Basic Concepts in Soil Fertility and Nutrient Management

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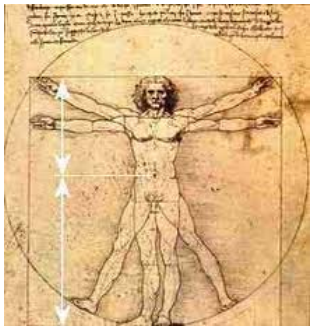
Outline

1. Nutrition
2. Water
3. Soil pH and Acidity
4. Soil Organic Matter
5. Nutrient Management
6. Fertilizers and soil amendments

Human Growth Requirements



Water

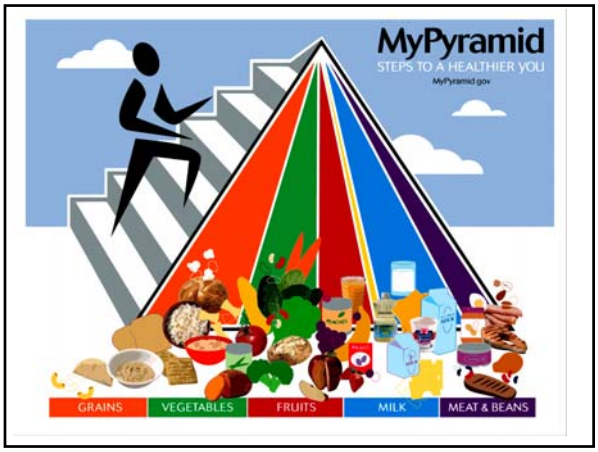
Proteins

Carbohydrates

Vitamins

Fats and oils

Minerals



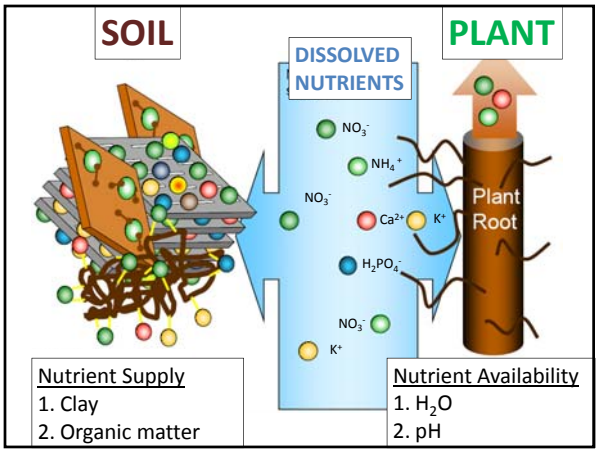
Plant Growth Depends on: Sunlight
Water

Macronutrients

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

Micronutrients

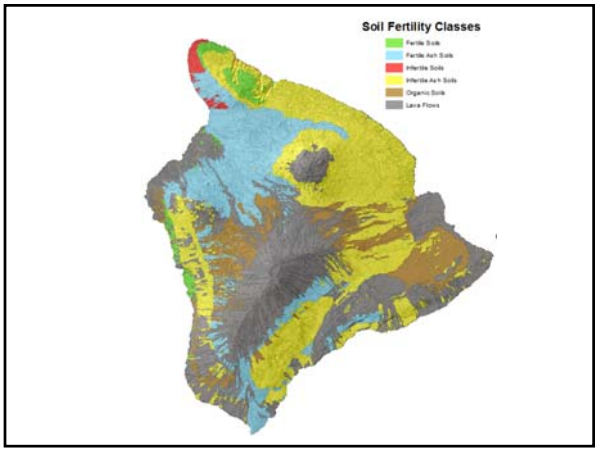
- Boron (B)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)



Too Little Water
- Drought
- Low nutrient availability
- Poor plant growth

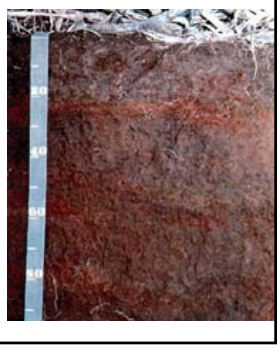
Too Much Water
- Nutrient leaching
- Nitrogen loss as gas

$NO_3^- \longrightarrow N_2O\uparrow$

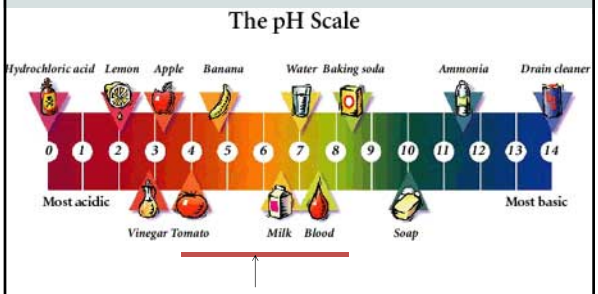


Hamakua Soils are Acid

- Very low nutrient status
  - Nutrients mainly found in soil organic matter
  - Deficient in Ca and K
- Very high P fixation
  - Soils deficient in P
  - P fertilizers required
  - Organic sources of P most effective
- When pH < 5.5 Al toxicity is possible



Soil pH is an Expression of Acidity/Alkalinity



Typical pH range in soils

Negative Effects of Soil Acidity (pH < 5.5)

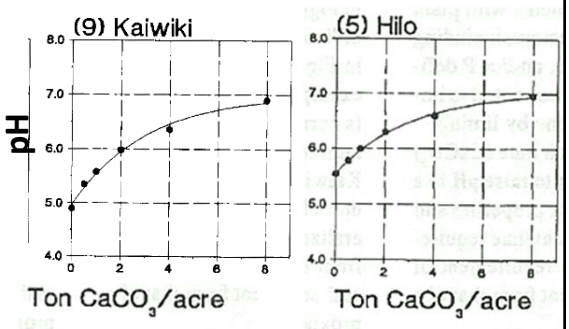
1. Ca, Mg, and K deficiency
2. P deficiency
3. Aluminum toxicity
4. Manganese toxicity

Negative Effects of Soil Alkalinity (pH > 7.5)

1. P deficiency
2. Fe, Cu, B, Mn, and Zn deficiency
3. Salt problems

Liming

1. Ideal pH range: 6.0 – 6.5
   - Liming is critical when pH drops below 5.5
   - pH > 7.0 results in micronutrient deficiencies
2. Raise pH:
   - Increases P availability
   - Corrects Al and Mn toxicity
   - Increases N, S, B, Cu and Mo availability
3. To supply Ca
4. Liming materials
   - calcium carbonate (limestone)
   - calcium/magnesium carbonate (dolomite)



Soil Organic Matter

Soil Organic Matter Provides:

1. Cation exchange capacity (CEC)
2. Water holding capacity
3. Essential plant nutrients (N, P, K, Ca …..)
4. Detoxification of Al
5. Habitat for soil microorganisms
   - Mycorrhiza
   - rhizobia

Organic Matter Improves Soil Physical Properties

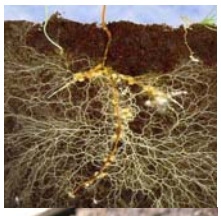
- OM increases H_2O infiltration
- OM decreases soil bulk density and increases aeration
- OM increases water retention

Organic Matter Improves Soil Chemical Properties

- OM increases nutrient availability and supply
- OM increases nutrient retention
- OM detoxifies Al

Organic Matter Improves Soil Biology

- OM is the food for soil organisms
- OM increases microbial diversity
- Microbial diversity ensures nutrient cycling
- Microbial diversity promotes pathogen suppression through competition



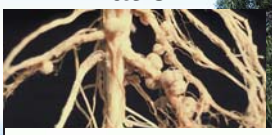
Nutrient Cycling in Natural Ecosystems

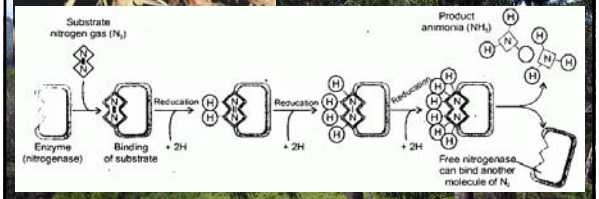
- Leaf litter source of plant nutrients
- Biological N fixation
- Mycorrhiza

Biological N Fixation

Mycorrhiza

Biological N Fixation





$N_2 + 8H^+ + 8e^- + 16\ ATP \rightarrow 2NH_3 + H_2 + 16\ ADP + 16\ P_i$

Mycorrhiza

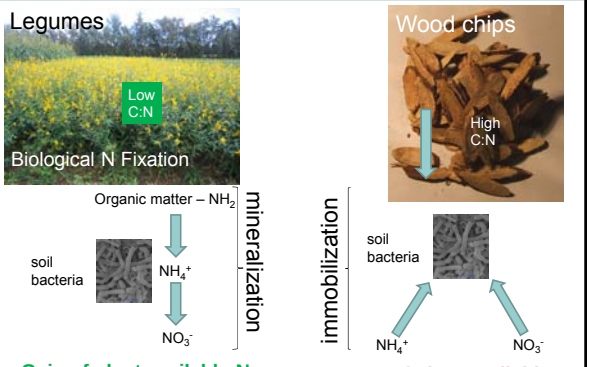
- Symbiotic relationship between soil fungi and roots
- Fungi brings scarce nutrients and water to plant, plant supplies sugars

A Note on Nitrogen

- Forms of Nitrogen
  - Gaseous N_2 (78%)
    - Non-reactive
  - N in soil organic matter (proteins and amino acids)
    - Not readily available for plant use

  Plant Available N
  - Ammonum N (NH_4^+)
  - Nitrate N (NO_3^-)

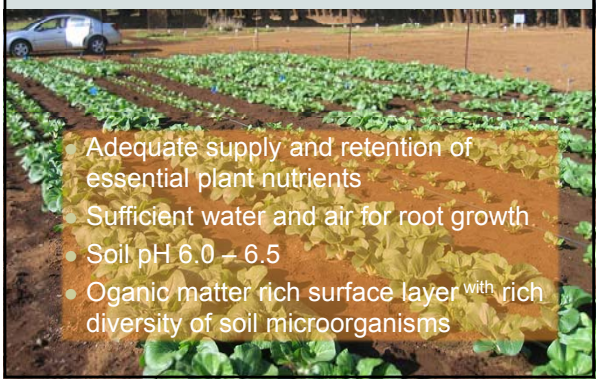
Nitrogen Availability



Gain of plant available N

Loss of plant available N

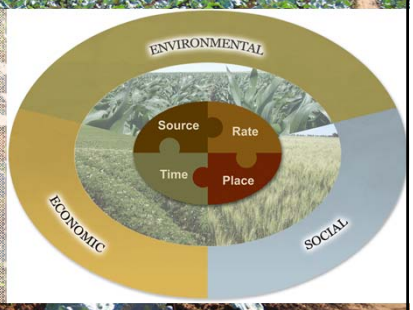
Soil Fertility Depends on:



- Adequate supply and retention of essential plant nutrients
- Sufficient water and air for root growth
- Soil pH 6.0 – 6.5
- Oganic matter rich surface layer with rich diversity of soil microorganisms

4R Nutrient Management Concept

1. Right Source
   - What type of fertilizer?
2. Right Rate
   - How much?
3. Right Time
   - When & how often?
4. Right Place
   - Where?



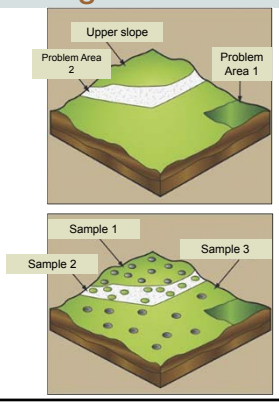
What is Missing?

Soil Test

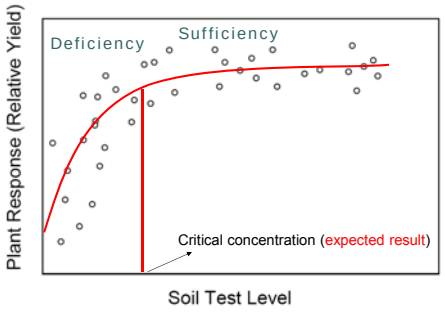
- Soil tests determine how much nutrients are in the soil
- Soil tests are used to make fertilizer recommendations
- Soil tests improve fertilizer application efficiency

Soil Testing

- Separate samples for distinct management areas
- Proper depth/s
- Usually 15 to 20 cores, mix well, take sub-sample
- Avoid contamination



Soil Test Calibration



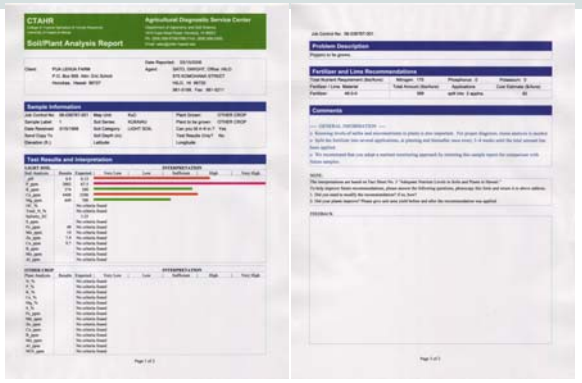
How Much to Add Depends on Crop

Some Examples:

Crop	Yield T/acre	N	P	K	Ca	Mg
		lbs/acre				
Corn (FW)	20	233	30	212	33	17
Cabbage	29	136	16	99	17	3
Onions	41	114	20	104	23	11
Lettuce	30	113	15.4	180	24	8
Cucumber	22	44	13	65	28	7
Tomato	27	200	20	297	103	29
Banana	47	252	27	933	97	18

Soil testing lab (ADSC) can provide guidance

Soil Test Printout



Soil Test Results

Test Results and Interpretation

LIGHT SOIL Soil Analysis	Results	Expected	INTERPRETATION Very Low | Low | Sufficient | High | Very High
_pH	5.6	6.15	
P_ppm	9.8	67.5	
K_ppm	223	300	
Ca_ppm	795	3500	
Mg_ppm	280	700	
OC_%		No criteria found	
Total_N_%		No criteria found	
Salinity_EC		1.25	

Fertilizer and Lime Recommendations

Total Nutrient Requirement (lbs/Acre):		Nitrogen: 300	Phosphorus: 989	Potassium: 92
Fertilizer / Lime	Material	Total Amount (lbs/100sq-ft.)	Applications	Cost Estimate ($/100sq-ft.)
Fertilizer:	10-30-10	6.88	split into 5 applns.	1.38
Lime Material:	Dolomite	3.33	split into 1 applns.	0.734
Ca Material:	Gypsum	16.5	split into 1 applns.	2.98
Mg Material:	Mg-Sulfate	4.52	split into 1 applns.	1.81

Fertilizers

Organic or conventional?

Organic
- Feeds the soil
- Recycles local materials increasing sustainability
- Growing market
- Difficult to predict nutrient availability
- Organic fertilizers less accessible
- Need to add large quantities

Conventional
- Feeds the plant
- Easier to control and apply
- Relatively cheap
- Relies on imported chemicals
- Negative impacts on soil quality

Nitrogen Fertilizers

- Urea: 46-0-0 (46% N)
- Ammonium sulfate: 21-0-0 (21% N)
- Calcium Nitrate: (15.5% N)

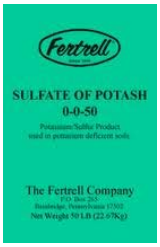
15.5-0-0

Phosphorus Fertilizers

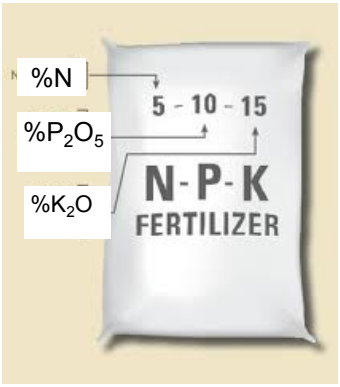
- TSP: 0-45-0 (45% P_2O_5 or 19.8% P)

Potassium Fertilizers

- Muriate of potash: 0-0-60 (49.8% K)
- Sulfate of potash: 0-0-50 (41.5%)



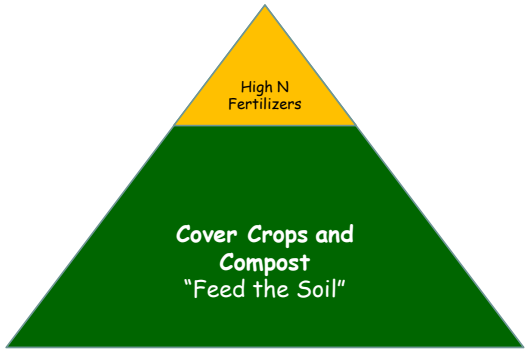
Blended Fertilizers



Common Blends

- 10-10-10
- 16-16-16
- 10-30-10

Organic Approach



Compost Properties

- Decomposed organic materials
- Dark material with particle size < 2.5 cm
- No foul odor
- pH = 6.0 – 7.0
- Balanced nutrient concentrations

Benefits of Compost

Soil Physical Properties
- Improve soil structure
- Increase water retention
- Decrease bulk density

Soil Chemical Properties
- Source of essential nutrients
- Increase nutrient retention (CEC)
- Detoxify Al
- Buffer pH

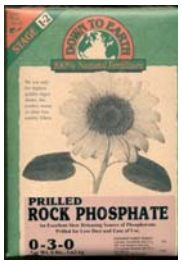
Soil Biological Properties
- Increase microbial abundance and diversity
- Create disease suppressive soils

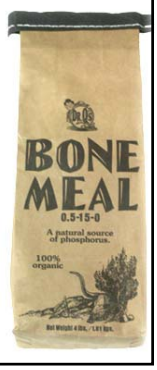
Organic Nitrogen Fertilizers

Organic
- Fish meal (≈10% N)
- Feather meal (12 - 13% N)
- Chicken manure (≈3% N)

Organic P Fertilizers

Organic
- Bonemeal
- Rock phosphate
- Chicken manure (≈2-3% P)

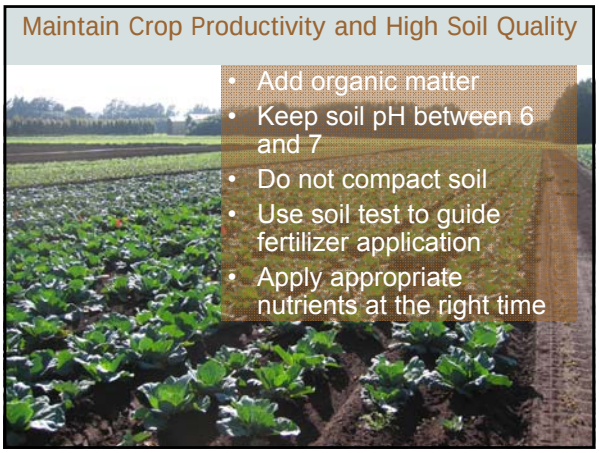




Organic K Fertilizers

Organic
- Wood ash
- Seaweed
- Green sand
- Sulfate of potash

Maintain Crop Productivity and High Soil Quality



- Add organic matter
- Keep soil pH between 6 and 7
- Do not compact soil
- Use soil test to guide fertilizer application
- Apply appropriate nutrients at the right time