Hemp Fertility Management

Dr. Heather Darby, Agronomist
University of Vermont

Temperature, Water, Light

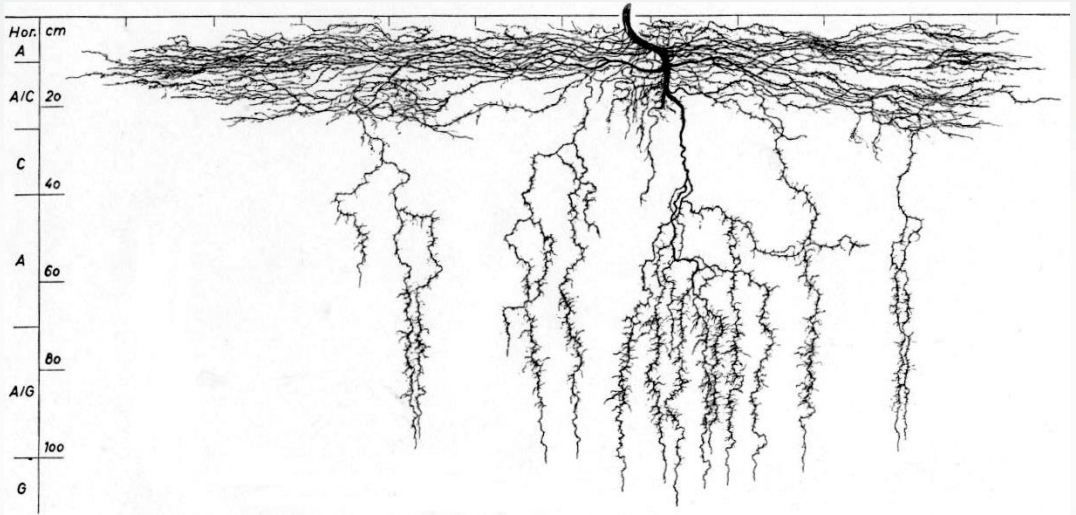
- Adapt to region – fairly cold tolerant.
- Tolerant of hot and arid conditions provided roots can reach water.
- Does not tolerate water logged soils.
- Thrive in full sun.

Soil Limitations

- Grows best on sandy loams.
- 40% or more clay not generally good.
- Adequate pH – over 6.0 (requires calcium).
- Nutrient loving especially N-P-K.

Root Ecology

- Long tap root (6 ft) if friable soil.
- Medium texture soil tap root 3 ft.
- High water table more lateral roots.



Fertility Requirements

Potassium (2.5 to 3.0%)

65 – 70 lbs per acre

Phosphorus (0.5 – 0.6%)

50 to 70 lbs per acre

Fertility Requirements

Nitrogen (5 to 6%)

100 to 200 lbs per acre

Applied early in growth

No response in rich soil

Reduce THC??

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

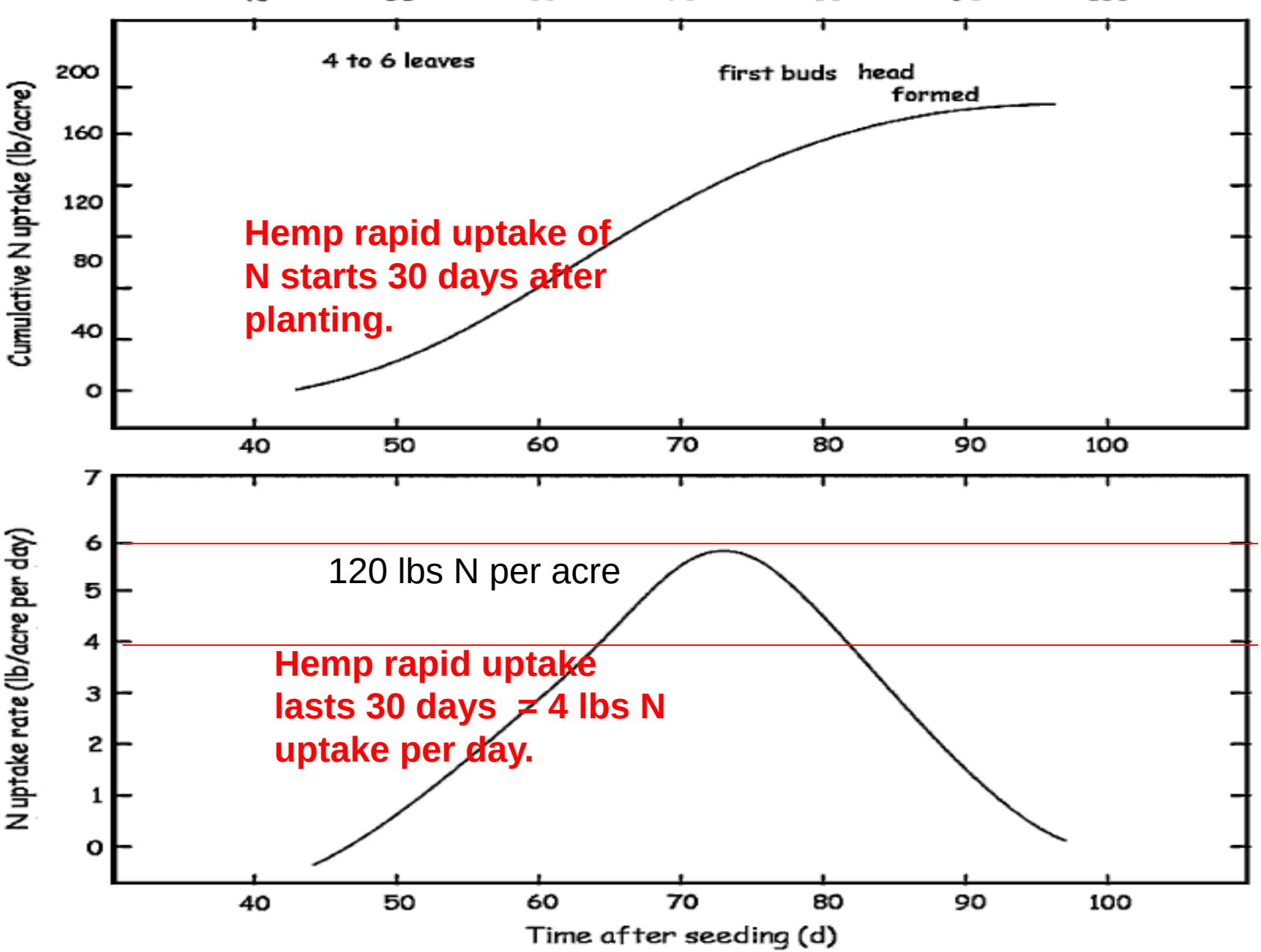


Fig. 4. Phases of broccoli crop nitrogen (N) uptake rate (lb/acre per day) and cumulative N uptake in lb/acre (1 lb/acre = 1.1209 kg·ha^{-1}) compared with broccoli biomass accumulation in ton/acre (1 ton/acre = 2.2417 mg·ha^{-1}) (Sullivan et al., 1999).

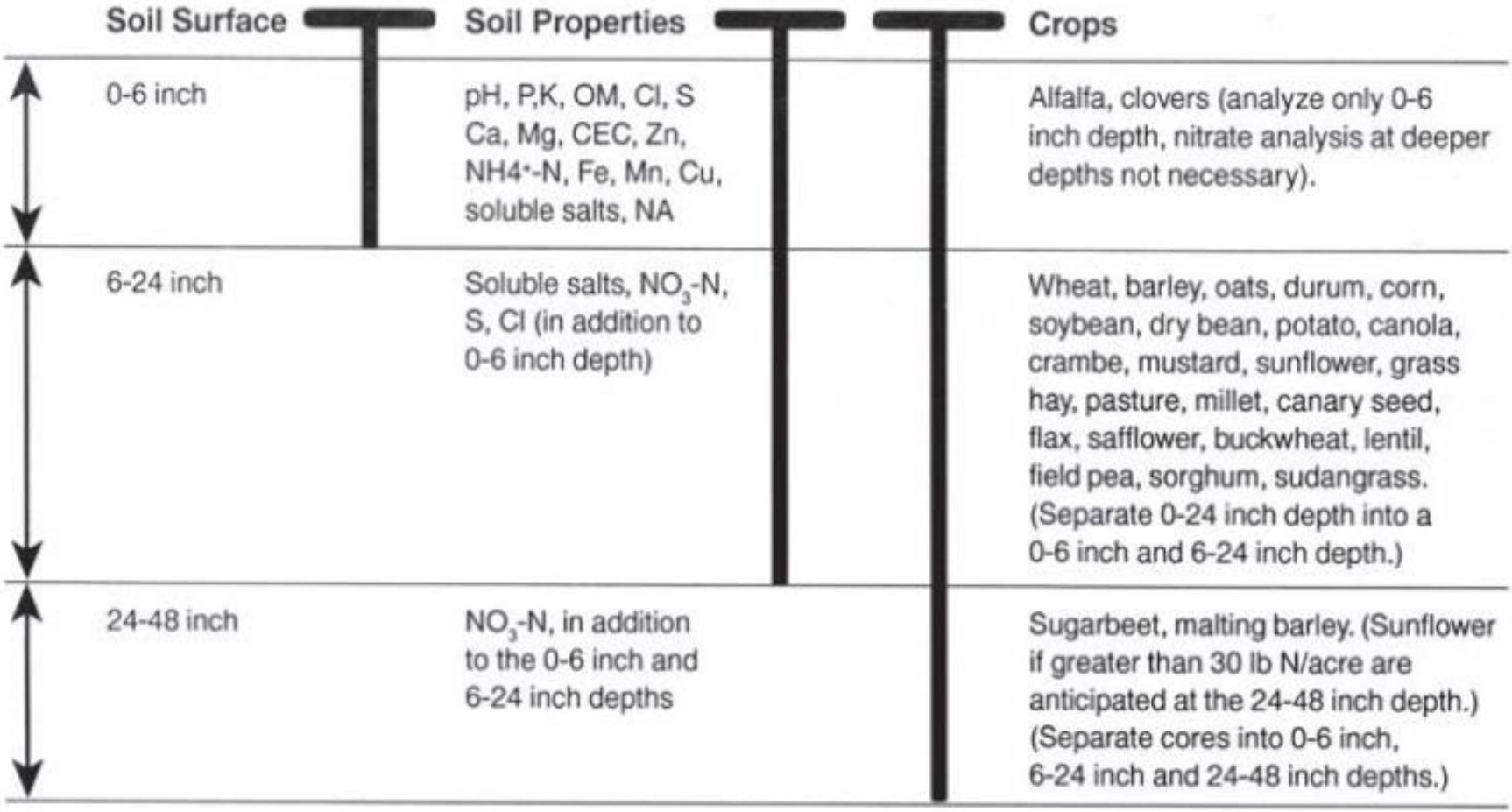


Figure 1. Depth recommended generally for soil analysis of certain properties and nitrate analysis for crops.

802-524-5151 802-524-8505 x119 Reported: 12/3/2014

VT County: Franklin

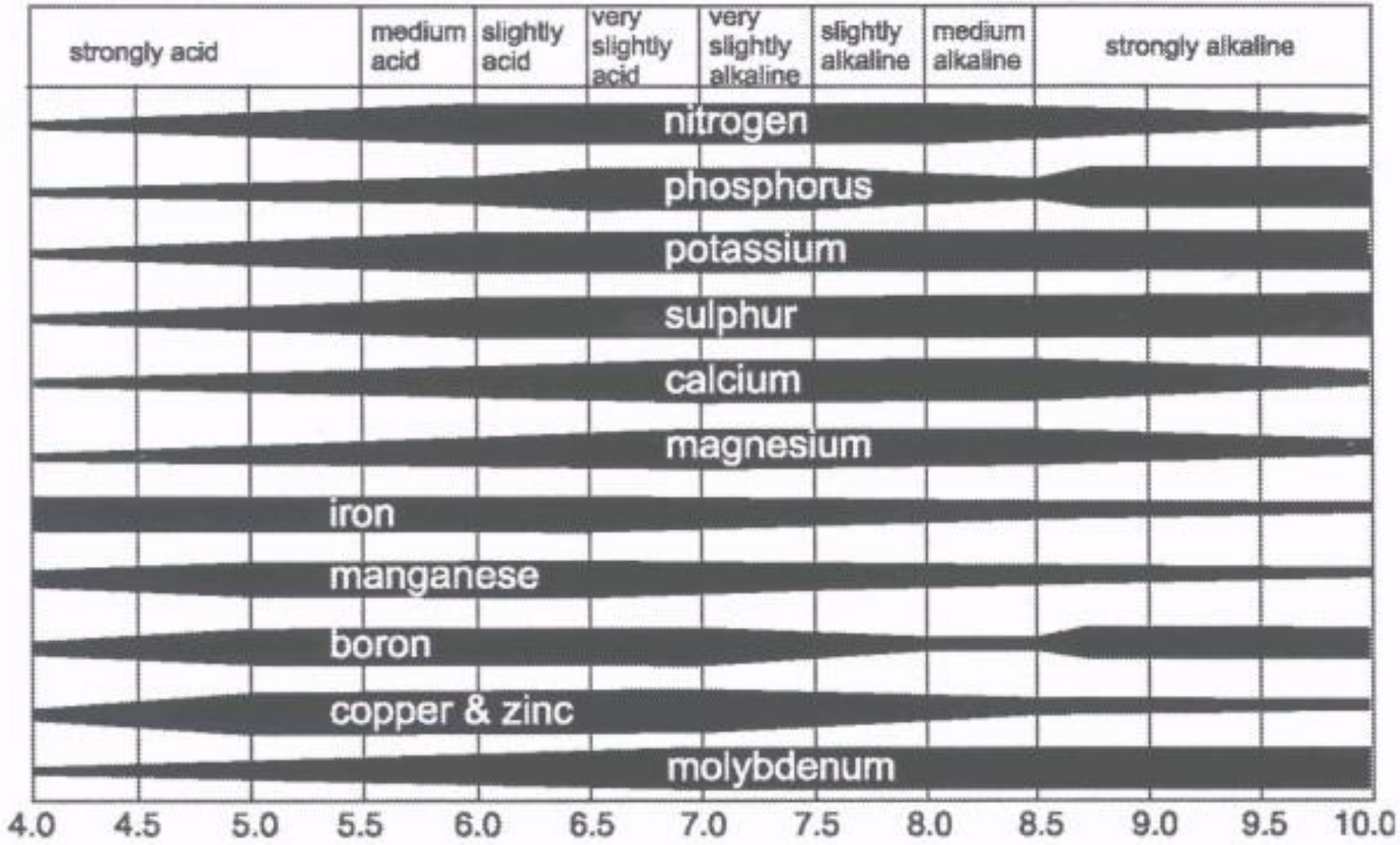
Results

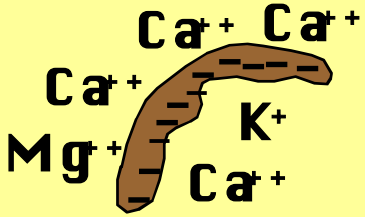
Nutrient	Low	Medium	Optimum	High or Excessive
Phosphorus (P):				
Potassium (K):				
Magnesium (Mg):				

Analysis	*Value Found*	*Optimum Range or Average*	*Analysis*	*Value Found*	*Optimum Range or Average*
Soil pH (2:1, water)	6.4		Copper (Cu)	0.3	0.5
Modified Morgan extractable, ppm			Zinc (Zn)	0.5	10
Macronutrients			Sodium (Na)	14.0	20.0
Phosphorus (P)	2.0	4-10	Aluminum (Al)	47	
Potassium (K)	54	100-160	**Soil Organic Matter %**	5.3	
Calcium (Ca)	1664		**Effective CEC, meq/100g**	9.6	
Magnesium (Mg)	134	50-120	**Base Saturation, %**		
Sulfur (S)	8.0		Calcium Saturation	77.4	40-80
Micronutrients			Potassium Saturation	1.3	2.0-7.0
Iron (Fe)	13.5	7.0	Magnesium Saturation	10.4	10-30
Manganese (Mn)	4.9	14.0			
Boron (B)	0.3	0.3			

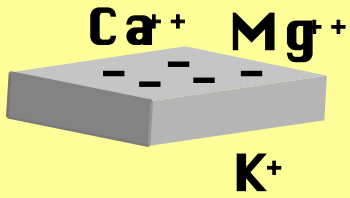
Recommendations for Pasture, Grass (< 30% legume) - Maintenance (2AM)

Limestone (Target pH of 6.2)	Nitrogen, N	Phosphate, P_2O_5	Potash, K_2O
tons / Acre	**lbs / Acre**	**lbs / Acre**	**lbs / Acre**
0	**50**	**60**	**80**

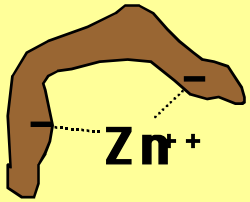




a)cations held on humus



b)cations held on clay particle

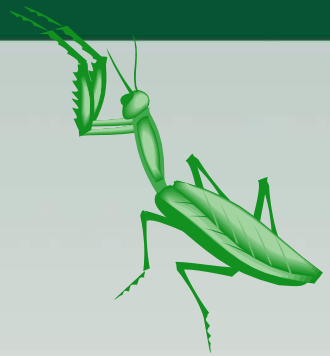


c)cations held by organic chelate

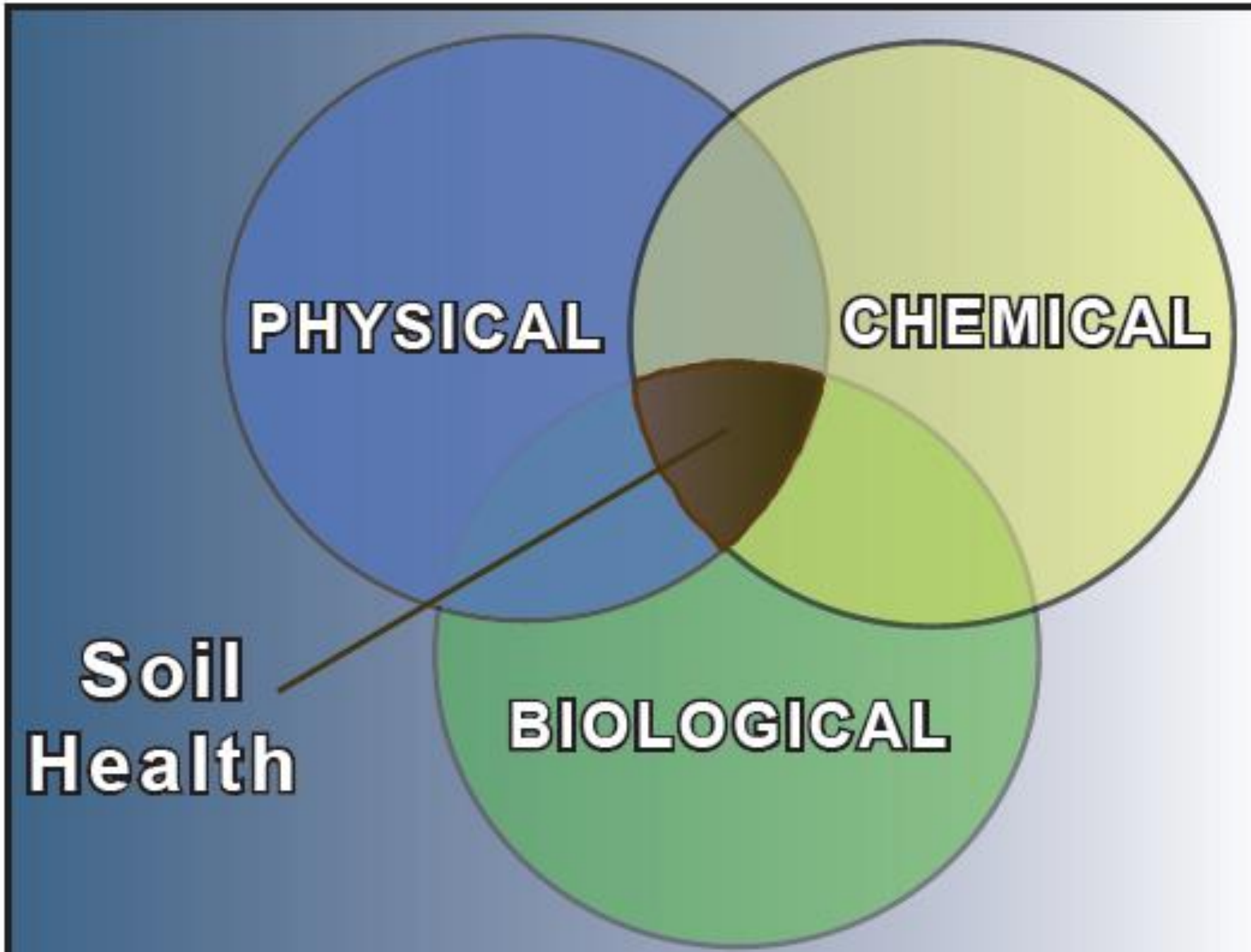
Cation Exchange Capacity

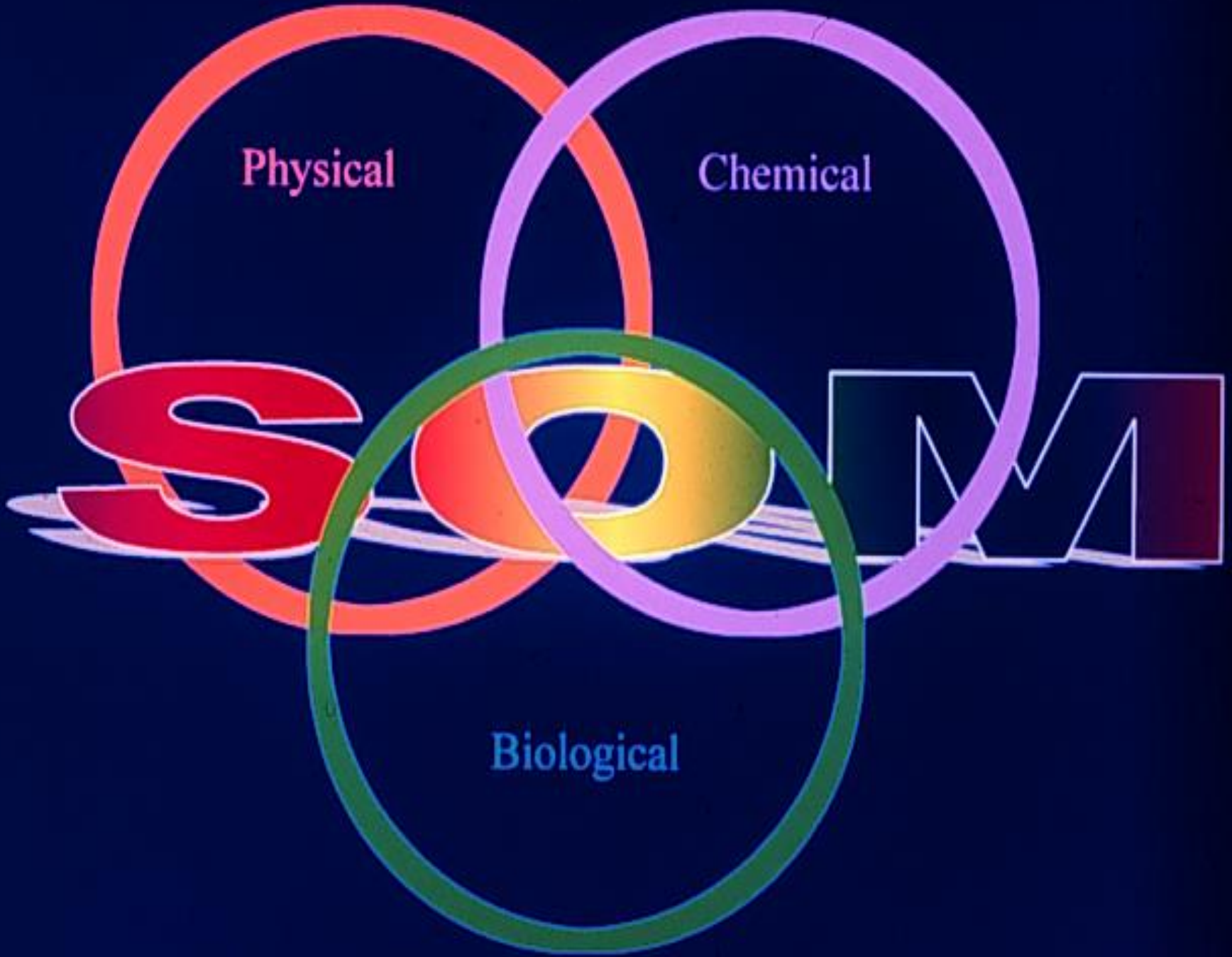
and Chelation

Soil Health is



The ability of a soil to provide a physical, chemical, and biological environment for the plant that is health sustaining.

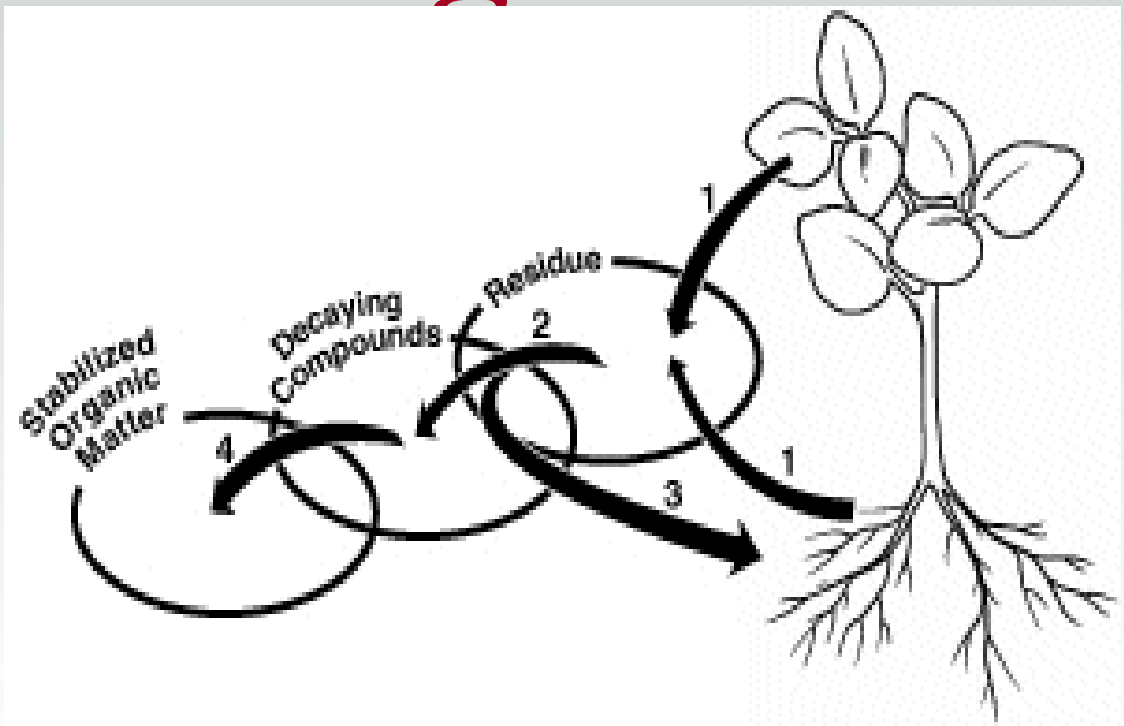

PHYSICAL
CHEMICAL
BIOLOGICAL
Soil Health


Physical
Chemical
Biological
SOM

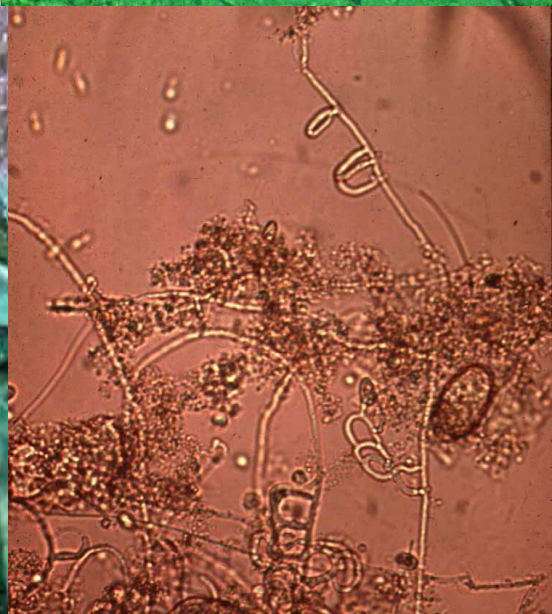
There are three general "types" of organic matter in soils

- ✓ Living
- ✓ Dead
- ✓ Very Dead

Changing Forms of Soil Organic Matter



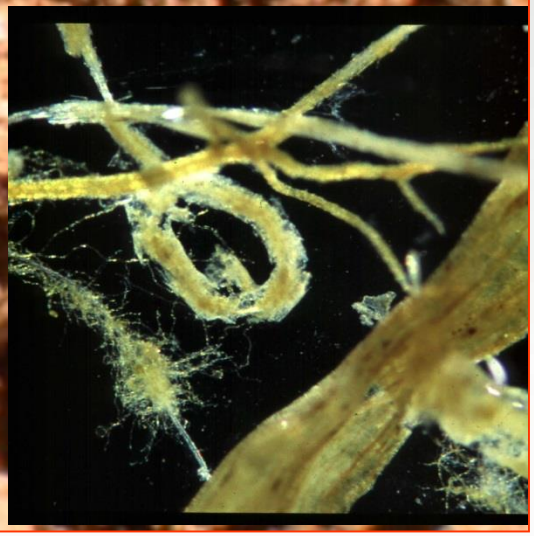
The Living



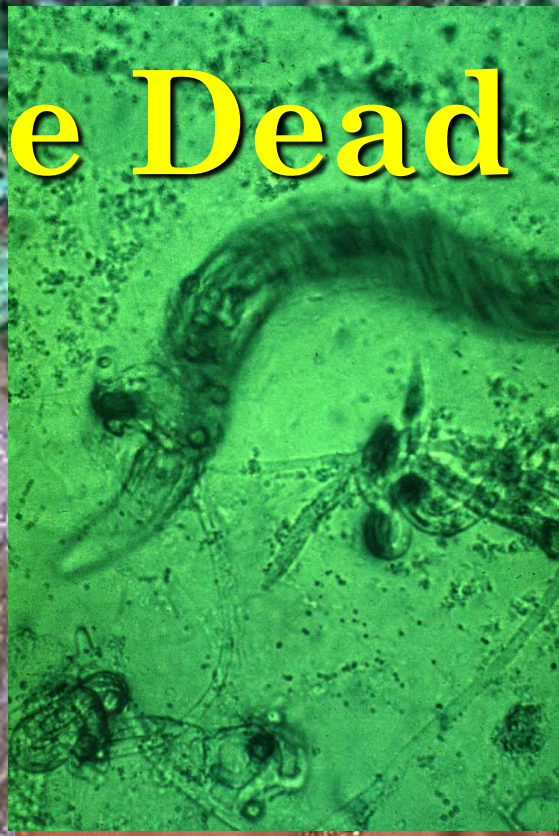
—Dead —

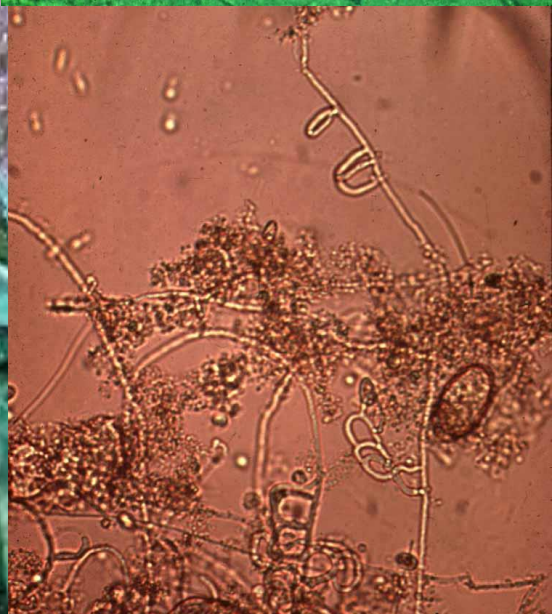
Recently dead soil organisms and crop residues provide the food (energy and nutrients) for soil organisms to live and function. Also called "active" or "particulate" organic matter.

Active OM



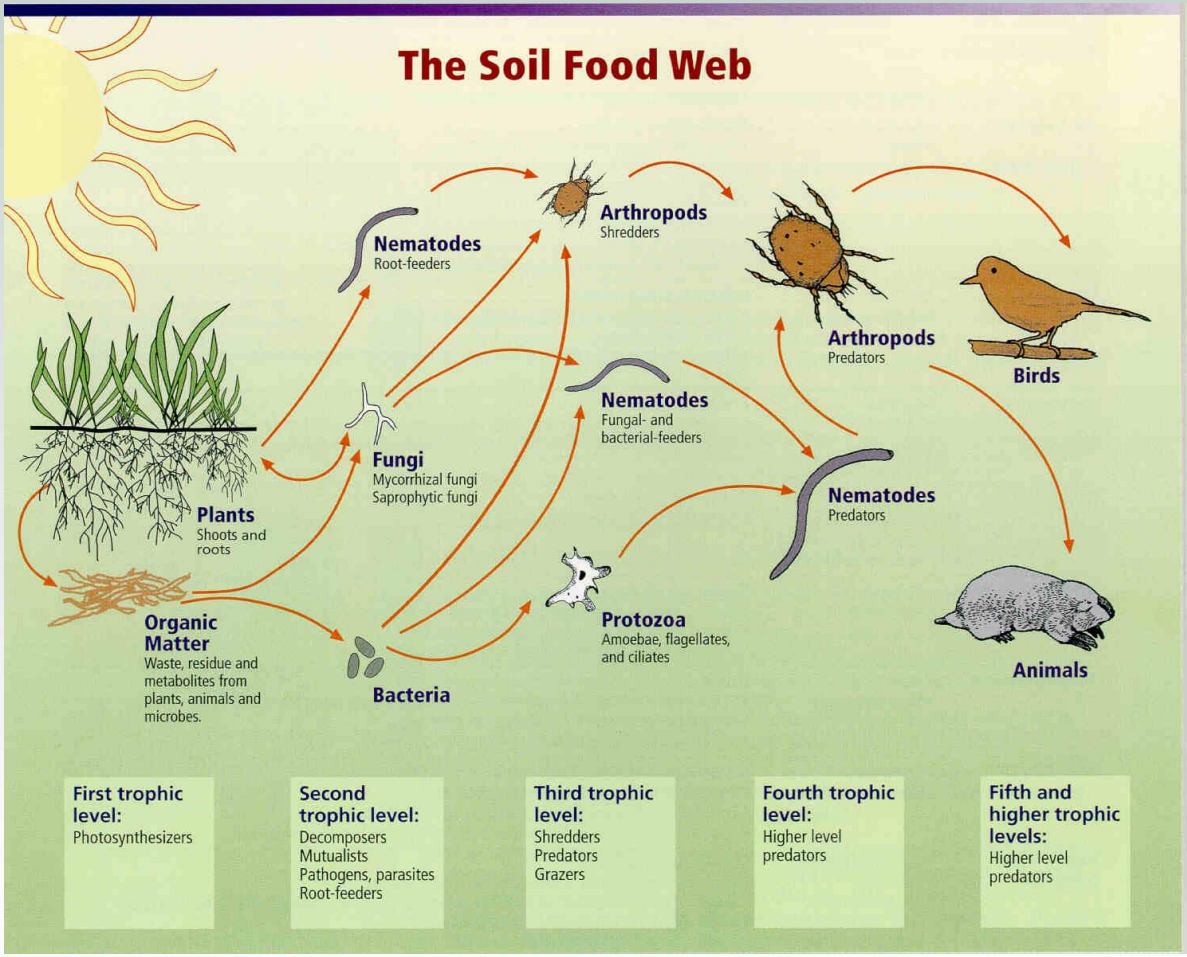
The Living Eat the Dead



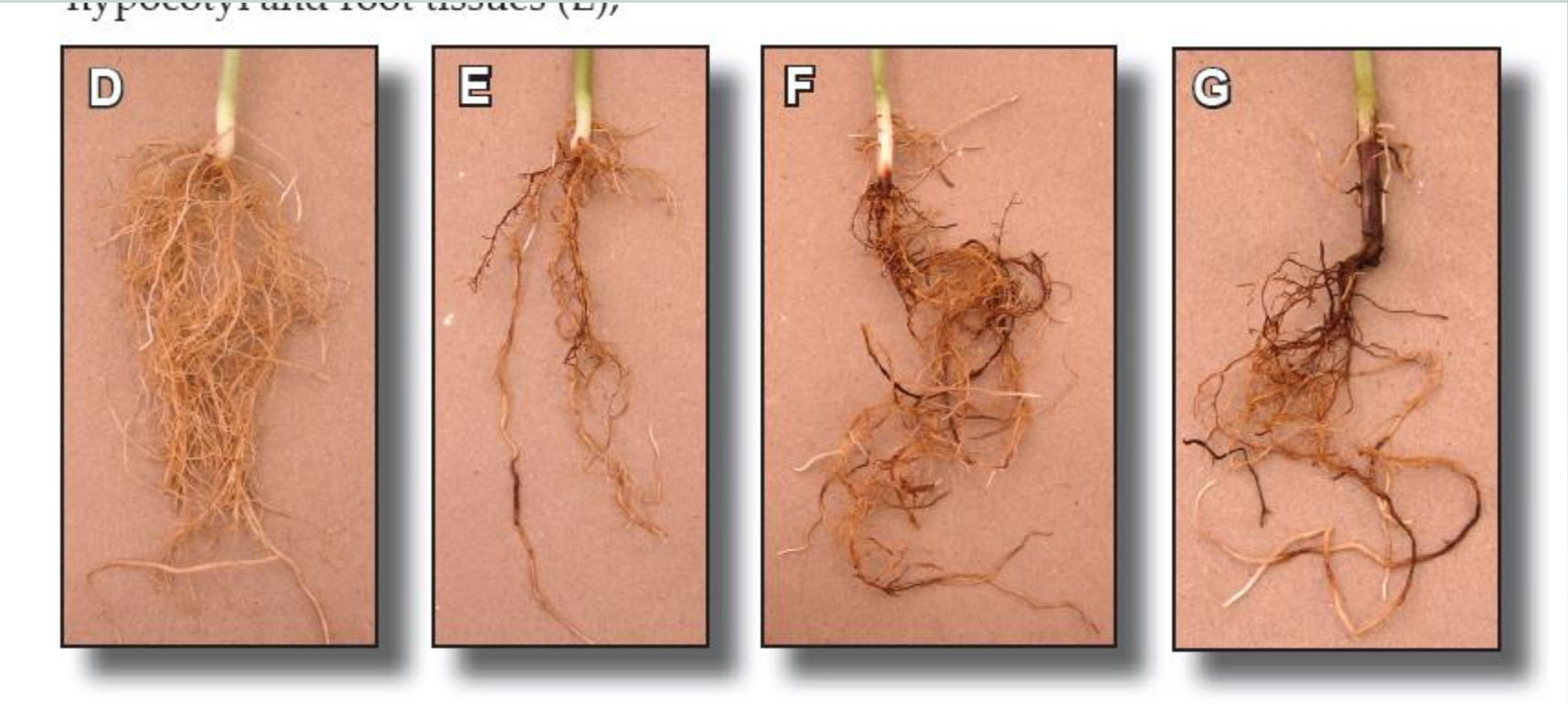


Living & Dead Organic Matter

Nutrient cycling in soil is highly dependent on an active and diverse community of microbes

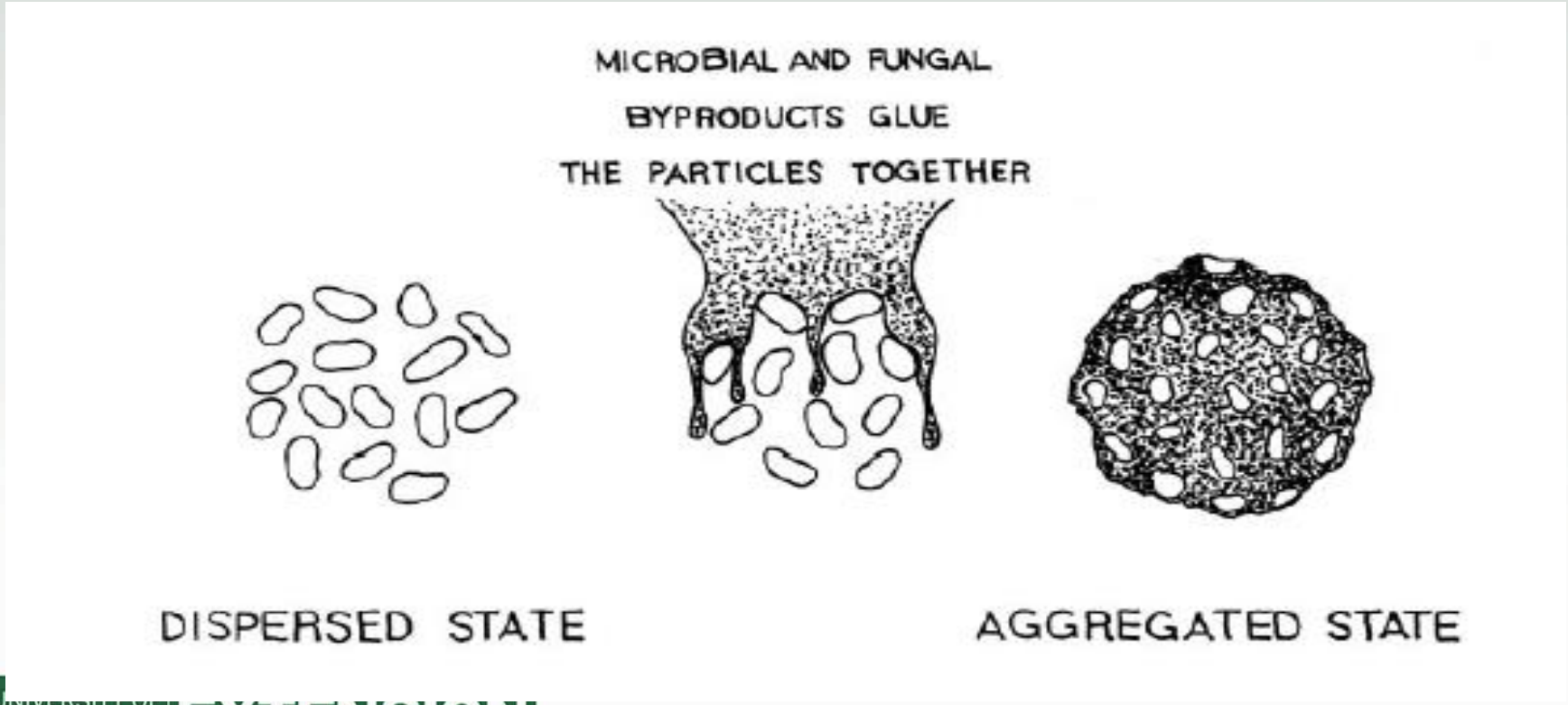


Disease Suppression



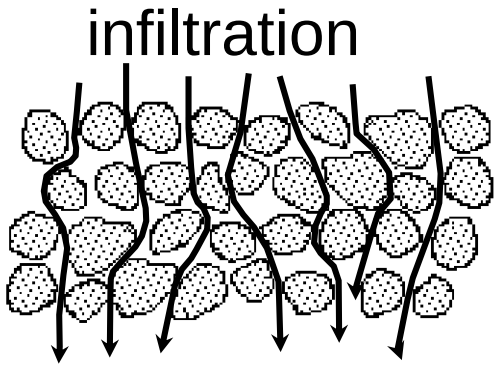
Living and Dead Form Aggregates

Humus, partially broken down organic matter, plant roots, fungal threads, bacterials gels, and earth worm feces, form glues that hold soil particles together creating a good soil structure

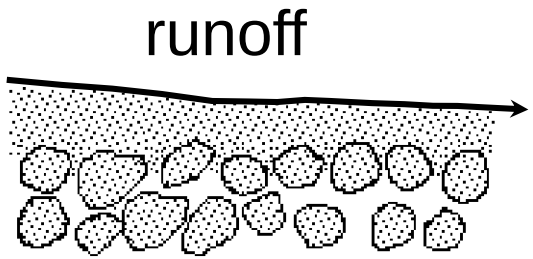



Macroaggregate
a
OM
Foster et al, 1983

Environmental Health

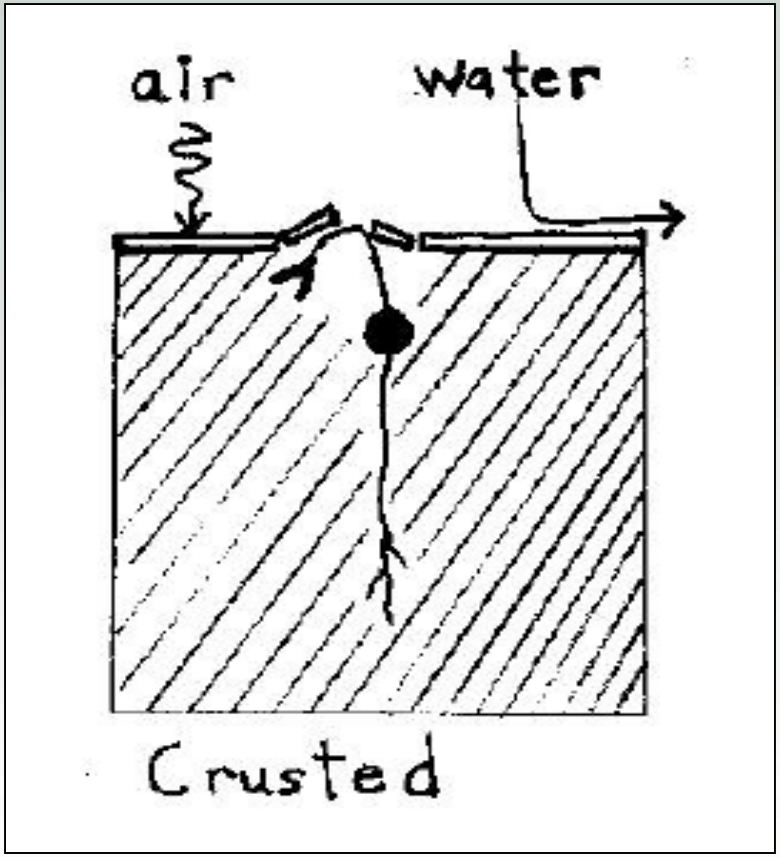


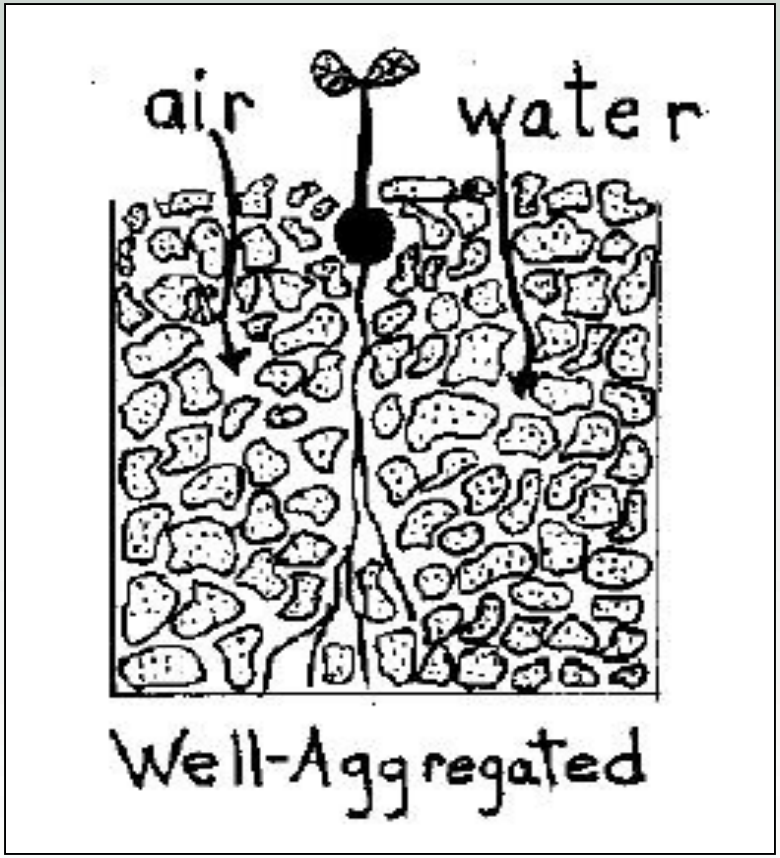
a) aggregated soil



b) soil crusts after aggregates break down

Microbe and Plant Health





Runoff from bare soil

Runoff from soil with vegetative cover

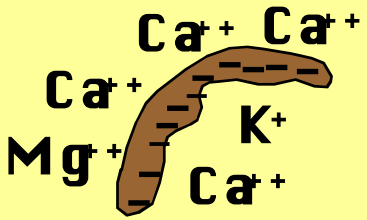
UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Resilancy

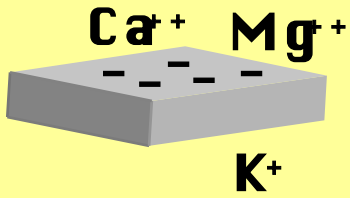
—Very Dead —

Well decomposed organic materials, also called humus. Humus contains very high amounts of negative charge.

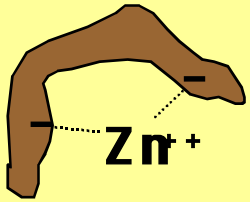
Very Dead Organic Matter



a)cations held on humus



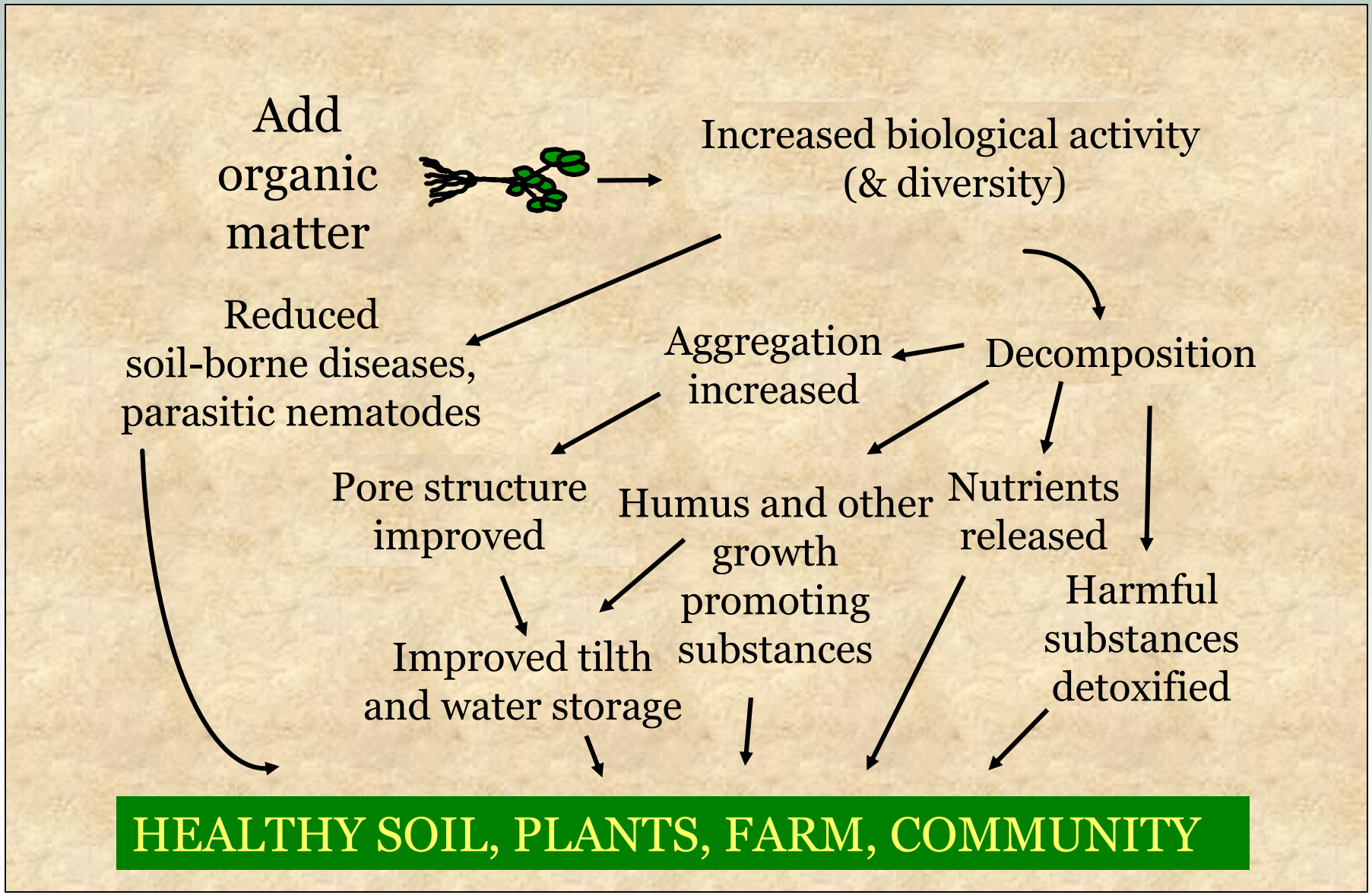
b)cations held on clay particle

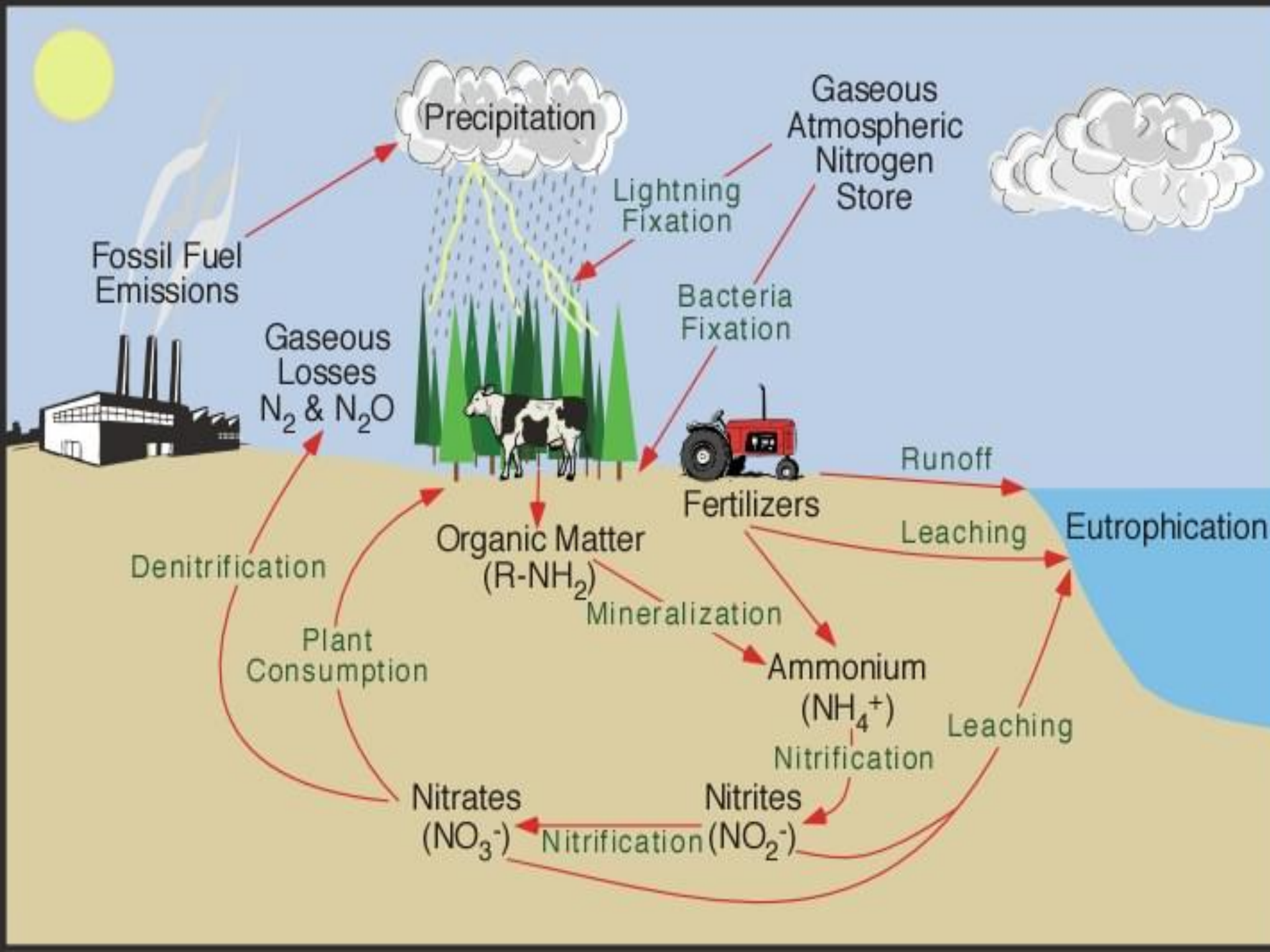


c)cations held by organic chelate

Cation Exchange Capacity

and Chelation




Precipitation
Gaseous Atmospheric Nitrogen Store
Lightning Fixation
Fossil Fuel Emissions
Bacteria Fixation
Gaseous Losses N_2 & N_2O
Runoff
Fertilizers
Eutrophication
Leaching
Organic Matter ($R\text{-}NH_2$)
Denitrification
Mineralization
Plant Consumption
Ammonium (NH_4^+)
Leaching
Nitrification
Nitrates (NO_3^-)
Nitrites (NO_2^-)
Nitrification

Soil Nitrogen

- **Organic Nitrogen (SOM)**
  - **slowly available to crops**
  - **microbes required**

- **Inorganic Nitrogen**
  - **rapidly available - Plant Available Nitrogen**
  - **ammonium ion (NH_4^+) and nitrate (NO_3^-)**

Mineralization

Manure
Legume
(Organic-N)

Plant available NH4+

(Soil Temp. > 50 degrees F)

Air, Moisture, Nice Home!

Immobilization

Manure
Legume
(Organic-N)

Soil
Microbes

Plant available NH4+

(Soil Temp. > 50 degrees F)

Air, Moisture, Nice Home!

Nitrification

Plant available NH4+

Soil

Bacteria

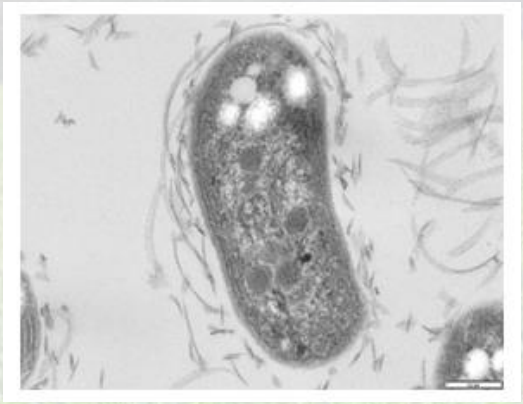
Plant available NO-3

Soil Temp. > 50 degrees F

pH near 7

Air, Moisture, Nice Home!

Produces H+ so reduce pH



Volatilization

Increase with high pH

Increase with wet to rapid dry conditions

Denitrification

(Soil Temp. > 50 degrees F)

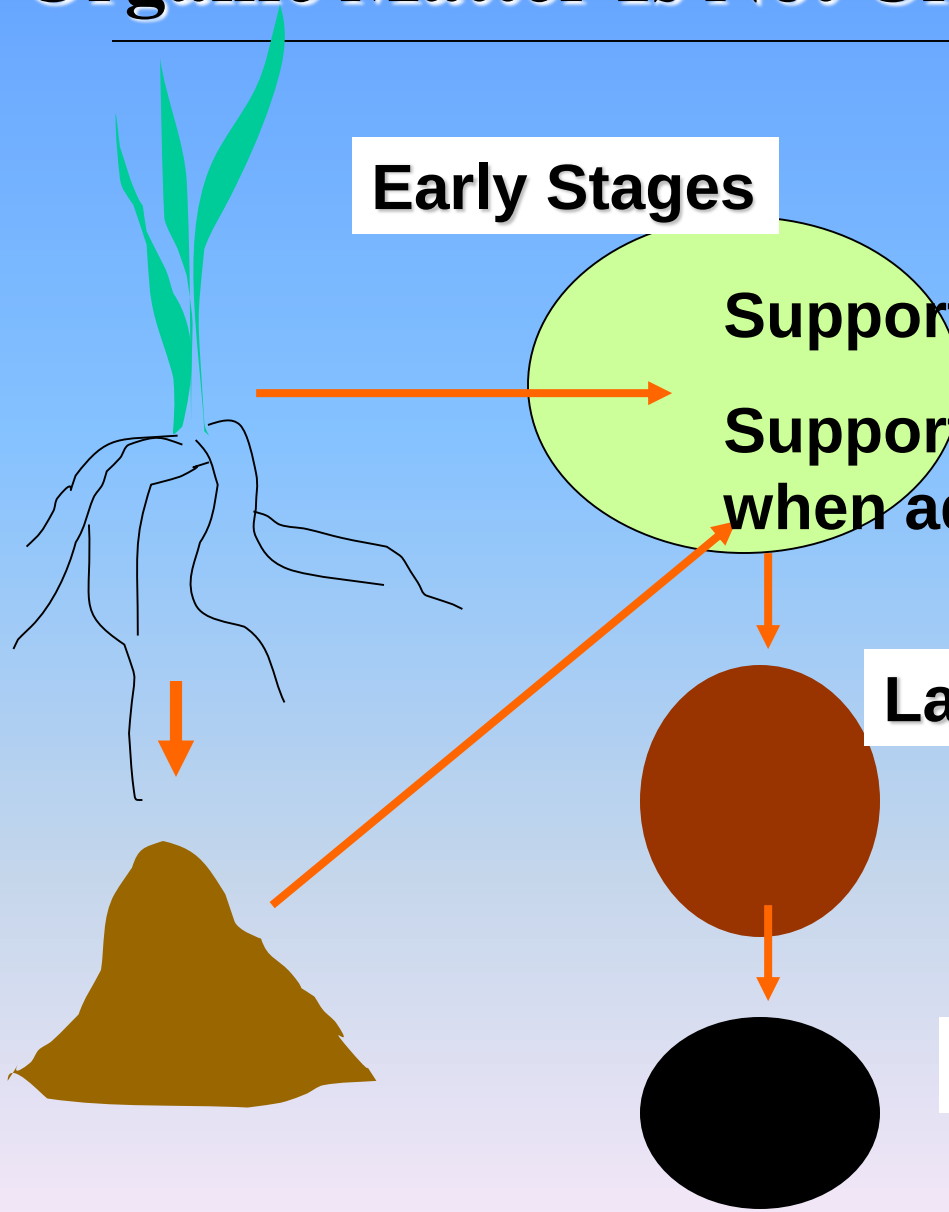
NO OXYGEN, Moisture

Nitrogen Supply - Organic Farms

- Backbone – Building Soil Organic Matter
  - N-fixed through legumes
  - Animal manure/composts
  - Organic fertilizers

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Organic Matter Is Not Created Equal



Early Stages

Supports high microbial activity

Supports rapid decomposition when adequate C and N.

Later Stages

Food but need some N

High C

Even Later Stages

Food but need lots N

Very High C

Nitrogen Credits for Alfalfa

Alfalfa Stand Density		Medium or Fine Textured Soils		Sandy Soils	
		> 8 inches regrowth	< 8 inches regrowth	> 8 inches regrowth	< 8 inches regrowth
		NITROGEN CREDIT			
		- - - - - - - - - - lbs N/acre - - - - - - - - - -			
Good	>70%	190	150	140	100
Fair	30-70%	160	120	110	70
Poor	<30%	130	90	80	40

Red Clover and Soybean Nitrogen Credits

- Sod
  - 70 lbs N/a maximum
    - *80% of alfalfa credit*
- Cereal Cover crops
  - 0 - 90 lbs N/a

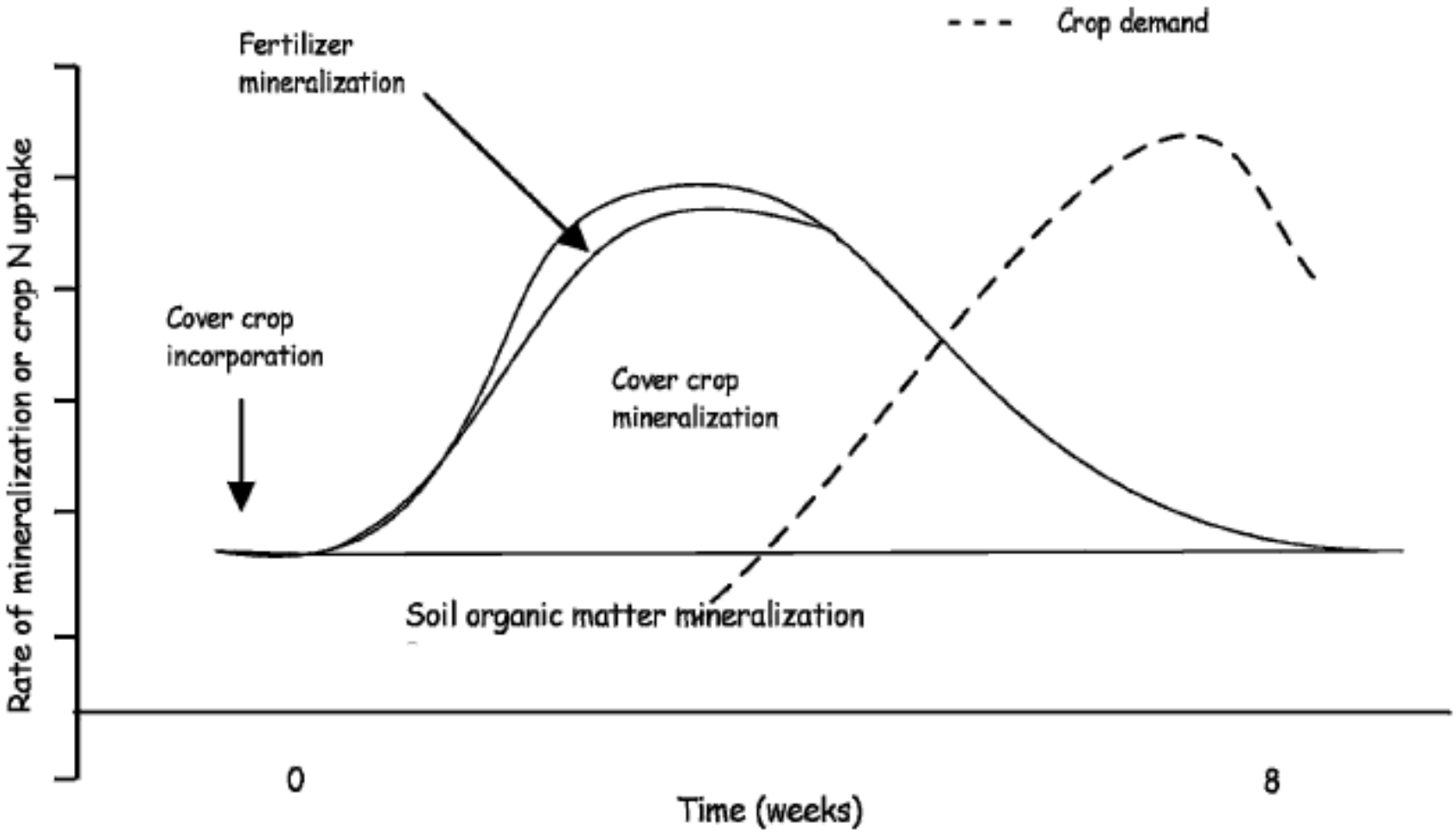


Fig. 2. Timing of nitrogen (N) mineralization from soil organic matter, cover crop residue, and organic fertilizer in relation to crop N uptake (from Gaskell et al., 2006).

Gaskell & Smith, 2007

Organic Fertilizers

Byproducts of Fish, Livestock, or Food

Table 1. Common organic nitrogen (N) fertilizer materials and their nutrient analysis.[z]

Material	Nitrogen (% N)	Phosphorus (% P)	Potassium (% K)
Fish meal or powder	10–11	1.3	<1
Pelleted chicken manure	2–4	<1	<1
Processed liquid fish residues	4	<1	<1
Feather meal	12	0	0
Seabird and bat guano	9–12	<1–1.75	<1
Alfalfa meal (*Medicago sativa*)	4	<1	<1
Soybean meal (*Glycine max*)	7	<1	<1
Bone meal	2	<1	0
Kelp (order Laminariales)	<1	0	1.7
Chilean nitrate	16	0	0
Blood meal	12	0	0
Meat and bone meal	8	2.2	<1

[z]Gaskell et al., 2006.

Important Supplements

Table. 2. Mineralization rates of several typical organic fertilizer materials at two temperature regimes.[z]

Product	Temp (°C)[y]	Proportion of initial organic nitrogen mineralized (%)		
		1 wk	4 wk	8 wk
Pelleted poultry manure	15	4	16	21
	25	10	23	36
Sea bird guano	15	49	57	60
	25	45	48	54
Pelleted seabird guano	15	42	61	64
	25	46	60	67
Fish powder	15	51	55	61
	25	48	60	64
Feather meal	15	42	56	59
	25	50	64	63
Blood meal	15	41	60	64
	25	51	67	70

[z]Gaskell et al., 2006; Hartz and Johnstone, 2006.
[y](1.8 × °C) + 32 = °F.

Gaskell & Smith, 2007

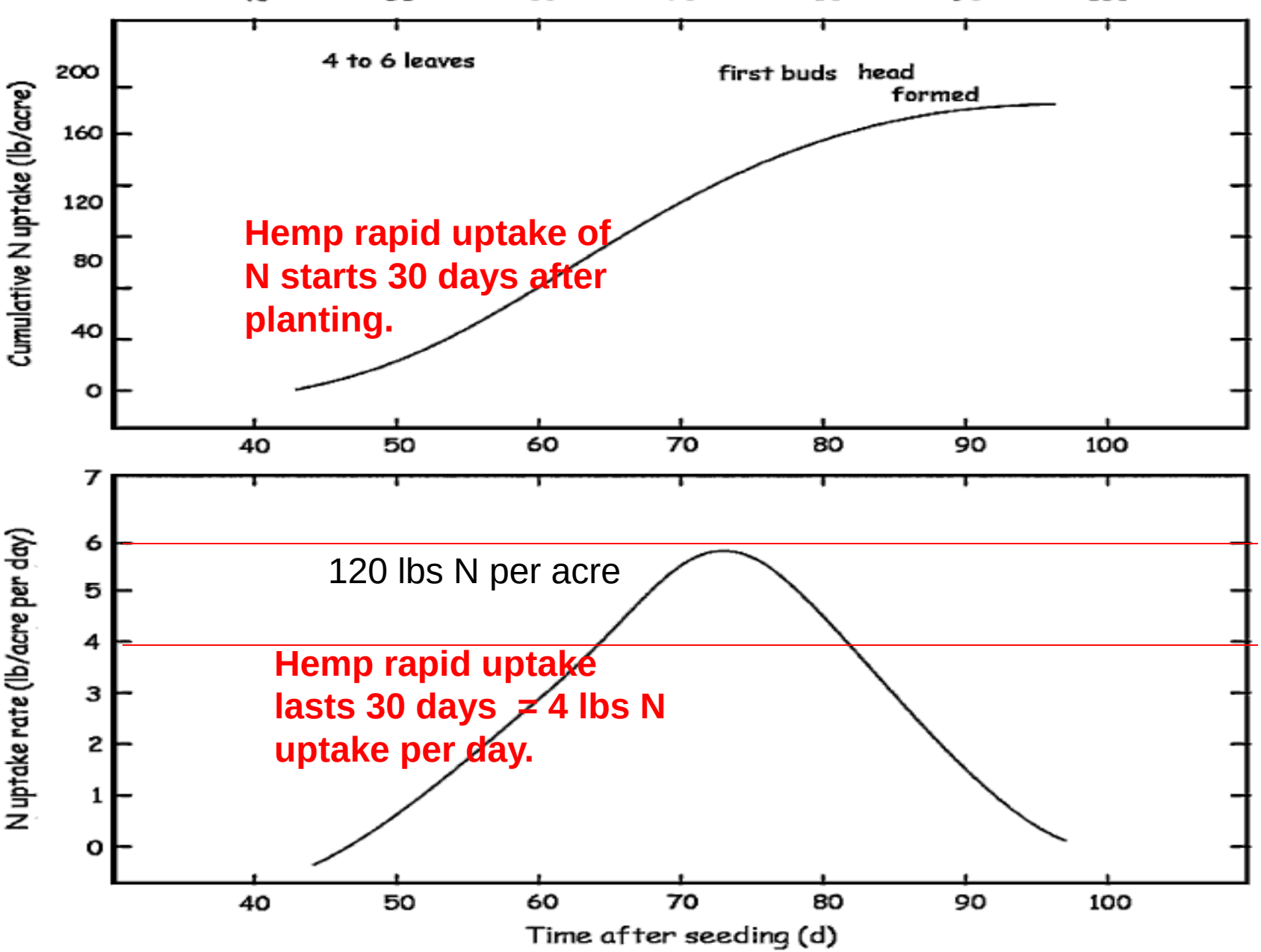


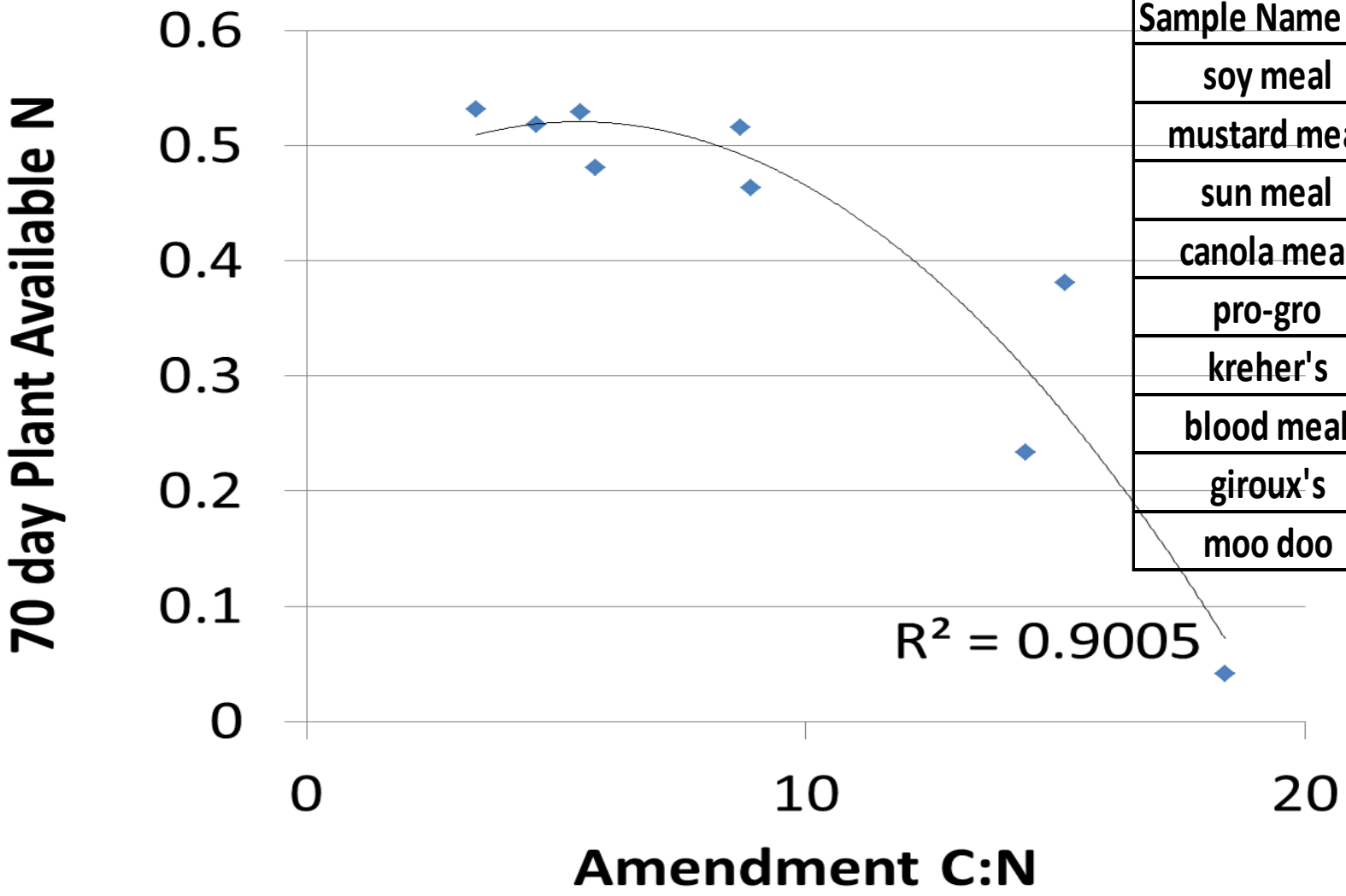
Fig. 4. Phases of broccoli crop nitrogen (N) uptake rate (lb/acre per day) and cumulative N uptake in lb/acre (1 lb/acre = 1.1209 kg·ha^{-1}) compared with broccoli biomass accumulation in ton/acre (1 ton/acre = 2.2417 mg·ha^{-1}) (Sullivan et al., 1999).

Organic Fertilizers

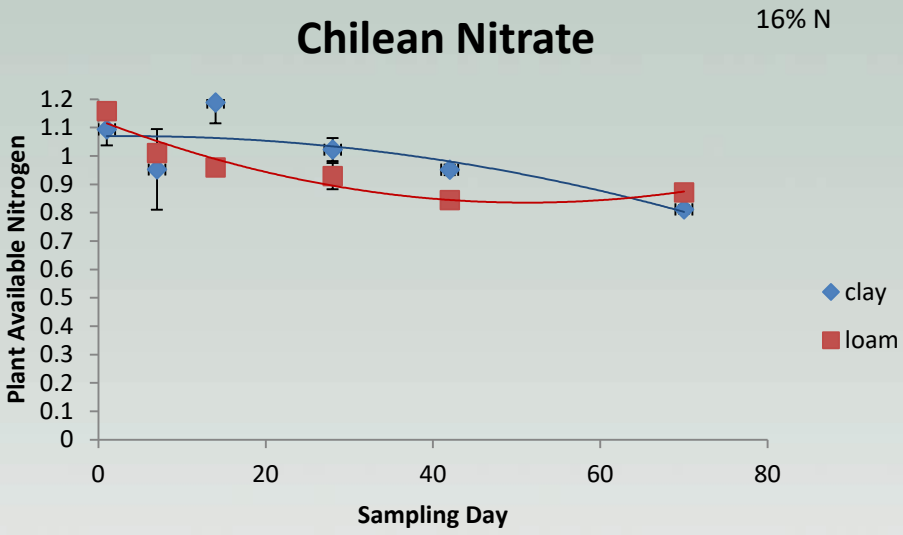
Amendment	Total C %	Total N %	C:N ratio
soybean meal	44.7	8.19	5.5
mustard meal	50.3	5.68	8.9
canola meal	48.7	5.57	8.7
pro-gro	23.1	5.07	4.6
kreher's	31.4	5.41	5.8
blood meal	51.3	15.2	3.4
giroux's	24.2	1.68	14.4
moo doo	37.0	2.01	18.4
chilean nitrate		16.0	

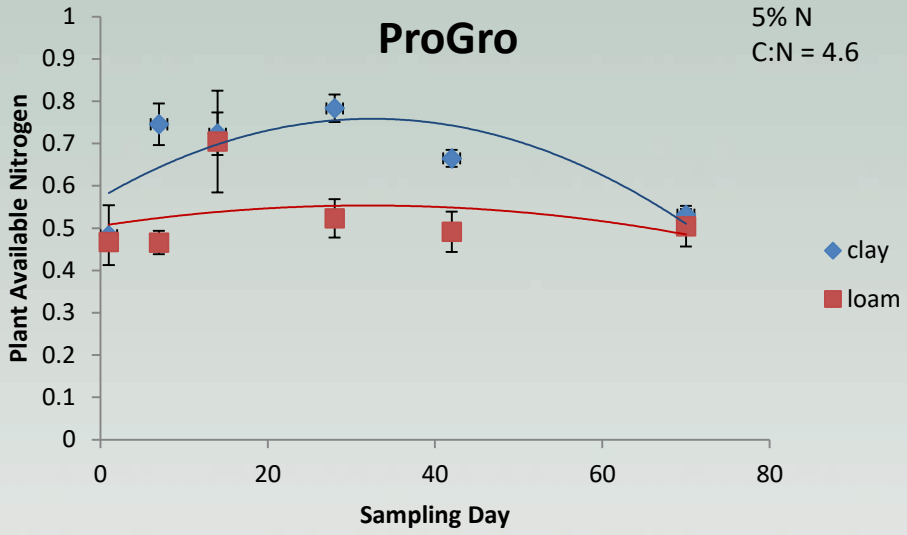
Feather meal, alfalfa meal, cheep cheep

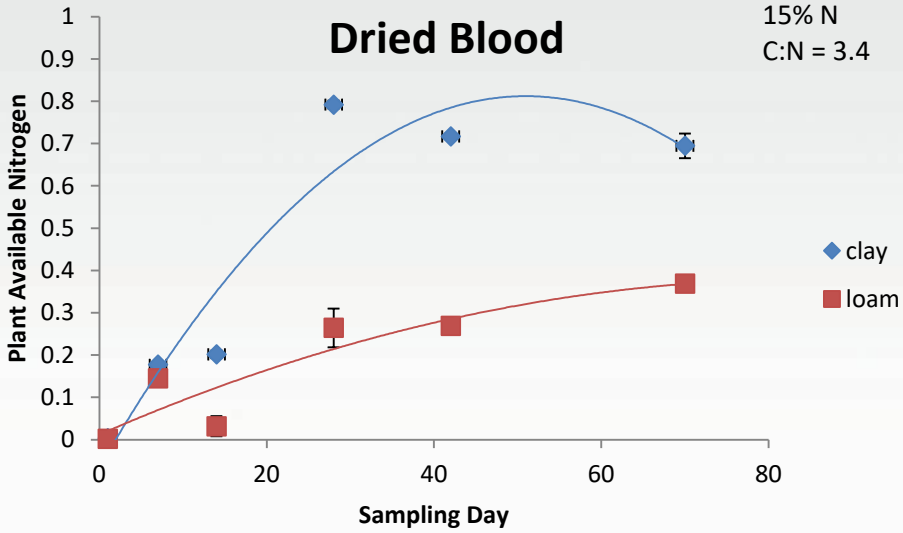
C:N Ratio



Sample Name	C:N ratio
soy meal	5.5
mustard meal	8.9
sun meal	15.2
canola meal	8.7
pro-gro	4.6
kreher's	5.8
blood meal	3.4
giroux's	14.4
moo doo	18.4







14 day

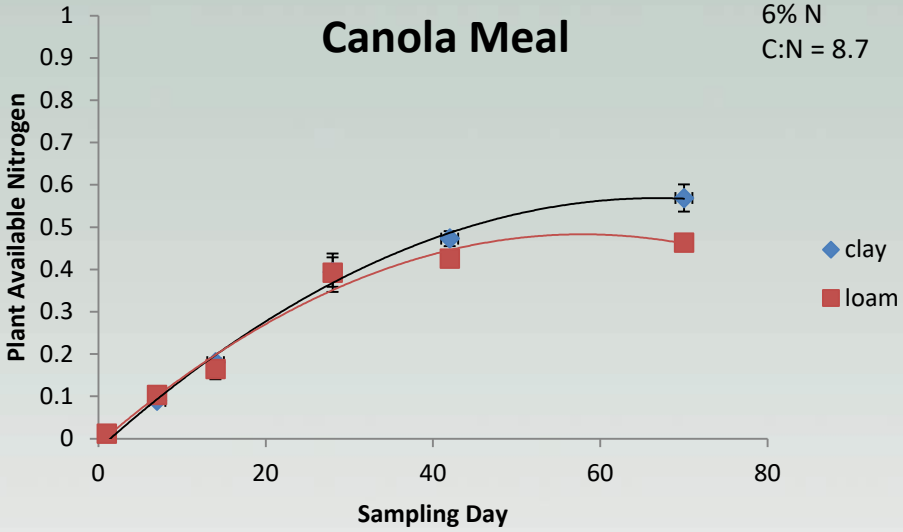
Chilean = 16 lbs N in 100

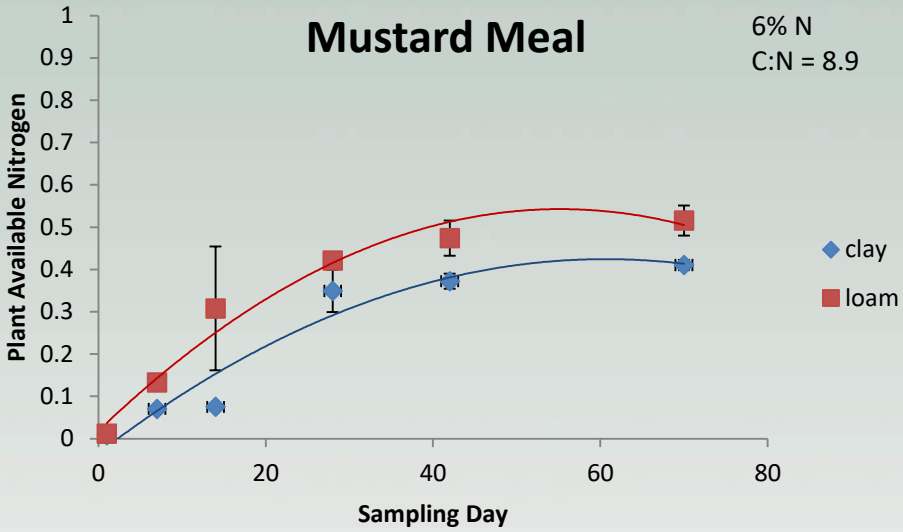
ProGro = 3.5 lbs N in 100

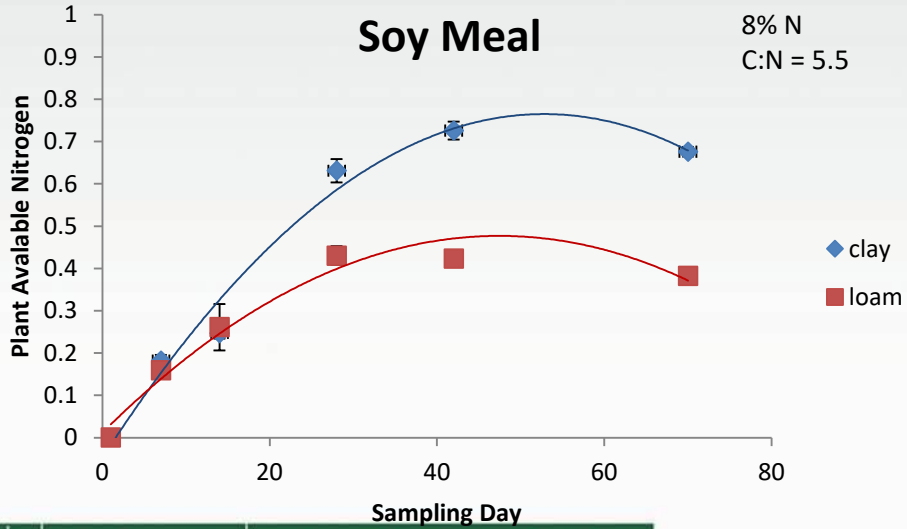
Blood = 3 lbs N in 100

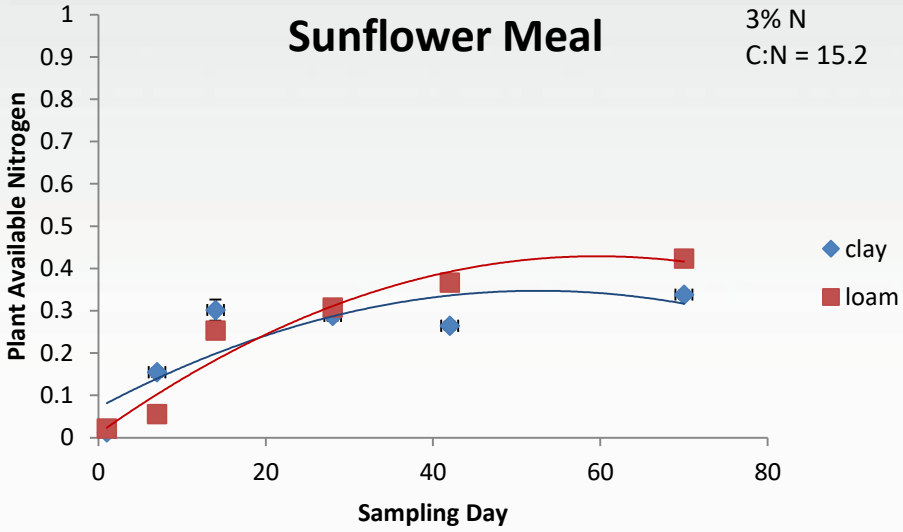
UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES





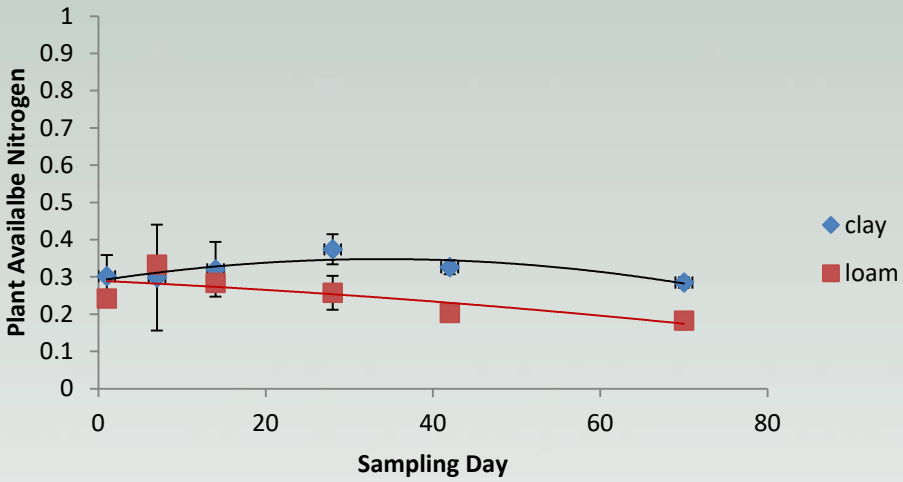




UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

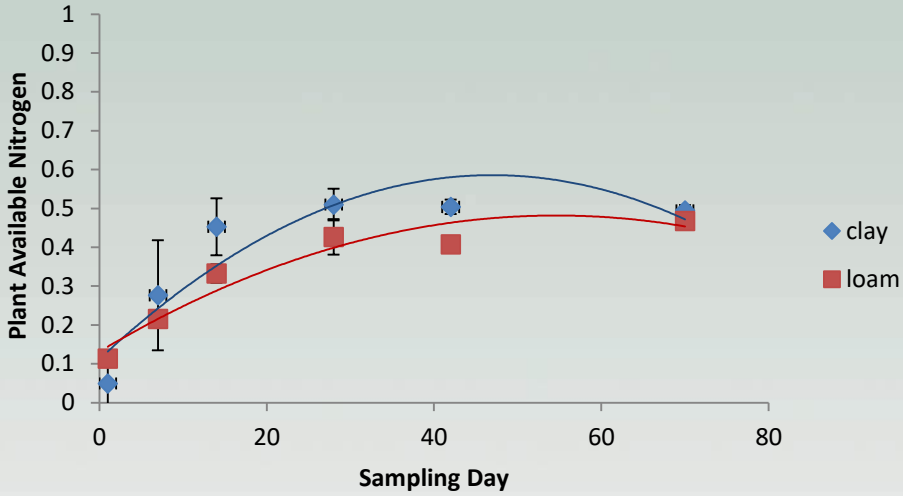
Giroux's Poultry Litter

1.7% N
C:N = 400



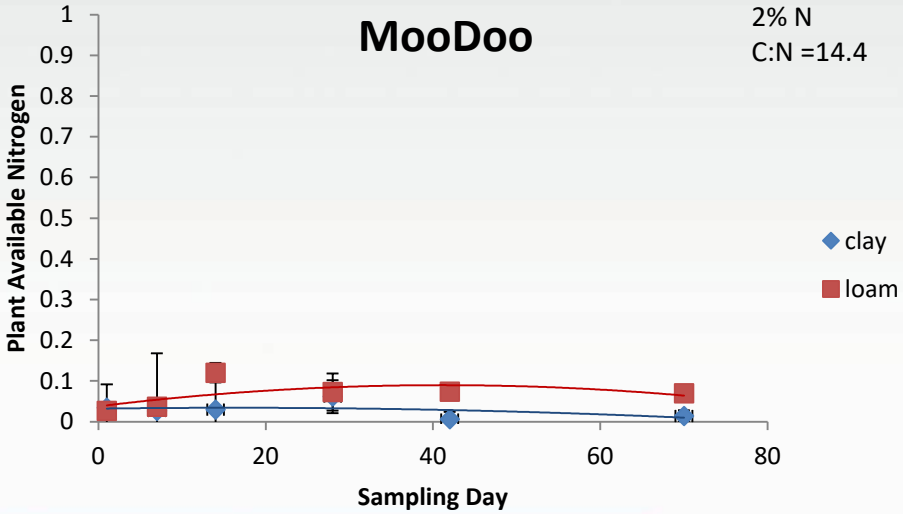
Kreher's

5.4% N
C:N = 5.8



MooDoo

2% N
C:N =14.4



14 day
Giroux's = 0.5 lbs N in 100
Kreher's = 1.62 lbs N in 100

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Amount of each amendment needed to contribute 100 lbs of Plant Available N during the 70 days after incorporation (average of two soils)

	Soy Meal	ProGro	Dried Blood	Poultry Litter	Chilean Nitrate
70 day PAN (%)	0.529	0.518	0.532	0.234	0.841
Amt needed (dm basis) †	2348	3807	1241	25470	744
Amt needed (wet basis) †	2647	4138	1340	45645	744
PAN†	**100**	**100**	**100**	**100**	**100**
Total N†	192	193	189	427	119
$/lb N‡	$2.87	$7.80	$6.95	††	$3.50
$/lb PA‡	$5.75	$15.0	$13.0	††	$4.46

Contact Information

heather.darby@uvm.edu

802-524-6501

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES