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# Agriculture

Ron Robertson

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# Issues

## World Population Growth

- 6.4 billion and increasing by 1.1% per year
- Constant percentage growth is Exponential Growth (also called Geometric Growth). This can be contrasted with Arithmetic Growth, where the growth is the same amount each time period.
- Doubling time for exponential growth is 72/% growth

## Quality of Soil

- Soil Erosion
- Overgrazing
- Deforestation

## Plant Protection with Pesticides

## Genetic Engineering

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# Soil

**Composed of mineral particles, organic matter, water, and air**

- Humus is the dark colored decomposed organic material in soil.

**Layers of the soil are called horizons.**

- topsoil – usually several inches thick and containing humus, rich
- subsoil – several feet thick and containing more inorganic material, poor

**Particle sizes**

clays (finest) to silt and sand to gravel (coarsest)

## **pH varies from acid (sour) to basic (sweet)**

- Soils naturally become more acidic due to carbon dioxide formation from decomposition of organic matter. Limestone ( $\text{CaCO}_3$ ) is added to increase the soil pH. The pH controls the absorption of nutrients and is very important.

## **Water**

- Can be absorbed or adsorbed.
- Can be removed by: (1) transpiration, (2) evaporation, (3) plant products, (4) movement through subsoil and rocks by percolation.

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# Nutrients

**Nonmineral – Carbon, Hydrogen, and Oxygen from air and water**

**Mineral – must be absorbed through the plant root system as solutes**

- Primary – N, P, K
- Secondary – Ca, Mg, S
- Micro – B, Cl, Cu, Fe, Mn, Mo, Na, V, Zn

## Primary

- Nitrogen from the air must be “fixed” so that it can be absorbed. Bolts of lightning form NO which is oxidized to NO<sub>2</sub> and then converted to the nitrate ion (NO<sub>3</sub><sup>-</sup>). Less than 10% is fixed in this way. A more important method is by nitrogen-fixing bacteria that live in the roots of legumes, such as soybeans and alfalfa, and convert the nitrogen into ammonia. Dead organisms and animal waste also contribute.
- Phosphorus comes totally from the mineral content of the soil in the form of monohydrogen phosphate and dihydrogen phosphate. The solubility of phosphate varies tremendously with pH.
- Potassium is absorbed in the form of the K<sup>+</sup> ion.

# Fertilizers

- Graded according to the % of N,  $P_2O_5$ , or  $K_2O$  (potash). There is no actual  $P_2O_5$  or  $K_2O$  in fertilizers. These are only used for calculations.
- May be straight (one nutrient) or complete (all three macronutrients).
- Ammonium nitrate and urea are common straight nitrogen fertilizers.
- Phosphate rock is a calcium phosphate compound. It can be reacted with sulfuric acid or phosphoric acid to get the phosphate into a more soluble compound - “superphosphate”  $Ca(H_2PO_4)_2$ .
- Potassium is found in the form of KCl.

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# Plant Protection

## Pesticides – insecticides, herbicides, fungicides

- Sales of about \$7.5 billion in 1995.

## Insecticides

- DDT – first of the chlorinated organic insecticides (now banned)
- Important classes
- chlorinated hydrocarbons (DDT) – neurotoxin – also interferes with Ca metabolism
- organophosphates (Malathion – neurotoxin - anticholinesterase poison)
- carbamates (Sevin– neurotoxin - anticholinesterase poison)
- natural – pyrethrum (from dried chrysanthemum flowers) and Bt bacterial toxins

# Herbicides

- Selective – kills only a particular group of plants, are usually growth hormones and cause cells to swell
- Nonselective – kills all plants, usually interfere with photosynthesis and starve the plant
- Examples: 2,4 – dichlorophenoxyacetic acid (2,4 – D) – results in an abnormally high level of RNA which causes the plants to grow themselves to death
- Triazines like Atrazine used in corn to control weeds – binds to protein in chloroplasts, inhibiting photosynthesis
- Glyphosate products like Roundup inhibit the synthesis of some essential amino acids.

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# Current topics

**Organic farming – farming without chemical fertilizers and pesticides**

**Agricultural engineering – transgenic crops (genetically altered) – research is ongoing**