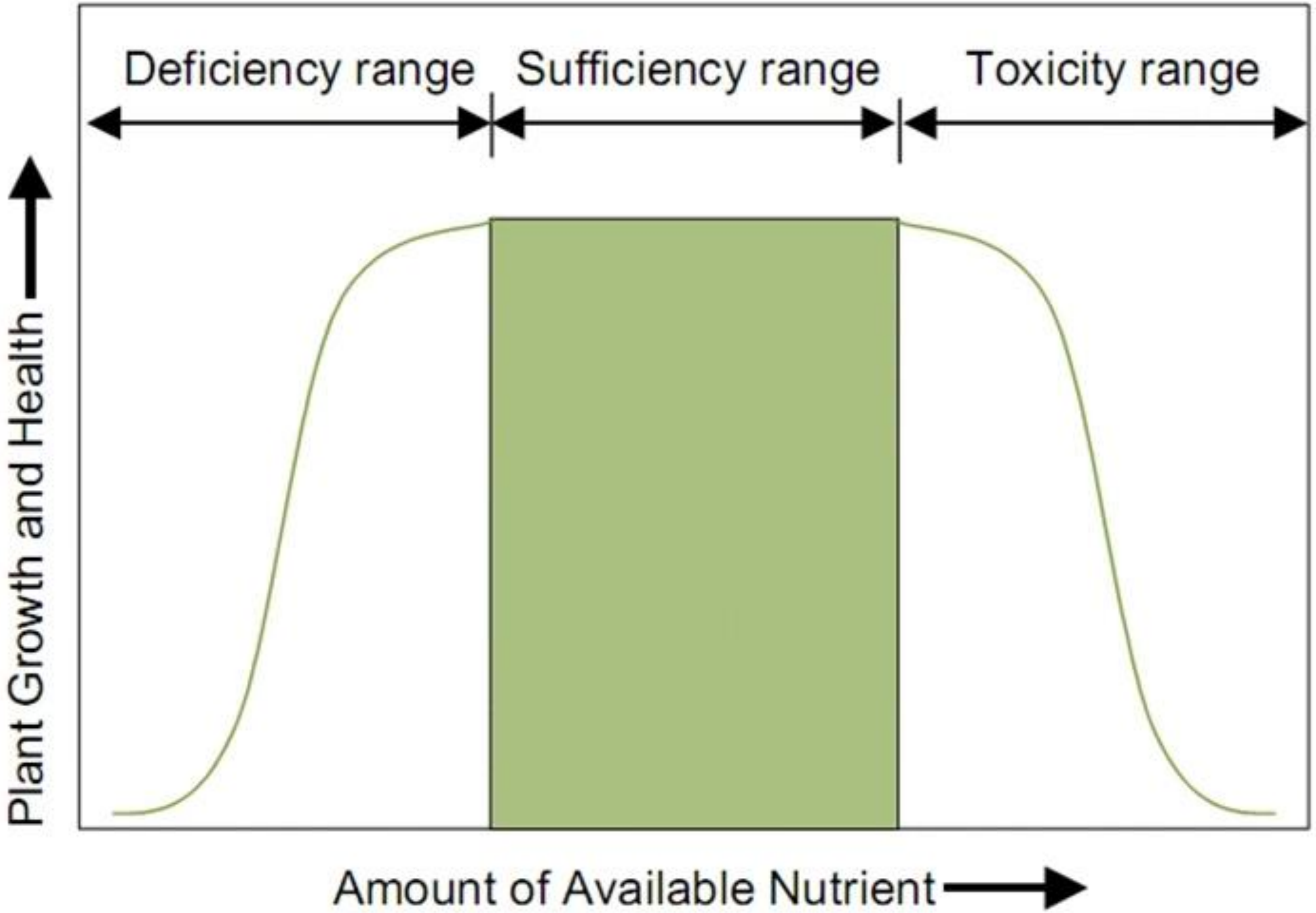


Figure Relationship between plant growth and health and amount of nutrient available (Brady and Weil, 1999).

Plant Deficiency Symptoms and Field Observation

- Characteristic symptoms on leaves and other plant parts may appear.

Disadvantages:

1. Confused with herbicide damages, pest damages, or damage from poor aeration
2. When deficiency symptoms become obvious, may be late for fertilizer application (due to hidden hunger)

Hidden hunger refers to a situation in which a crop needs more of a given nutrient yet has shown no deficiency symptoms. The nutrient content is above the deficiency symptom zone but still considerably needed for optimum crop production.

Part 2

Soil Fertility Management

Dr. S R Amarasinghe

SS2101@2020

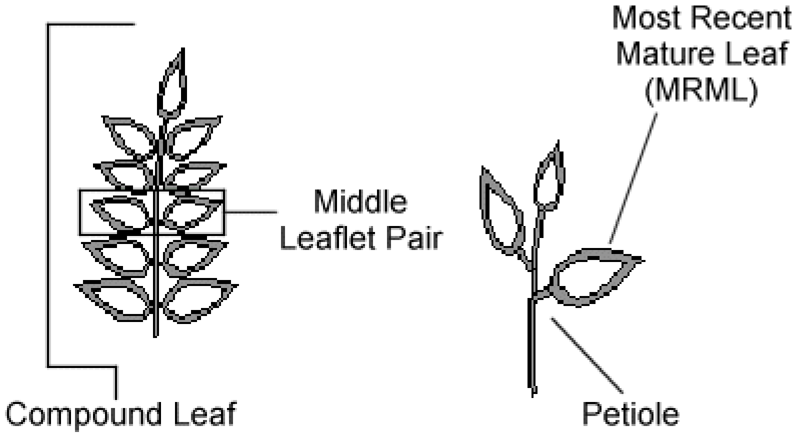
Plant and Soil Analysis

Plant analysis

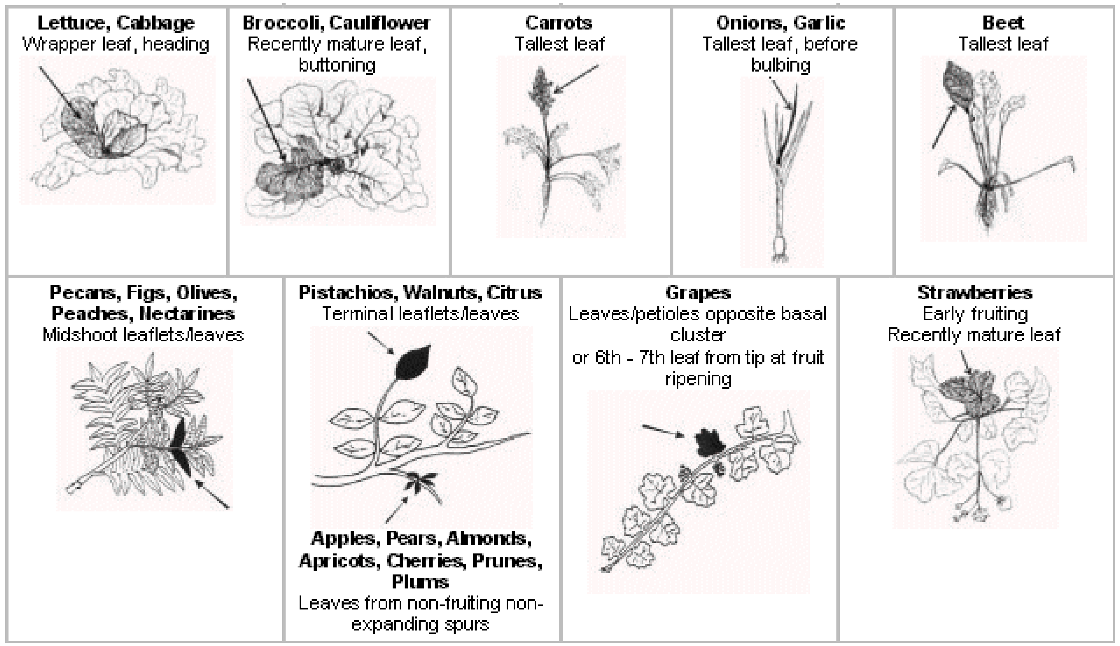
- Important to evaluate the soil fertility and nutrient deficiencies
- Used as the basis for fertilizer recommendations for crops
- Plant tissue Analysis:
  - Correct plant part must be sampled
  - Plant part must be sampled at the specific stage of growth
  - should identify the concentration of one nutrient that may be affected by another nutrient and sometimes the ratio of one nutrient to another (Ex: Mg/K, Fe/Mn)

Plant/Leaf sampling

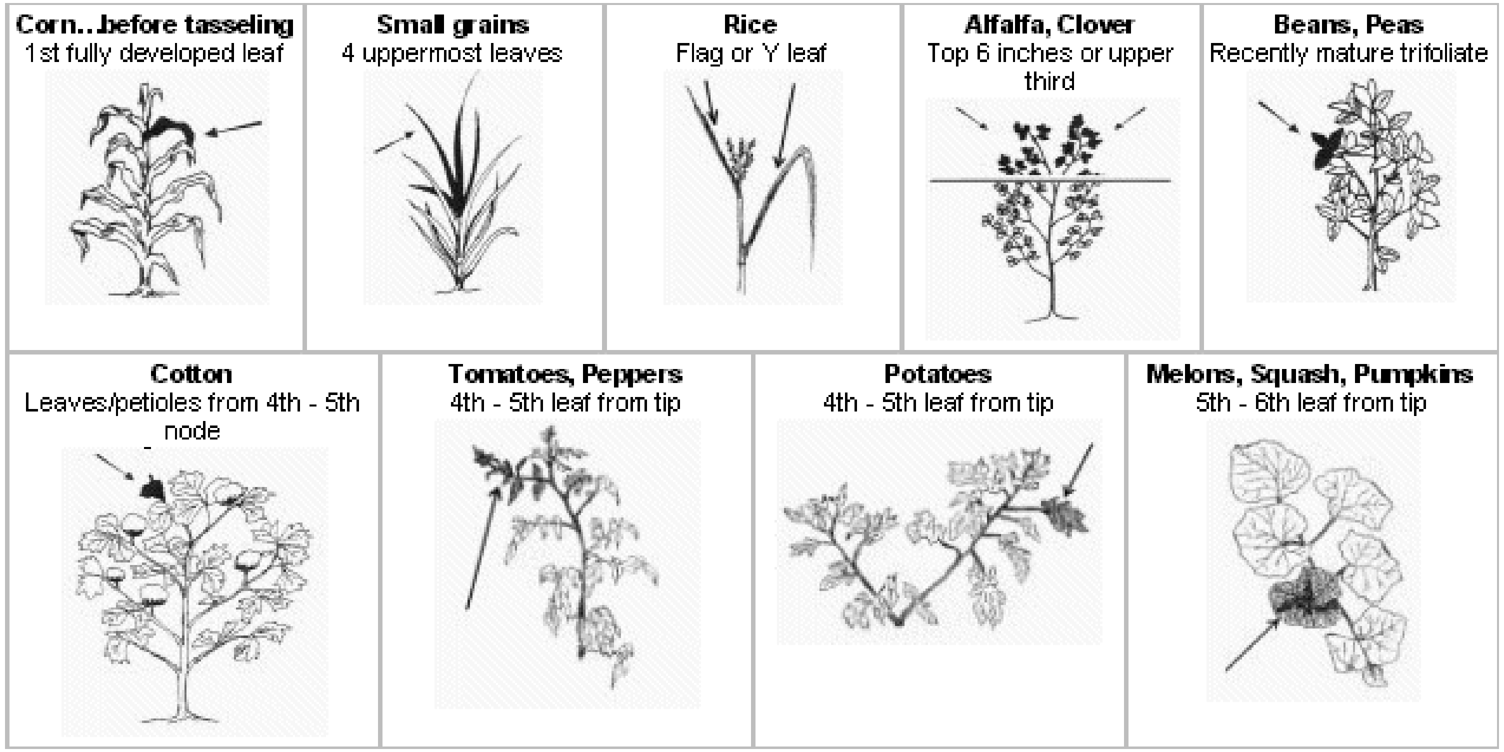
- Plant testing has been used as a tool for confirming usual symptoms of nutrient deficiencies, excess or imbalances in plants and guide in fertilizing soils
- For most routine analysis mother leaf is taken for analysis (This is the leaf from the axil of which the present pluckable shoot has emerged)
- When young leaf is specified for analysis, this refers to the second leaf on the plucking shoot
- Plants should selected in zig-zag random pattern
- Plants growing in abnormal areas such as close to roads, drains, bare patches should be avoided
- It's not advisable to collect leaf samples after a period of very heavy rainfall



Compound Leaf
Middle Leaflet Pair
Most Recent Mature Leaf (MRML)
Petiole



Lettuce, Cabbage
Wrapper leaf, heading
Broccoli, Cauliflower
Recently mature leaf, buttoning
Carrots
Tallest leaf
Onions, Garlic
Tallest leaf, before bulbing
Beet
Tallest leaf
Pecans, Figs, Olives, Peaches, Nectarines
Midshoot leaflets/leaves
Pistachios, Walnuts, Citrus
Terminal leaflets/leaves
Apples, Pears, Almonds, Apricots, Cherries, Prunes, Plums
Leaves from non-fruiting non-expanding spurs
Grapes
Leaves/petioles opposite basal cluster
or 6th - 7th leaf from tip at fruit ripening
Strawberries
Early fruiting
Recently mature leaf



Corn...before tasseling
1st fully developed leaf
Small grains
4 uppermost leaves
Rice
Flag or Y leaf
Alfalfa, Clover
Top 6 inches or upper third
Beans, Peas
Recently mature trifoliate
Cotton
Leaves/petioles from 4th - 5th node
Tomatoes, Peppers
4th - 5th leaf from tip
Potatoes
4th - 5th leaf from tip
Melons, Squash, Pumpkins
5th - 6th leaf from tip

Leaf sample preparation

- When the samples reached the laboratory they should spread on a clean sheet of blotting paper
- Both surfaces of each leaf gently but quickly wipe with a clean cotton dipped in 0.1 % v/v teepol in distilled water
- The cleaned leaves are placed on a tray with label and covered with paper in forced air oven and dry overnight at 105^{o} C
- The dried samples are crushed by hand and pass through 40 mesh stainless steel sieve
- Once again this sample is dried in an oven to 85^{0} C and transferred to a desiccator
- They should store in sealed polythene bags together with the label
- At the time of weighing, samples should mixed thoroughly by a spatula

Soil analysis

- Routine practical analysis of soils is important for the purpose of guiding the nutrient management

- It includes
  - Soil sampling
  - Chemical analysis of the sample
  - Interpretation the results to make the recommendation
- Proper collection and preparation of soil samples intended for analysis are extremely important
- Correct interpretation of the tests can be made only when the samples are truly representative of the soil conditions in the field
- Special effort should be taken to avoid contamination during & after sampling

Soil sampling

- An <u>auger</u> is the most useful sampling tool; other tools are spades, mammoty/hoe etc.

- The stem should be marked at intervals of six inches (15 cm) so that the depth of sampling can be determined at a glance
- Collect samples away from fences, roads, buildings, straw piles, manure piles and other abnormal occurrences
- Surface should be cleaned of leaf litter before sampling
- Take a field layout before sampling and collect samples in a zig-zag random manner
- The collected samples must put into a clean polythene bag and tied and labeled with a waterproof marking pen (location, date, depth etc.)

Preparation of Soil Samples

- Spread the samples on a labeled paper in the soil preparation room and allow it to air-dry
- Crush the clods occasionally during the drying process
- It takes about a week for a soil to dry
- Pass the soil through a 2 mm sieve
- Discard the particles that do not pass through the sieve
- Store the soil samples in plastic bags/jars with appropriate labels

Nutrients

1. **Macronutrients**
2. **Micro Nutrients**

Macronutrients

Nitrogen (N)

- Amino acid/Protein formation
- Photosynthesis

Phosphorus (P)

- Energy storage/transfer
- Root growth
- Crop maturity
- stem strength
- Disease resistance
- Required for N_2-fixation by legumes

Potassium (K)

- Plant turgor pressure maintenance
- Accumulation and transport of the products of plant metabolism
- Disease resistance
- Required for N_2-fixation by legumes

- **Sulphur (S)**
- Part of amino acids (protein formation)
- Synthesis of chlorophyll and some vitamins
- Required for N_2-fixation by legumes

- **Magnesium (Mg)**
- Photosynthesis
- Activates enzymes
- Carbohydrate transport

- **Calcium (Ca)**
- Cell growth and walls
- Activates enzymes (protein formation and carbohydrate transfer)
- Essential in ‘calcicole’ plants (e.g. Groundnut) for seed production.
- Influences water movement, cell growth and cell division
- Required for uptake of N and other minerals

Micronutrients

Iron (Fe):

- Essential for Photosyntheiss
- Respiration

Manganese (Mn):

- Essential for Photosynthesis
- Enzyme function

Boron (B):

- For development/growth of new cells

Zinc (Zn):

- Nucleic acid synthesis and enzyme activation

Micronutrients contd.....

- **Copper (Cu):**
- Chlorophyll formation
- Seed formation
- Protein synthesis

- **Molybdenum (Mo):**
- Protein synthesis and N uptake
- N_2-fixation by legumes

- **Chlorine (Cl):**
- Movement of water and solutes
- Nutrient uptake
- Photosynthesis
- Early crop maturity
- Disease control

- **Cobalt (Co):**
- N_2-fixation by legumes

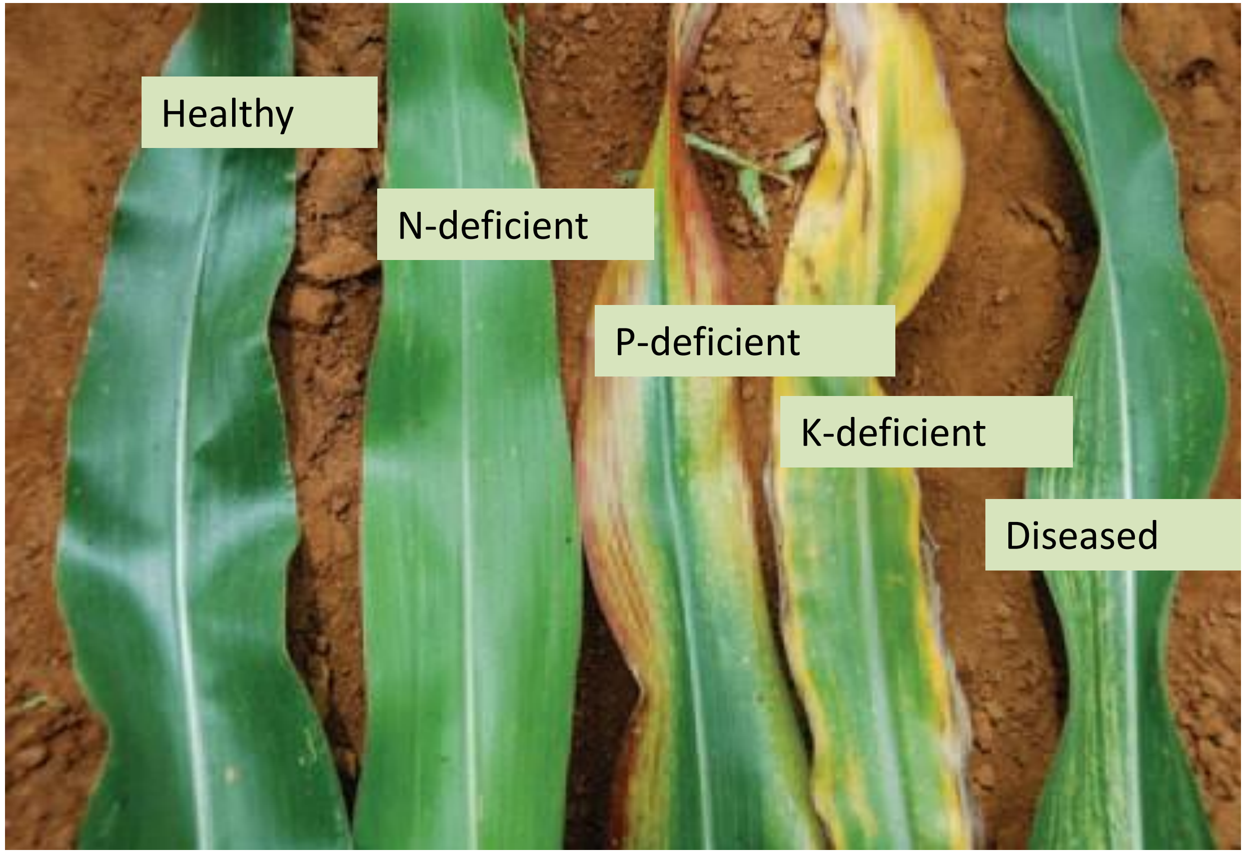
Micronutrients contd.....

- **Nickel (Ni):**
- Required for enzyme urease

- **Sodium (Na):**
- Water movement and balance of minerals

- **Silicon (Si)**
- Need for the development of cell walls
- Protection against piercing by sucking insects
- Leaf presentation
- Heat and drought tolerance

Nutrient deficiency



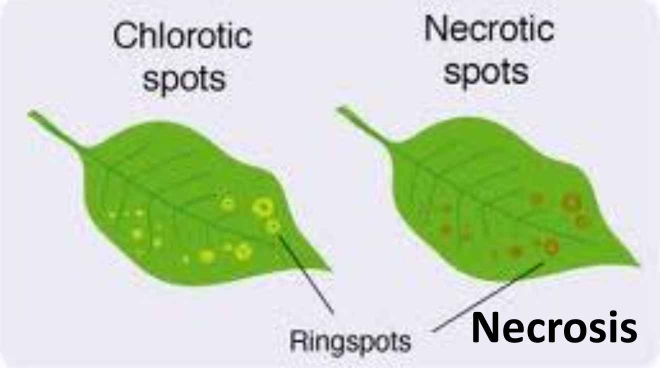
Visual symptoms of plant nutrient deficiencies

Generally grouped into **5 categories**

1. Stunted growth
2. Chlorosis
3. Interveinal chlorosis
4. Purplish red colouring
5. Necrosis

Plant nutrient deficiency terminology

- Burning
- Chlorosis
- Generalized
- Localized
- Mobile
- Immobile
- Mottling
- Necrosis
- Stunting



Mobile & Immobile Nutrients

- Mobile nutrients are nutrients that are able to move out of older leaves to younger plant parts when supplies are inadequate
- Mobile nutrients include **N, P, K, Cl, Mg,** and molybdenum (**Mo**)
- Because these nutrients are mobile, visual deficiencies will first occur in the <u>older or lower leaves</u>
- Effects can be either <u>localized or generalized</u>

- Immobile nutrients (**B, Ca, Cu, Fe, Mn, Ni, S,** and **Zn**) are not able to move from one plant part to another and deficiency symptoms will initially occur in the younger or upper leaves and be localized
- Zn is a partial exception to this as it is only somewhat immobile in the plant, causing Zn deficiency symptoms to initially appear on **middle leaves** and then affect both older and younger leaves as the deficiency develops

Deficiency by Mobile Nutrients

Nitrogen (N)

Phosphorus (P)

Potassium (K)

Chlorine (Cl)

Magnesium (Mg)

Molybdenum (Mo)

N Deficiency

Yellow discoloration and stunted growth
Leaf on bottom is normal

Figure 4. N deficiency in barley. Top leaves are N deficient, bottom leaf is normal.

Nitrogen (N)

- Symptoms of N deficiency are general chlorosis of lower leaves (light green to yellow) or yellow discoloration from the leaf tip
- Stunted and slow growth
- Necrosis of older leaves in severe cases
- N deficient plants will mature early and crop quality and yield are often reduced

- In cereals, yellow discoloration from the leaf tip backward in the form of a “V” is common.
- Insufficient amounts of N in cereals will also result in few tillers, slender stalks, short heads, and grains with low protein content.
- Leaf curling and small tubers are common in potatoes deficient of N.
- Fields deficient in N can be either uniform or patchy in appearance, depending on conditions favoring the deficiency.

Phosphorus (P)

- P deficiency symptoms are usually more noticeable in young plants, which have a greater relative demand for P than more mature plants
- P deficient plants generally turn dark green (both leaves and stems)
- The plants show stunted growth.
- Older leaves are affected first and may acquire a purplish discoloration due to the accumulation of sugars in P deficient plants which favor anthocyanin synthesis; in some cases, leaf tips will become brown and die

- Plants suffering from P deficiency appear weak and maturity is delayed.
- Leaf expansion and leaf surface area may also be inhibited, causing leaves to curl and be small.
- Wheat and small grains with P deficiency tend to be stressed and prone to root rot diseases, and some cultivars will turn red or purple.
- Potato P deficiency symptoms include leaves curling upward and tubers having brown internal specks, often radiating out from the core
- P deficiency in corn is usually visual in young plants with leaves turning purple
- Crops grown in soils high in $CaCO_3$ are prone to P deficiency due to precipitation of Ca-P insoluble minerals

Purple margins in corn

P deficiency symptoms in potato

Potassium (K)

- K deficiency does not immediately show visible symptoms (hidden hunger)
- Initially, there is only a reduction in growth rate, with chlorosis and necrosis occurring in later stages (Affected older leaves will show localized mottled or chlorotic areas with leaf burn at margins
- Chlorotic symptoms typically begin on the leaf tip, but unlike the ‘V’ effect caused by N deficiency, K deficient chlorosis will advance along the leaf margins towards the base, usually leaving the **midrib alive and green.**
- As the deficiency progresses, the **entire leaf will yellow**.
- Small white or yellow necrotic spots may also develop, beginning along leaf margins

- Another indication of K deficiency is reduced stalk strength
- Produced grains will be low in protein and appear wrinkled
- Due to lack of sugar accumulation in root crops (i.e., potatoes, sugarbeets) will have small tubers.

Chlorine (Cl)

- Plants with insufficient Cl concentrations show chlorotic and necrotic spotting along leaves.
- Wilting of leaves at margins and highly branched root systems are also typical Cl deficient symptoms.
- Found mainly in cereal crops
- Cl deficiencies are highly cultivar specific and can be easily mistaken for leaf diseases

Magnesium (Mg)

- Symptoms of Mg deficiency include **interveinal chlorosis** and leaf margins becoming yellow or reddish-purple while the midrib remains green.
- Distinct mottling as yellowish-green patches will occur.
- Leaves of Mg deficient sugarbeets and potatoes are stiff and brittle and veins are often twisted /abnormal.

Molybdenum (Mo)

- Molybdenum is needed for **enzyme activity** in the plant and for **nitrogen- fixation** in legumes
- Due to this interrelationship, Mo deficiency symptoms often resemble N deficiency symptoms with stunted growth and chlorosis occurring in legumes
- Other symptoms of Mo deficiency include pale leaves that may be scorched, cupped, or rolled
- Leaves may also appear thick or brittle, and will eventually wither, leaving only the midrib


CONTROL
−Mo

Part 3

Soil Nutrient Management

Dr. S R Amarasinghe

SS2101@2020

Immobile Nutrients

- Sulphur (S)
- Boron (B)
- Iron (Fe)
- Zinc (Zn)
- Calcium (Ca)
- Copper (Cu)
- Manganese (Mn)

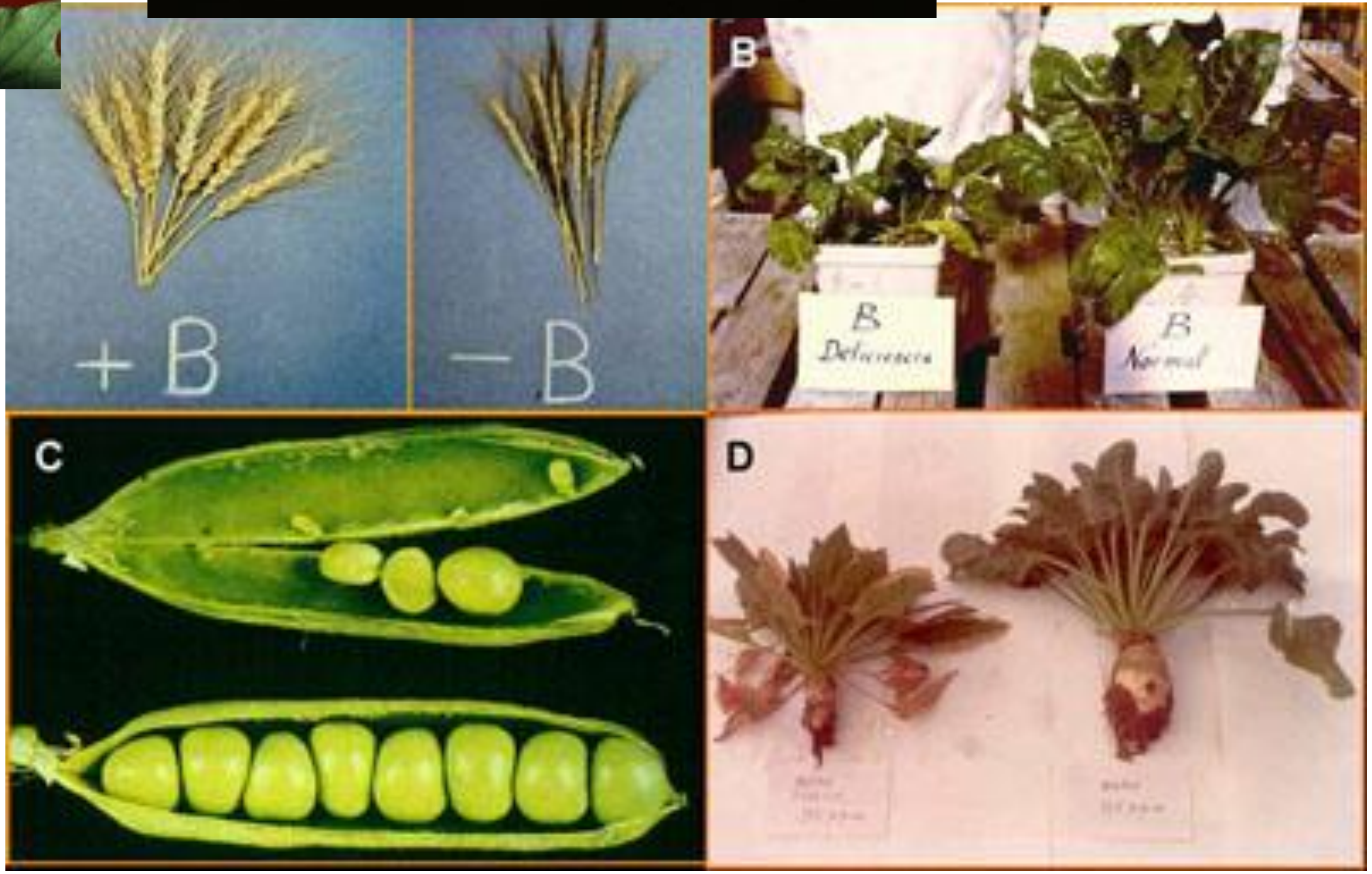
Sulphur (S)

- S deficiency symptoms can be difficult to diagnose as effects can resemble symptoms of N and Mo deficiencies.
- In contrast to N or Mo deficiency, however, S deficiency symptoms initially occur in younger leaves, causing them to turn light green to yellow *(chlorosis)*
- In later growth, the entire plant may be pale green
- Characteristic spots or stripes are generally not displayed.
- Additionally, plants deficient in S tend to be spindly and small and stems are often thin

Boron (B)

- Plants suffering from B deficiency exhibit chlorotic young leaves and death of the main growing point (terminal bud)
- In addition to chlorosis, leaves may develop dark brown, irregular lesions that will progress to leaf necrosis in severe cases.
- Whitish-yellow spots may also form at the bases of leaves
- Due to disturbances in cell wall growth, leaves and stems of B deficient plants will become brittle and distorted and leaf tips tend to thicken and curl

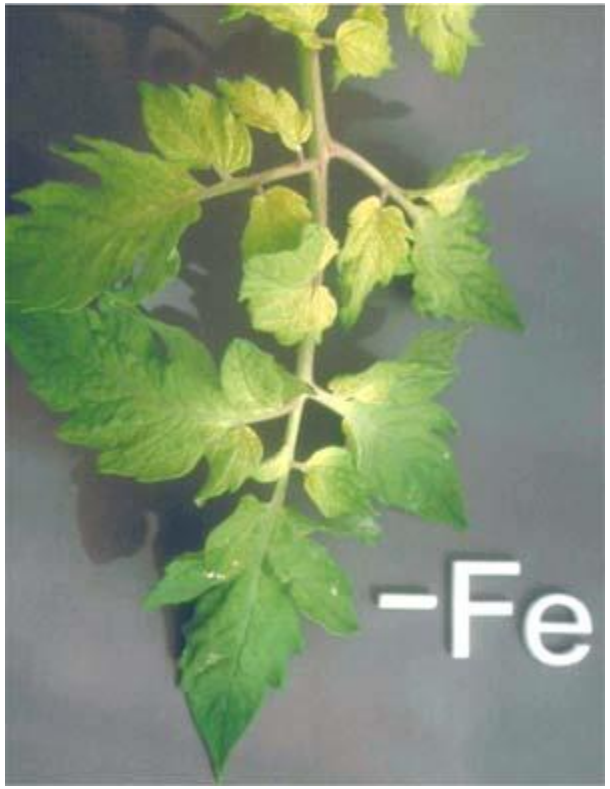
- Affected plants will grow slowly and appear stunted as a result of shortened internodes (stem segment between points where leaves are attached)
- Because B tends to accumulate in reproductive tissues, flower buds may fail to form or are misshapen, and pollination and seed viability is usually poor in B deficient plants
- A well-documented B deficiency in sugarbeets is crown and heart rot
- Along with stunted growth, symptoms include young leaves curling and turning brown or black in color
- In later stages of the deficiency, the crown of the beet begins to rot and disease sets in, affecting the whole plant; The healthy part of the beet will be low in sugar


+B
−B
B
B
Deficiency
B
Normal
C
D

Iron (Fe)

- Fe deficiency reduces chlorophyll production and is characterized by interveinal chlorosis with a sharp distinction between veins and chlorotic areas in young leaves
- As the deficiency develops, the entire leaf will become whitish-yellow and progress to necrosis
- Slow plant growth also occurs
- When viewed from a distance, Fe deficient fields exhibit irregularly shaped yellow areas, especially where the subsoil is exposed at the surface

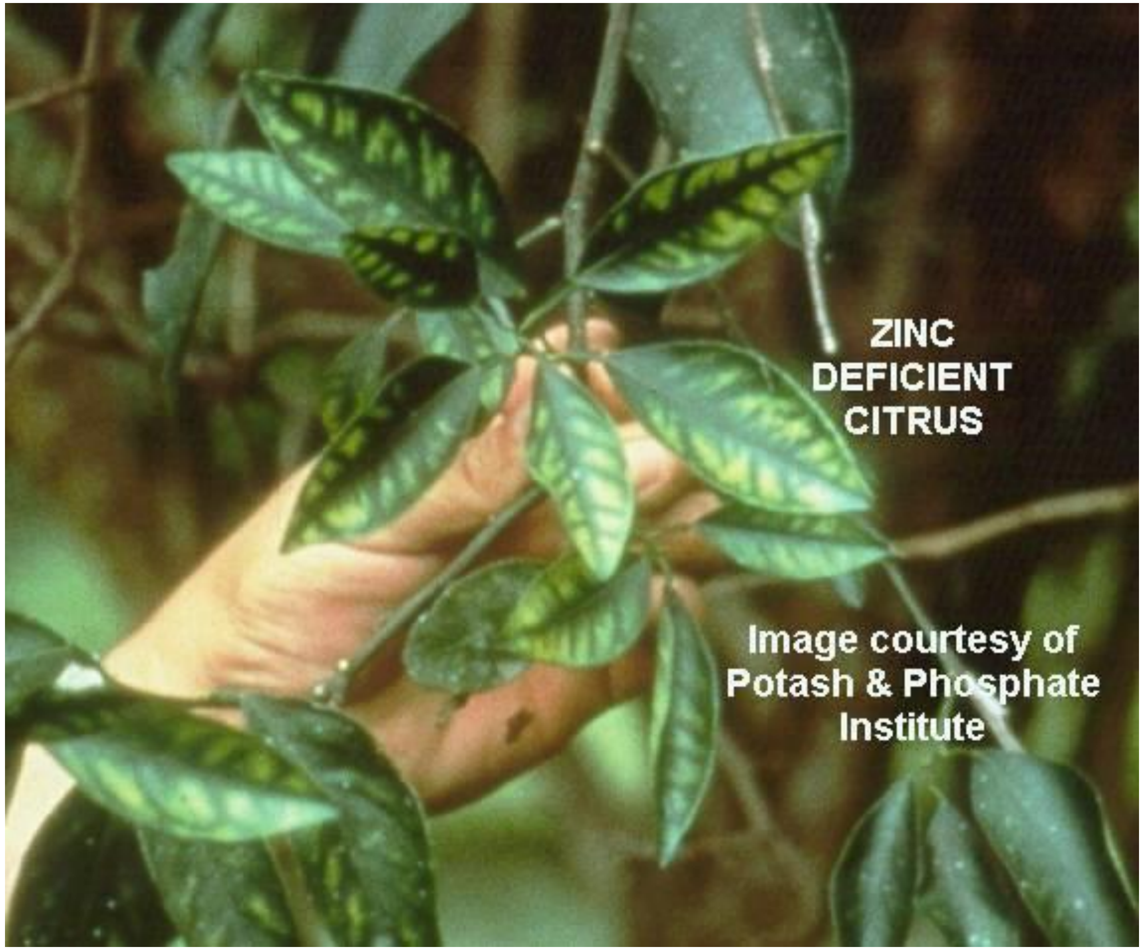

+Fe
-Fe
IRON
DEFICIENT
AZALEA
Photo
courtesy of
Ray Weil
University
of Maryland


-Fe

Zinc (Zn)

- Zn has intermediate mobility in the plant and symptoms will initially show up in middle leaves
- Zn deficient leaves display interveinal chlorosis, especially midway between the margin and midrib, producing a striping effect; some mottling may also occur
- Chlorotic areas can be pale green, yellow, or even white.
- Severe Zn deficiencies will cause leaves to turn gray-white and fall prematurely or die.
- Because Zn plays a prominent role in internode elongation, Zn deficient plants generally exhibit severe stunting

- Flowering and seed set is also poor in affected plants.
- Crop specific symptoms include gray or bronze banding in cereal leaves, reduced tiller production in wheat and other small grains, and abnormal grain formation
- In cattle, Zn deficiencies in forage have been shown to reduce reproductive efficiency
- Zn deficiency generally does not affect fields uniformly and deficient areas usually occur where topsoil has been removed


ZINC
DEFICIENT
CITRUS
Image courtesy of
Potash & Phosphate
Institute


-Zn

Calcium (Ca)

- Calcium is a component of plant cell walls and regulates cell wall construction.
- Insufficient Ca can cause young leaves to become distorted and turn abnormally dark green.
- Leaf tips often become dry or brittle and will eventually wither and die.
- Stems are weak and germination is poor.

Copper (Cu)

- Cu deficient plants display chlorosis in younger leaves, stunted growth, delayed maturity (excessively late tillering in grain crops), lodging, and, in some cases, melanosis (brown discoloration)
- In cereals, grain production and fill is often poor, and under severe deficiency, grain heads may not even form
- Cu deficient plants are prone to increased disease, specifically ergot (a fungus causing reduced yield and grain quality)


0.1Cu

- The onset of disease-caused symptoms may confound the identification of Cu deficient symptoms.
- Winter and spring wheat are the most sensitive crops to Cu deficiency
- In the field, Cu deficiency symptoms occur in irregular patches (melanosis) being the most obvious symptom, particularly in wheat stands.
- Similar to Zn, forage that is deficient in Cu can cause a reduction in the reproductive efficiency of cattle

Manganese (Mn)

- Chloroplasts (plant organelles where photosynthesis occurs) are the most sensitive of cell organelles to Mn deficiency
- As a result, a common symptom of Mn deficiency is interveinal chlorosis in young leaves
- However, unlike Fe, there is no sharp distinction between veins and interveinal areas, but rather a more diffuse chlorotic effect
- Two well known Mn deficiencies in arable crops are grey speck in oats and marsh spot in peas
- White streak in wheat and interveinal brown spot in barley are also symptoms of Mn deficiency


-Mn

Part 4

Soil Fertility Management

Dr. S R Amarasinghe

Concept of limiting factors

- Growth Requirements of plants

Nutrients

Water

Temperature (Heat)

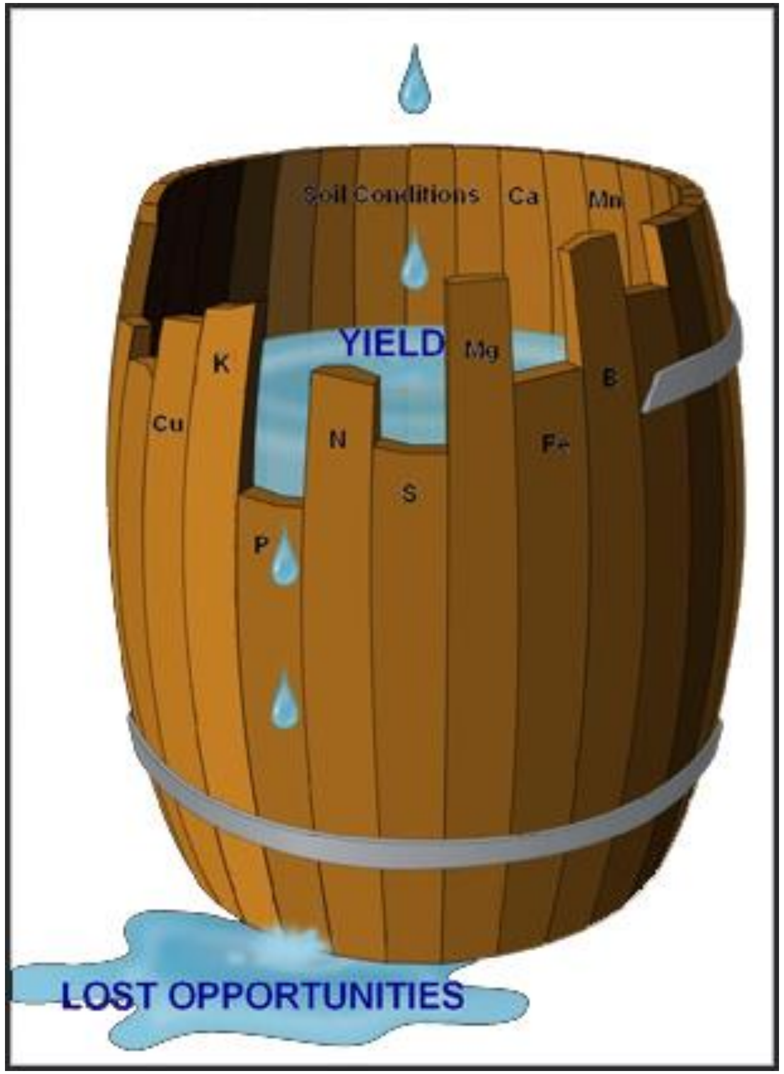
Light

Growth Substances (Hormones)

Concept of Limiting Factor

- Almost always, one of the growth requirements is limiting the plant production.
- The limiting factor could be any of the growth requirements.
- Once you correct the limiting factor, another growth factor will likely limit production.
- If all the growth requirements are optimized, genetics will limit production

Law of minimum (Barrel theory)



- The law of minimum says that one nutrient cannot be substituted for another.
- Plant growth is limited by the nutrient that is least available when all other elements are present in adequate quantities.
- The “law of minimum” can be illustrated with a water barrel, with staves of different lengths that represent particular nutrient availability.
- The barrels capacity to hold water is determined by the shortest stave.
- Similarly, plant growth is limited by shortages of the least available nutrients.
- Once the limiting factor (nutrient) has been corrected, yield and growth will increase until the next limiting factor is encountered.

Fertilizer

- material that is added to the growing media and plants.
- Is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more plant nutrients essential to the growth of plants.

Composting

What is Compost?

Compost is an organic product which formed by the transformation of organic material through decomposition which has excellent chemical and physical properties that can condition soils.

- Composting is a biological process.
- There are many methods of composting
- It can be either aerobic or anaerobic decomposition

Advantages of Composting

- As a Soil conditioner

- Recycles kitchen and yard waste

  Composting can divert as much as 30% of household waste

- Introduces beneficial organisms to the soil

  Microscopic organisms in compost help <u>aerate</u> the soil, <u>break down organic material</u> for plant use and protect from plant diseases

- Good for the environment

  Composting offers a natural alternative to chemical fertilizers.

- Reduces landfill waste

  Most landfills are quickly filling up and has to close down. One-third of landfill waste is made up of compostable materials.

Common home composting systems in Sri Lanka

- Heap method
- Pit method
- Traditional ‘Jeewakotu’ and basket methods
- Composting bin systems
- Rotating drums

Methods of composting

- Compost bins

compost production by aeration (Windrow method)

c Digestion of compost


27
37
02/02/2008 16:32


02/02/2008 16:38

Conditions required in composting process

1. **Aeration:**

- Oxygen is an essential requirement for aerobic microbes to thrive and they effectively break down organic waste into simple components.
- Anaerobic decomposition is comparatively slow and it produces unpleasant odours and therefore anaerobic composting is not a very popular method.

2. **Moisture:**

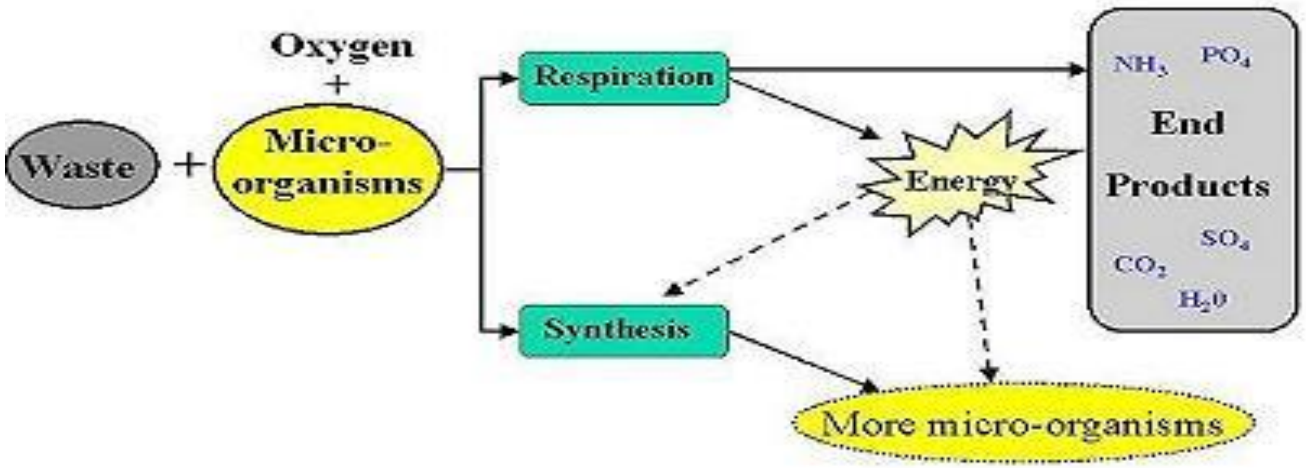
- Moisture/water is a very essential component for all microbial activities.
- 40% - 65% of moisture content is ideal for effective composting.
- When the moisture content is below 40%, microbial activity will continue at a slower rate.
- When the moisture content is above 65%, water will displace air from the compost pile leading to anaerobic conditions.

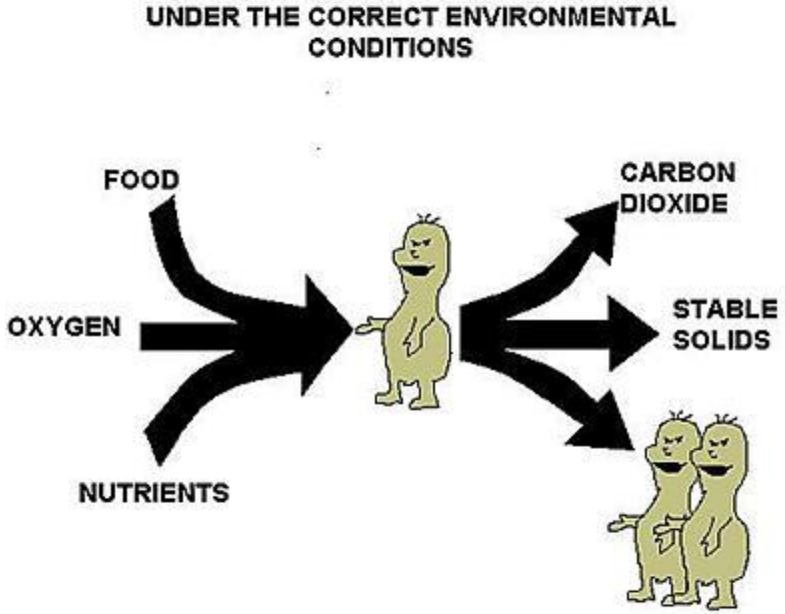
3. Temperature:

- In a well mixed compost pile, temperature can reach up to 65-70^{0}C due to activities of the micro-organisms.
- This heat is desirable and helps to accelerate the degradation process.
- In addition to this, it destroys the weed seeds, pathogens in the composting material and makes it unsuitable for fly breeding.

Aerobic digestion

- As aerobic digestion within a composter / compost pile takes place, the by products are heat, water, and carbon dioxide (CO_2).
- While CO_2 is a greenhouse gas, it is at least 1/20th as strong as methane.
- To minimize the impact on the environment, the CO_2 gas can be safely collected via a gas collection system that will prevent the gas from seeping out into the environment.
- Naturally, one of the most important benefits of aerobic compositing is that the **heat** which is produced during the decomposition process is great enough that it kills harmful bacteria and pathogens within the pile.
- While this heat is killing the harmful bacteria, it is also facilitating the growth of beneficial bacteria species including psychrophilic, mesophilic, and thermophilic bacteria which thrive at the higher temperature levels.


Oxygen
+
Waste
+
Micro-
organisms
Respiration
Synthesis
Energy
End
Products
NH_3
PO_4
SO_4
CO_2
H_20
More micro-organisms


UNDER THE CORRECT ENVIRONMENTAL
CONDITIONS
FOOD
OXYGEN
NUTRIENTS
CARBON
DIOXIDE
STABLE
SOLIDS

c Digestion of compost


27
37
02/02/2008 16:32


02/02/2008 16:38


COMPOST BIN

Advantages of Aerobic Digestion

- **Aerobic bacteria** are very efficient in breaking down waste products.
- As a result, aerobic treatment usually yields better compost quality.
- The aerobic pathway also releases a substantial amount of energy.
- A portion is used by the microorganisms for synthesis and growth of new microorganisms.





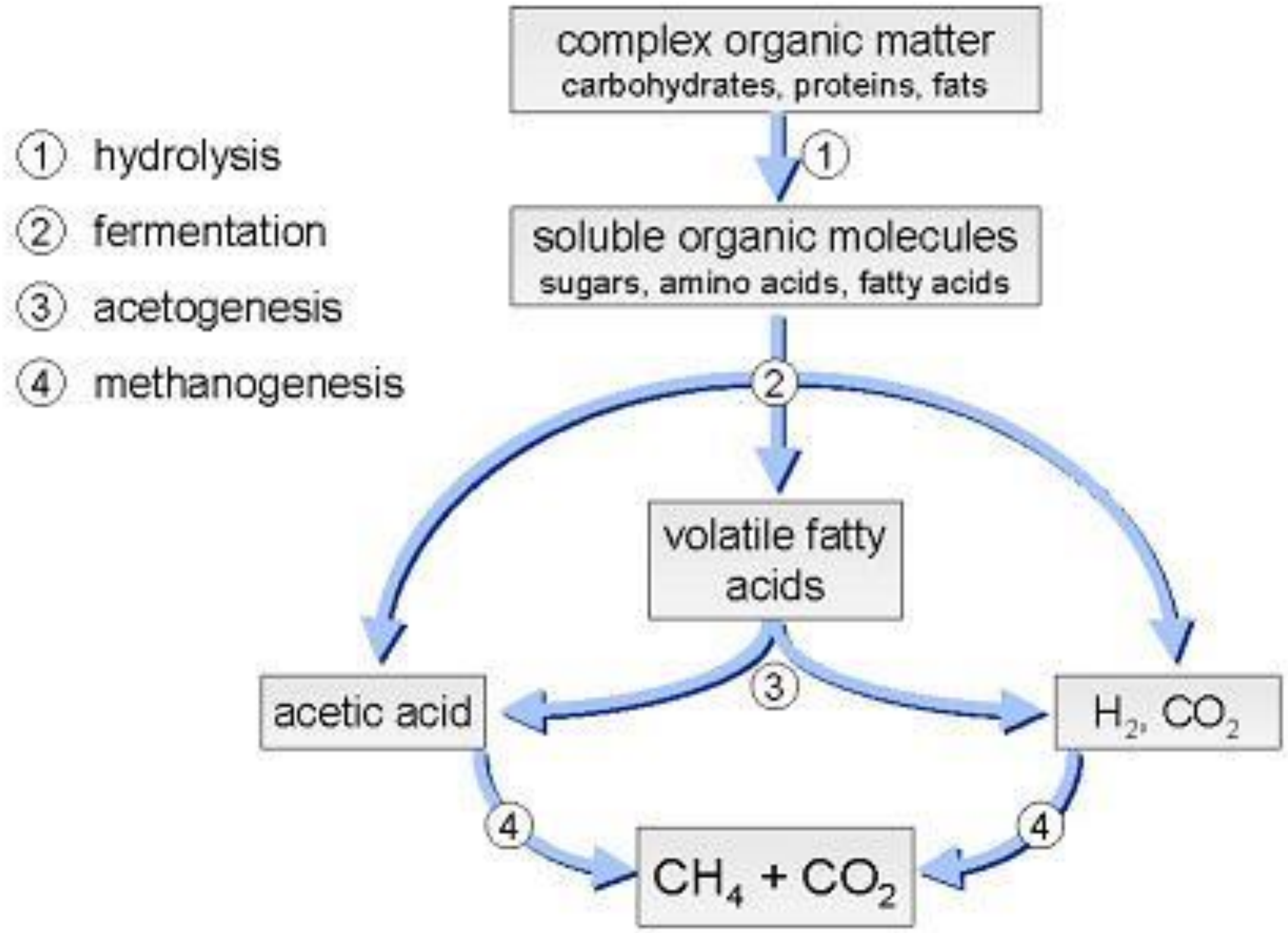
පොහොර
"සරු අස්වැන්නක්-සුව දිවි පෙවෙතක්"
රන්පොහොණිය අලෙවි සැල

Anaerobic digestion

- It is a complex process.
- The decomposition process produces a gaseous by product often called biogas, which consists primarily of methane (CH_4)-50-80%, carbon dioxide (CO_2)20-50%, and hydrogen sulfide (H_2S).
- It can be operated in an anaerobic digester.
- Anaerobic bacteria break down or "digest" organic material in the absence of oxygen and produce biogas as a waste product.

- Anaerobic decomposition occurs naturally in swamps, water-logged soils as rice fields, deep bodies of water, and in the digestive systems of termites and large animals.
- Anaerobic processes can be managed in a digester (an airtight tank) or a covered lagoon (a pond used to store manure).

- It occurs in 4 basic stages as the result of the activity of a variety of microorganisms.



1. **Hydrolysis** : Complex organic matter is decomposed into simple soluble organic molecules using water to split the chemical bonds between the substances.
2. **Fermentation or Acidogenesis:** The chemical decomposition of carbohydrates by enzymes, bacteria, in the absence of oxygen to volatile fatty acids.
3. **Acetogenesis:** The fermentation products are converted into acetic acid, hydrogen and carbon dioxide by acetogenic bacteria.
4. **Methanogenesis:** CH_4 and CO_2 is formed from acetic acid and carbon dioxide by methanogenic bacteria.

- Factors affect the rate of digestion and biogas production

1. **Temperature**

   Anaerobic bacteria can survive in temperatures ranging from below freezing to above 57.2°C, but they thrive best at temperatures of about **36.7°C** (mesophilic) and **54.4°C** (thermophilic)

   In the thermophilic range, decomposition and biogas production occur more rapidly than in the mesophilic range

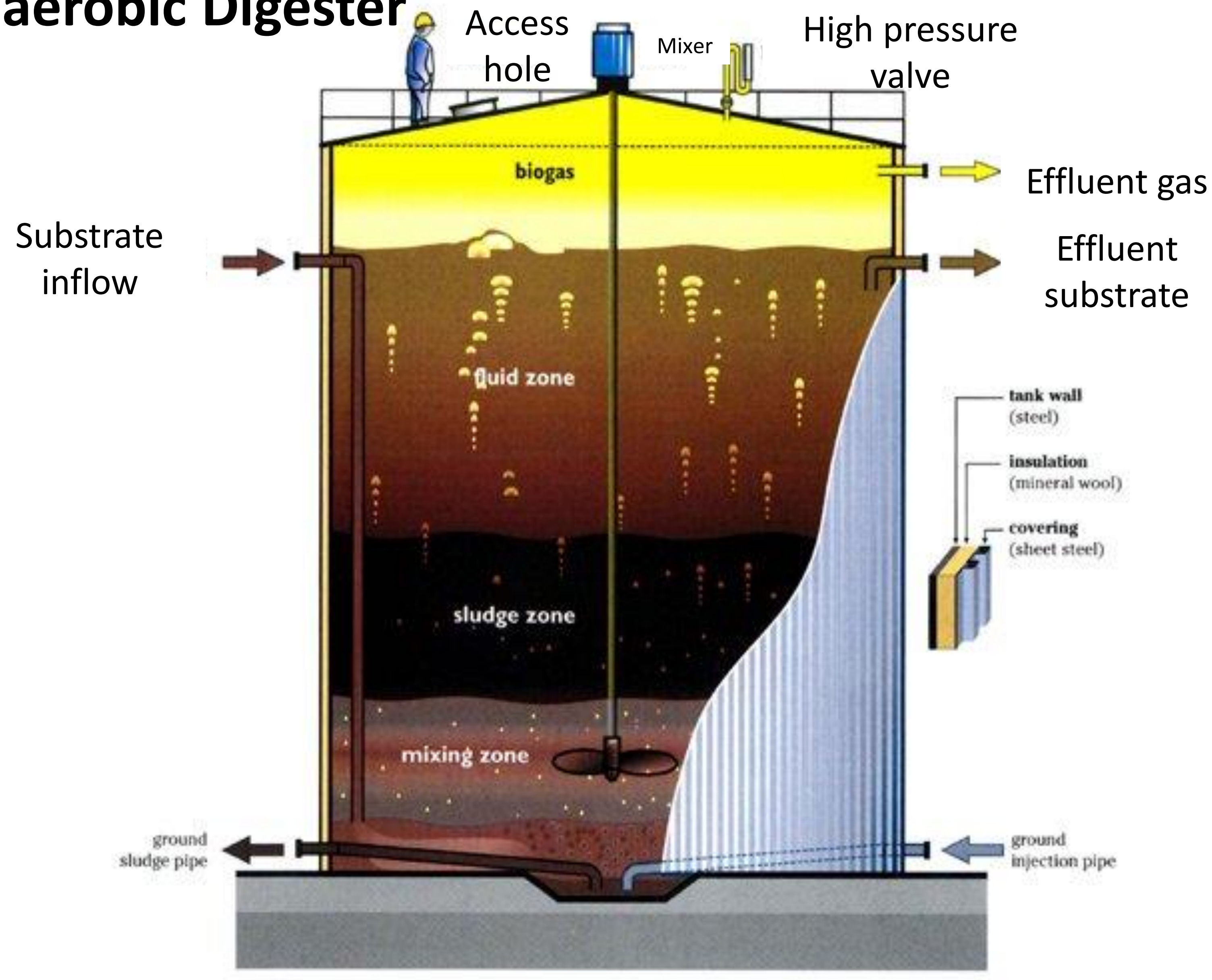
2. **pH**

   should be slightly basic, to optimize the creation of methane (sodium bicarbonate is added)

3. **water/solids ratio (MC)**
4. **carbon/nitrogen ratio: 20:1 to 30:1 is best**
5. **mixing of the digesting material or composition of waste**

6. **the particle size of the material being digested**
   should be in equal size
7. retention time
8. Bacteria types (thermophilic or mesophilic)

Anaerobic Digester



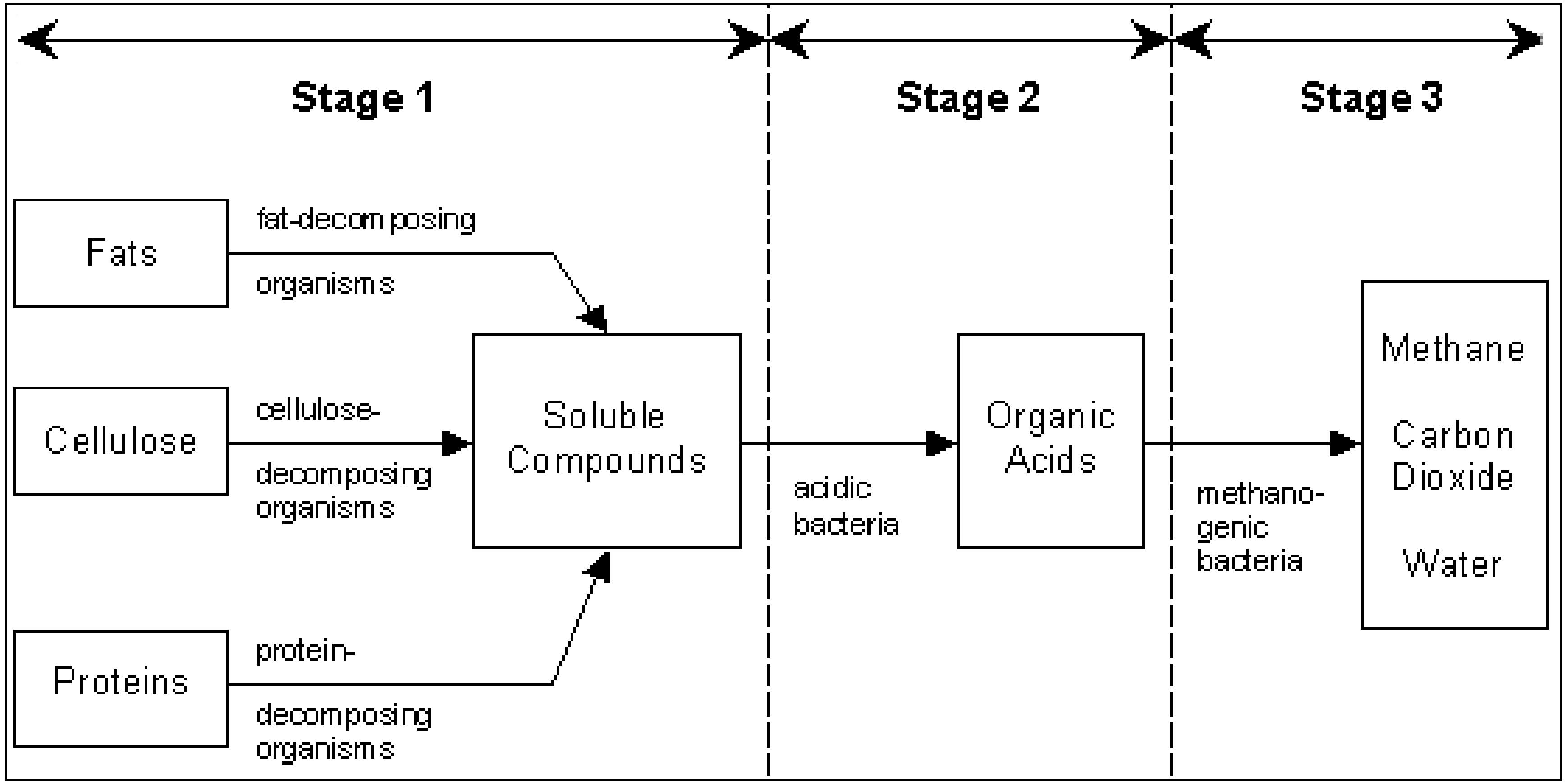
Advantages of Anaerobic Digestion

- Waste are transformed into methane, carbon dioxide and smaller amount of bio-solids.
- The biomass growth is much lower compared to those in the aerobic processes.
- They are also much <u>more compact</u> than the aerobic bio-solids.

Sludge or effluent by anaerobic digester

- The material drawn from the anaerobic digester is called **sludge,** or **effluent**.
- It is rich in nutrients (ammonia, phosphorus, potassium, and more than a dozen trace elements) and is an excellent soil conditioner.
- It can also be used as a livestock feed additive when dried.
- Any toxic compounds (pesticides, etc.) that are in the digester feedstock material may become concentrated in the effluent.
- Therefore, it is important to test the effluent before using it on a large scale.

Anaerobic digestion of Compost



Inorganic commercial Fertilizers
composed of raw chemicals that have been manufactured at a factory into liquid or solid forms that specifically target plants' nutritional needs.

Reference

- http://slideplayer.com/slide/7328643/

Inorganic fertilizers take many physical forms

- Solid powder
- Granules/pellets
- Liquid
- Gas (Ex. anhydrous ammonia)
- Aqueous solutions

Fertilizer Grade

It expresses the nutrient content of the fertilizers

The grade is the percentage composition expressed in order

Ex. N-P_2O_5-K_2O grade- 27-3-9 (N 27% P_2O_5 3% and K_2O 9%)

Fertilizer ratio

Is the relative proportion of primary nutrients in a fertilizer grade divided by the lowest percentage of the nutrients

Ex. Fertilizer ration of the above grade – 9-1-3 (N:P:K)

Determine ratios for the following fertilizer grades: 21-7-7; 22-6-8, and 18-5-9.

Types of inorganic commercial Fertilizers

Nitrogenous Fertilizer

1. Urea (NH_2-CO-NH_2)

   Nitrogen content: 46%

2. Ammonium nitrate—NH_4NO_3 Nitrogen content: N 33–34%
3. Ammonium sulfate—$(NH_4)_2SO_4$ Nitrogen content: N 21%
4. Diammonium phosphate (DAP)—$(NH_4)_2HPO_4$ N18% P 46%
5. Monoammonium phosphate (MAP)—$NH_4H_2PO_4$ N 11% P 52%

Phosphoric fertilizer

1. Triple superphosphate $Ca(H_2PO_4)_2$ P 46%
2. Eppawala Rock Posphate (P_2O_5) 35.20%
3. High grade Eppawala Rock Posphate (P_2O_5) 37.96%

Potassium fertilizer

1. Muriate of potash (MOP)—K 60–62% KCl:NaCl (95:5 or higher)
2. Potasium sulphate K_2SO_4 K 50%
3. Potassium nitrate—KNO_3 N 13% K 45%
4. Potassium hydroxide—KOH K 70%

Magnesium Fertilizer

1. Kiesarite ($MgSO_4 \cdot H_2O$) Mg 15% S 21%

Fate of fertilizer materials

- A common myth about inorganic fertilizers is that when they add to the soil, it directly feeds the plants
- However, the reality is that they are incorporated with complex nutrient cycles
- Therefore, relatively little amount of fertilizer may taken by the plants
- Generally, when the rate of fertilizer application is increased, the efficiency of the nutrient use decreases.

What would be the reason?????

Application of fertilizers

- There are some important factors that should be considered before the application of fertilizers
  - Which
  - How much
  - What type
  - In what manner (methods)
  - when
- Fertilizer application methods

1. Broadcasting
2. Localized placement
3. Foliar application

- Broadcasting
  - Evenly spread over the area
  - Suitable for large extent to spread large amount
- Localized placement
  - Mixed fertilizer around the root zone
  - Less fertilizer fixation
  - High fertilizer absorption
- Foliar application
  - Spray as a liquid fertilizer
  - Burning effects on leaves
  - Can mixed with pesticides

Chemical Fertilizers vs Organic Fertilizers?

Discussion….

	Chemical Fertilizer	Organic Fertilizer
Example:	Ammonium sulfate, ammonium phosphate, ammonium nitrate, urea, ammonium chloride and the like.	Cottonseed meal, blood meal, fish emulsion, and manure and sewage sludge, etc.
Advantages:	Chemical fertilizers are rich equally in three essential nutrients that are needed for crops and always ready for immediate supply of nutrients to plants if situation demands.	Adds natural nutrients to soil, increases soil organic matter, improves soil structure and tilth, improves water holding capacity, reduces soil crusting problems, reduces erosion from wind and water, Slow and consistent release of nutrients,
Disadvantages:	Several chemical fertilizers have high acid content. They have the ability to burn the skin. Changes soil fertility.	Have slow release capability; distribution of nutrients in organic fertilizers is not equal.

	Chemical Fertilizer	Organic Fertilizer
Rate of production:	Immediate supply.	Slow release
About:	Chemical fertilizers are manufactured from synthetic material	Organic fertilizers are made from materials derived from living things.
Preparation:	Artificially prepared.	Prepared naturally. One can prepare organic fertilizers, themselves or can also buy.
Cost:	Costly	Cheap
Nutrients:	Have equal distribution of three essential nutrients: phosphorous, nitrogen, potassium.	Have unequal distribution of essential nutrients.

Application of organic amendments

A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure.

- On clayey soils, soil amendments improve the soil aggregation, increase porosity and permeability, and improve aeration, drainage, and rooting depth.
- On sandy soils, soil amendments increase the water and nutrient holding capacity.

Material	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
	% dry weight						ppm (mg/kg) of dry weight			
Poultry (broiler) manure[a]	4.4	2.1	2.6	2.3	1.0	0.6	1000	413	480	172
Composted chicken (layer) manure [b]	2.3	3.5	2.9	15.5	1.3					
Dairy cow manure[a]	2.4	0.7	2.1	1.4	0.8	0.3	1800	165	165	30
Swine manure[c]	2.1	0.8	1.2	1.6	0.3	0.3	1100	182	390	150
Sheep manure[c]	3.5	0.6	1.0	0.5	0.2	0.2	-	150	175	30
Horse manure[c]	1.4	0.4	1.0	1.6	0.6	0.3	-	200	125	25
Feedlot cattle manure[d]	1.9	0.7	2.0	1.3	0.7	0.5	5000	40	8	2
Young rye green manure	2.5	0.2	2.1	0.1	0.05	0.04	100	50	40	5
Spoiled legume hay	2.5	0.2	1.8	0.2	0.2	0.2	100	100	50	10
Cowpea green manure[e]	3.6	0.4	3.5	1.5	0.4					
Leucaena green manure[e]	3.8	0.2	1.7	1.1	0.3					
Sewage sludge:										
Anaerobically digested[f]	5.2	0.6	0.06	1.5	0.3	–	15,000	80	1000	400
Primary[f]	1.8	0.4	0.03	0.8	0.1	-	8000	200	450	300

[a]Composition estimated from means of approximately 800 and 400 samples analyzed by the University of Maryland manure analysis program from 1985 to 1990.
[b]Silva, J.A., et al. 1995. The use of composted poultry manure as a fertilizer. In: Hawaii Agriculture: Positioning for Growth. College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa.