Photosynthesis: Conversion of Solar Energy to Chemical Energy by Plants
Photosynthesis in plants converts light energy in the form of photons into chemical energy in the form of ATP and NADPH.
The energy stored in ATP and NADPH can then be used to convert CO₂ and H₂O (water) into simple sugars.
An added bonus of photosynthesis is the production of $O_2$ (oxygen) by the plant.
Light Reaction

NADPH & H^+ → ATP → ADP + Pi → Glucose

Light Reaction → O₂ → H₂O

Calvin Cycle

CO₂ → ATP → ADP + Pi → C₆H₁₂O₆ = Glucose
Photosynthesis

$6\text{CO}_2 + 12\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$
Water, Soil and Plant Nutrients
Why is soil important for the majority of agricultural crops?

Soil is critical as a holding for plants, and supplies water and nutrients that are critical for photosynthesis and plant function.
Soil Profile

Horizon | Characteristics
---|---
O | Freshly fallen leaves, twigs, animal remains
A | Partially decomposed organic matter
 | Well-decomposed organic matter
 | Mineral layer from which leaching of aluminum and iron occur
B | Layer of accumulation of minerals from A horizon
C | Weathered bedrock material or subsoil layer
R | Bedrock
Soil Types

The diagram illustrates the classification of soil types based on the percentage of sand, silt, and clay. The triangle divides the soil types into various regions, with each region representing a specific combination of sand, silt, and clay content. The labels on the triangle's sides indicate the primary content of each soil type: Clay, Silt, and Sand. The points within the triangle correspond to soil types such as Clay Loam, Sandy Clay Loam, and Loamy Sand.
Soil

• The size of the soil particle, size of space between soil particles and the availability of water in the soil influences the ability of a plant's roots to extract water from the soil.
• The type(s) of soil particles in a particular soil controls the water-holding capacity of the soil and the tension that water is held to the surface of the soil particles.
Soil

• There are three basic types of soil particles based on size:
  – sand – 2 to 0.02 mm in diameter.
  – silt – 0.02 to 0.002 mm in diameter.
  – clay – smaller than 0.002 mm in diameter.

• The water-holding capacity of a soil is determined by the porosity of the soil and the surface area of the soil particles in the soil.
Soil Particle Size

Coarse Sand

Sand

Fine Sand

Very Fine Sand

Silt

Clay
Soil Compaction
Water

- All plants require water to grow.
- About 90% of a plant, by weight, is water.
- Water is taken up from the roots and is lost through transpiration.
- Transpiration is greater than soil evaporation
- Transpiration + evaporation = evapotranspiration.
Water

- A single corn plant near harvest can contain 2 liters (4.5 pints) of water.
- A single corn plant in a growing season will take up ~ 200 liters or 440 pints of water.

- ‘Bad’ water is usually contaminated with either sodium or chloride.
Water Movement

Endodermis

Xylem vessels
Water Movement

Diagram showing water movement through the plant:
- Stem
- Conductive tissue (xylem)
- Root hair
- Water
- Stoma
- Water vapor

Diagram explains the process of water movement from the roots to the leaves through the xylem, facilitated by root hairs and stomata.
Water Movement

• Water moves through the xylem in the plant by going from regions of high water potential to regions of low water potential.

• In reality the water moves from a low level of negative water potential to a region of a higher level of negative water potential.
Water Potential

Air      -95 Ψ
Leaf     -0.8 Ψ
Stem     -0.7 Ψ
Root     -0.6 Ψ
Soil     -0.4 Ψ
Hydrologic Cycle

- Percolation
- Uptake
- Transpiration
- Evaporation
- Rainfall/Irrigation
- Capillary rise
- Run off
Flood Irrigation
Furrow Irrigation
Hand Move
Solid Set
Low-Flow Drip Irrigation

- plants
- drip emitter
- plastic mulch
- feeder pipe
Nutrients

Macro Nutrients

• Nitrogen (N)
• Phosphorous (P)
• Potassium (K)
• Calcium
• Magnesium
• Sulfur

Micro Nutrients

• Boron
• Iron
• Copper
• Nickel
• Chlorine
• Zinc
• Manganese
Soil Testing

2. Soil test before applying fertilizers

- Soil tests will measure the amounts of plant available
  - nitrogen (N)
  - phosphorus (P)
  - potassium (K)
  - sulfur (S)
Soil Sampling
Fertilizer applicators
Fertilizer placement
Nitrogen (N)

- Nitrogen stimulates leaf and stem growth.
- Nitrogen deficiency causes reduced growth and pale yellowish green leaves.
  - The older leaves turn yellowish first since the nitrogen is readily moved from the old leaves to the new growth.
  - If the soil is cold and wet, nitrogen in the soil is not as available to the plants.
- Excess nitrogen may cause potassium deficiency.
N-Deficiency
Phosphorus (P)

• Phosphorus is important in the germination and growth of seeds, the production of flowers and fruit, and the growth of roots.

• Phosphorus deficiency causes reduced growth and small leaves that drop early, starting with the oldest leaves.
  – Leaf color is a dull, bluish green that becomes purplish or bronzy. Leaf edges often turn scorched brown.

• Excess phosphorus may cause potassium deficiency.
P-Deficiency
Potassium (K)

- Potassium promotes general vigor, disease resistance and sturdy growth.
- Potassium deficiency causes stunted growth with leaves close together.
  - Starting with the older leaves, the leaf tips and edges turn scorched brown and leaf edges roll.
- Excess potassium may cause calcium and magnesium deficiencies
K-Deficiency
Others

• Calcium is a major ingredient in cell walls and is important for root growth, especially root tips.
• Magnesium is vital to chlorophyll production and is important in most enzyme reactions.
• Sulfur is an ingredient in proteins and is necessary for chlorophyll formation.
Ph Reaction in the Soil

Acid
4.5  5.0  5.5  6.0  6.5  7.0  7.5  8.0

Alkaline

NITROGEN

PHOSPHOROUS

POTASSIUM

CALCIUM & MAGNESIUM

SULPHUR

IRON, ALUMINIUM & MANGANESE

BORON
Nutrient Deficiency Diagnosis

Old and mature leaves

Chlorosis
- Uniform over leaf, small leaves
  - Nitrogen
- Possibly S if symptoms are also on young leaves
  - Magnesium
- Intervenial or blotchy
  - Potassium
- Tip or edge scorch, possibly intervenial yellowing or browning
  - Magnesium

Necrosis
- Intervenial or blotchy, varying shades of colour

Young leaves

Chlorosis
- Uniform over leaf
  - Sulphur, iron
- Leaf edges purple, intervenial yellowing cupping
  - Sulphur
- Zinc, Manganese, iron, Copper
- Intervenial or blotchy

Necrosis
- Intervenial biotches, and leaf edge scorching
  - Calcium
- Yellow to brown intervenial areas, red to brown-purple leaves, deformed, curled, torn leaves
  - Boron
Next Class