Soil Amendments and Their Role in Soil Health Management

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- Richard Smith - UCCE Monterey County

Topics to be Covered

- **Soil Organic Matter and its Effects on Soil Quality**
- Organic Soil Amendments
- Organic Fertilizers
- Cover Crops and Their Effects on Soil Nitrogen
- Gypsum and Changing Soil pH

Soil Organic Matter

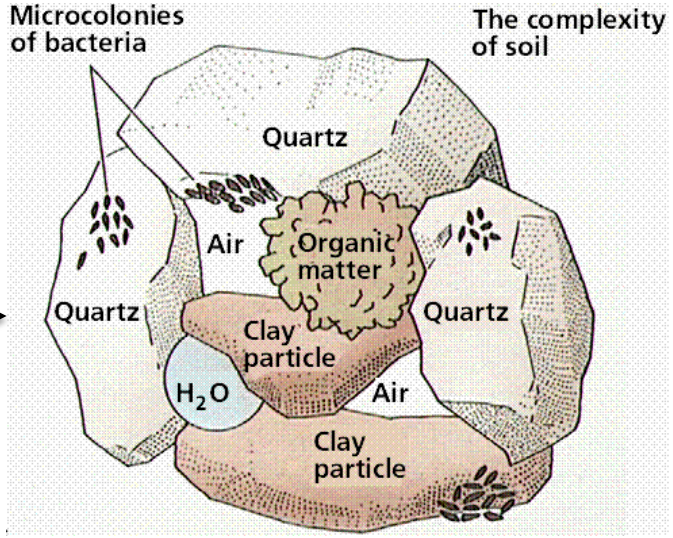
- Serves as energy source (food) for microorganisms, which promote stable aggregation of the soil particles
- Essential nutrients are obtained by plants as organic matter decomposes
- Enhanced by OM additions but destroyed by cultivation

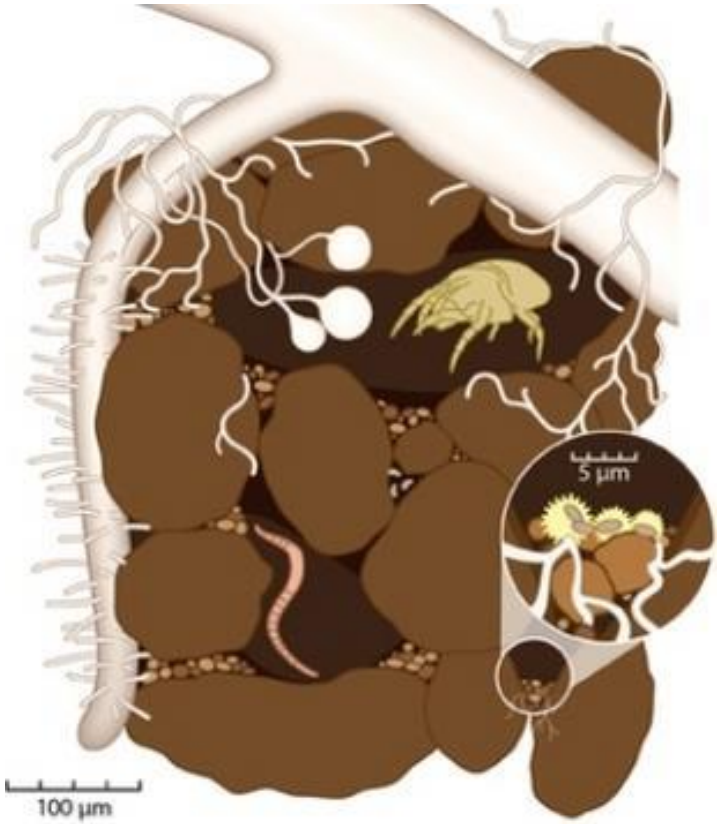
How Organic Matter Additions Improve the Soil

- Increased biological activity
- Decomposition releases nutrients
- Increased soil aggregation
- Increased pore structure
  - Improved water retention (sandy soil) and infiltration (clay soil)

Soil Aggregation

- Bacteria, polysaccharides, etc. – micro-aggregate formation
- Fungal hyphae – enmeshing micro-aggregates into macro-aggregates





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Fertilizers vs. Soil Amendments

Fertilizers

- Affect plant growth mainly by improving supply of available nutrients

Amendments

- Affect plant growth indirectly by improving soil physical condition

Sometimes it's a fine line, e.g., poultry and other high-N manures do both

“Finished” Compost

- Has undergone thermophilic heating process with turning and water
- Temperature low, no ammonia smell
- Contains diverse microbial populations
- Contains most nutrients required by plants
- N content usually 1-2%, very slow release
- Adding an organic soil amendment builds organic matter, fertilizers generally don’t

Earthworm Castings vs. Compost

- Both improve soil structure & nutrient retention
- Earthworm castings likely better:
  - Greater microbial activity
  - Formation of more humic acids (humification)
  - Improved soil aggregation
- Earthworm castings more expensive
- Using compost and some EW castings ideal

Soil Builders vs Organic Fertilizers

- <2% nitrogen
- Can apply at higher rates to build SOM
- C/N ratio: 15-30:1
- Potential build-up of P from manures

- >2% nitrogen
- Applied at rates estimated to meet crop nutrient needs
- Dry organic fertilizers: C/N ratio: 5:1

N Content of Raw Manures

Type	Total N	C/N ratio	Available N[c]	
	% dry weight		% of total N	lb/ton as-is
Broiler with litter	4.1	11	40 to 60	22–34
Laying hen	5.1	8	40 to 60	16–24
Turkey	4.7	9	40 to 60	20–30
Rabbit	2.8	12	20 to 40	4–8
Sheep	2.9	12	20 to 40	3–7
Goat	2.2	14	15 to 30	2–5
Beef	2.4	15	15 to 30	2–4
Llama	2.1	15	15 to 30	2–4
Alpaca	2.4	15	15 to 30	2–4
Stockpiled dairy manure[f]	1.9	15	10 to 20	2–4
Horse no bedding	1.6	20	0 to 15	0–1
Horse with bedding	1.4	30	-5[g] to 10	< 1
Dairy cow separated solids	1.4	32	-5 to 10	< 1

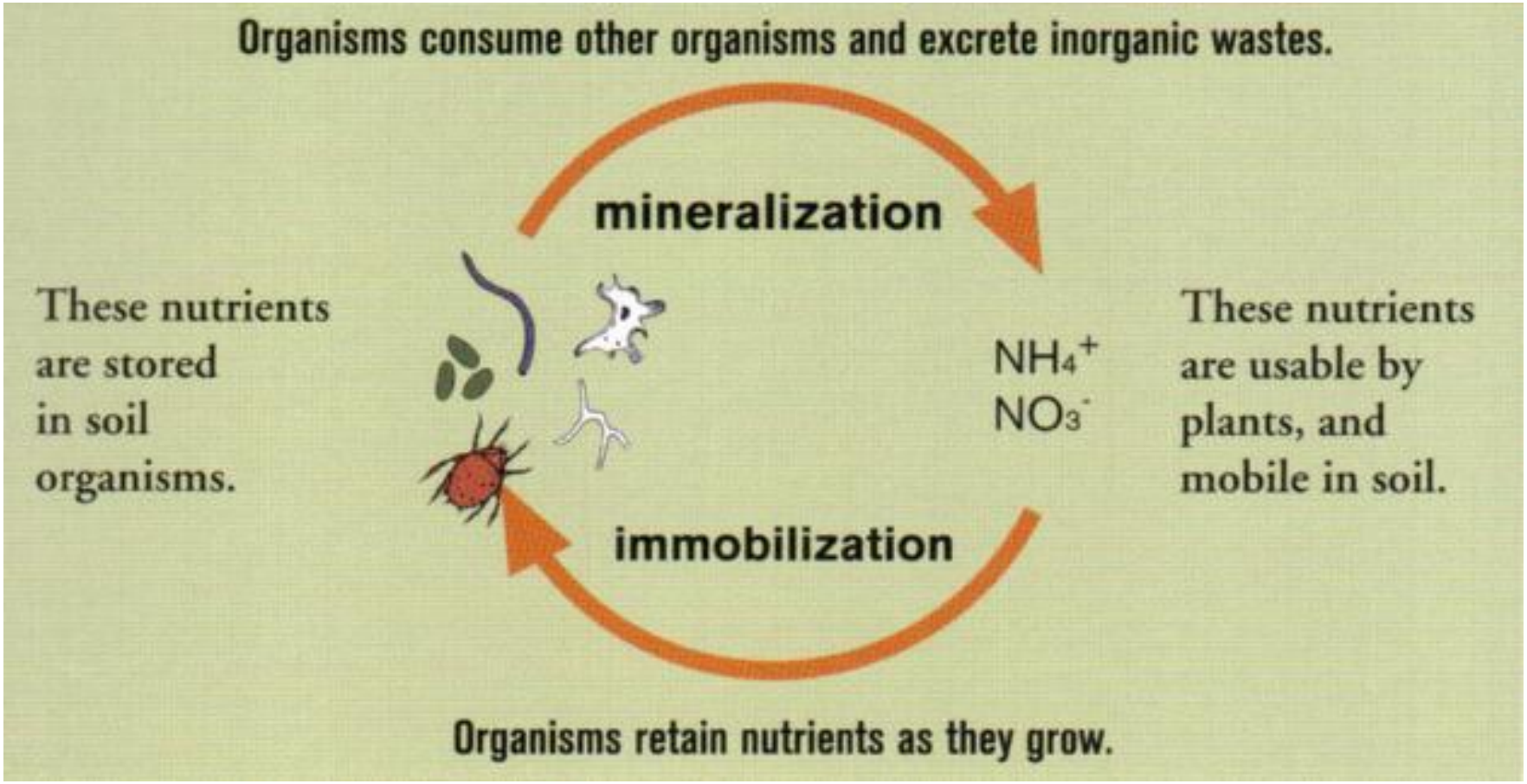
(Bary et al., 2000)

N in Composts & Manures

Material	Total N	C/N Ratio
Pelletized poultry manure	4.7	4.5
Aged poultry manure	3.1	9.1
Poultry compost	3.8	5.7
Aged feedlot manure	2.0	12.4
Feedlot manure compost	2.2	11.4
Yard waste compost	1.6	14.4
Yard waste compost	1.0	12.0

Hartz et al, 2000

Mineralization and Immobilization



N Mineralization

Compost and Manures

- **Nitrogen release from compost and manures was measured as:**

Material	Mean N recovery (%)	High N recovery (%)
Manure	11	27
Composted Manure	6	15
Composted Yard Waste	2	6

Source: Richard Smith

Nitrogen Release Rates

Composts vs Manures

Mineralization rates vary widely
Generally, composting reduces N mineralization rates

Total N mineralized over 6 months

Manure (fresh): 35-53%
Manure (aged): 5-18%
Compost: <8%

Hartz et al, 2000

Manures and Food Safety

- Do not use raw manure with leafy green crops
- LGMA requires an interval of at least one year
- NOP - Contact of crop edible portions with soil:
  - ≥ 90 days before harvest for crops that do not.
  - ≥ 120 days before harvest for crops that that do.

Composts and Food Safety

- Must maintain 131-170 F for 3 days (enclosed) or 15 days (windrow)
  - Turned at least 5 times, then cured for 45 days
  - Finished and curing piles should be covered to prevent recontamination
- 0 day interval if treated by a scientifically valid controlled physical or chemical process

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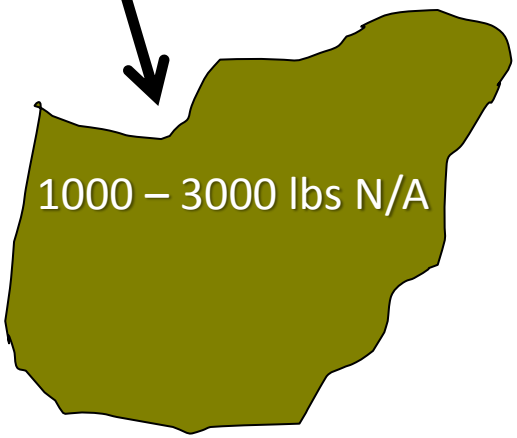
- **Organic Fertilizers**
- Cover Crops and Their Effects on Soil Nitrogen
- Gypsum and Changing Soil pH

Crop Residue

Compost

Organic Fertilizers

Chicken Pellets



1000 – 3000 lbs N/A

Soil Organic Matter

NH_4^+

NO_3^-

Crop Growth

Supplier and Product Information

(From Org. Orchard Presentation, Wenatchee 10/2016)

- Companies were contacted and several responded
- Mention or omission of companies or products does not imply preference
- Nutrient values are approximate
  - May vary greatly and may change

Selected Compost/Manure/Fertilizer Products

- Dairy compost (1.5% N)
- Chicken manure/compost (3-4% N)
- Dried poultry waste (NW Wholesale) (3-7% N)
- Royal Organic Products
  - Royal Classic (1.4% N), green waste + herbal matter
  - Soil Suplimint (4.2% N), mint biomass

Selected Compost/Manure/Fertilizer Products

- Strutzman Farms
  - Nutri-Rich
    - 4-3-2 (dried poultry waste), pelleted
    - 8-2-4 (DPW + blood, feather, SOP), granular
  - Sup'r Green (3% N), composted chicken manure
- Perfect Blend
  - 4-4-2, 4-4-4, 6-3-3, and 7-2-2
  - Mostly chicken manure + feather meal/raw fish

Selected Specialty Fertilizer Products

- Feather meal (12-13% N)
- True Organic Products
  - Protein meals: Feather, meat, bone (& fish)
  - 12-3-0 (and many other products)
- ProNatural Dry
  - 10-1-0 (feather, crab, and shrimp meals)
  - 6-2-1 (feather, alfalfa, shrimp, fish bone meals)

Enter your information in yellow cells. Results are in green cells.

MATERIAL	FERTILIZER ANALYSIS						
	Total % N from label ("as-is" basis; % of product)	Total % dry matter (% of product)	%PAN at 28 days (% of amendment total N, dry wt basis)	%PAN after full season (% of amendment total N, dry wt basis)	PAN at 28 days (lb N per 100lb amendment "as-is" basis)	PAN after full season (lb N per 100lb amendment "as-is" basis)	
ORGANIC FERTILIZERS							
Blood meal (12.5-1.5-0.6)	12.5	91	60	75	7.50	9.38	
Bone meal (3-20-0.5)	3.0	95	17	32	0.52	0.97	
Chicken manure - dried (4-3-2)	4.0	85	41	56	1.62	2.22	
Feather meal (granulated) (13-0-0)	13.0	97	60	75	7.80	9.75	
Fish meal (10-6-2)	10.0	92	60	75	6.00	7.50	
Meat and bone meal (7-8-0)	7.0	93	60	75	4.20	5.25	
Muriate of potash (KCl) (0-0-60)	0.0	100	0	0	0.00	0.00	
Soy meal (6.5-1.5-2.4)	6.5	90	60	75	3.90	4.88	
Sulfate of potash (0-0-50)	0.0	99	0	0	0.00	0.00	
Sulfate of potash magnesia (0-0-22	0.0	99	0	0	0.00	0.00	
chicken manure 433	4.0	90	37	52	1.47	2.07	
			0	0	0.00	0.00	
SYNTHETIC FERTILIZERS							
Triple super phosphate (0-40-0)	0.0	N/A	100	100	0.00	0.00	
Urea (46-0-0)	46.0	N/A	100	100	46.00	46.00	
		N/A	100	100	0.00	0.00	
		N/A	100	100	0.00	0.00	
COMPOST							
Composted manure (1.5-0.5-0.5)	1.5	60	5	10	0.08	0.15	
HIP compost	2.2	100	5	10	0.11	0.22	
			0	0	0.00	0.00	
COVER CROPS				%PAN after full season (70 days)			
0	N/A	0	N/A	0	N/A	N/A	

OSU Organic Fertilizer Calculator

N. Andrews et al.

PAN of Selected Organic N Fertilizers

Amendment	%N	% PAN, Season DW Basis	PAN, Season Lb. N/100 lb. "As Is"
Chilean nitrate	16	75	12
Feather meal	13	75	10
Blood meal	12	75	9
True Organic	12	75	9
Fish meal	10	75	8
Meat & bone	7	75	5
Soy meal	7	75	5

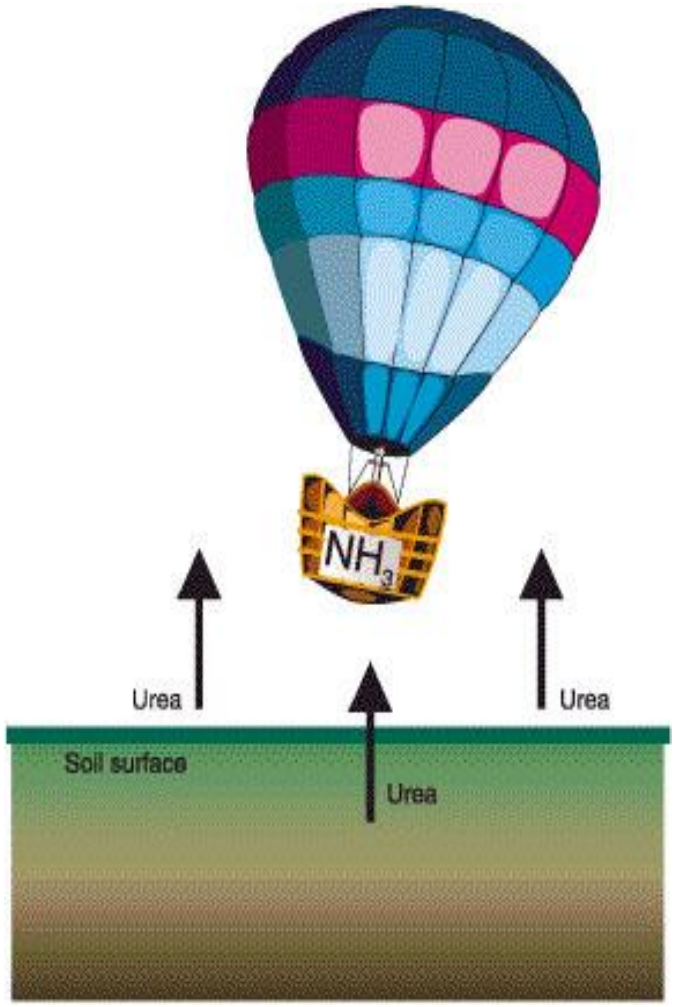
Org. Fertilizer Calculator

PAN of Selected Organic N Fertilizers

Amendment	%N	% PAN, Season DW Basis	PAN, Season Lb. N/100 lb. "As Is"
Perfect Blend	7	75	5
ProNatural	5	67	3.3
Ch. manure dried	4	56	2.2
Bone meal	3	32	1.0
Nutri-Rich	4	10	0.4
Comp. manure	1.5	10	0.2

Org. Fertilizer Calculator

Volatilization



% of N Retained

Application Strategy: Incorporation…	Poultry manure	Other manure
The same day	0.75	0.50
Within 1 day	0.50	0.40
Within 2–4 days	0.45	0.35
Within 5–7 days	0.30	0.30
After 7 days/none	0.15	0.20

Courtesy T. DuPont

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- **Cover Crops and Their Effects on Soil Nitrogen**
- Gypsum and Changing Soil pH

Cover Crops

Potential Advantages

- Reduced soil erosion
- Addition or conservation of N
- Addition of organic matter
- Improved soil structure & water penetration
- Orchards & vineyards:
  - Improved accessibility
  - Enhanced pest management

Cover Crops

Potential drawbacks

- Increased water use
- Increased costs and management
- Additional equipment required
- Orchards & vineyards:
  - Competition with trees
  - Increased frost hazard

Cover Crops

Winter Annuals for Green Manures

- Legumes
  - Vetch, bell beans, field peas
- Grasses
  - Oats, barley, cereal rye, etc.
- Legume/grass blends
- Brassicas

Green Manure Mix

Bell bean, pea, vetch

Roots

Grasses vs. Legumes

Oats

Bur clover

Bell Bean

Nodulation on Berseem Clover

Created by N-Fixing Bacteria (Rhizobium)

N Release from Cover Crop Residue

N Release	%N	Examples
Will Tie up N	0.5	Cereal Straw
Will Tie up N	1.0	Cereal Straw
Will Tie up N	1.5	Cereal at heading
May Tie up N*	2.0	Cereal pre heading
May Tie up N*	2.5	Mustards at heading & immature cereal
Will Release N	3.0	Mustards, legumes and juvenile cereal
Will Release N	3.5	Legumes and immature mustards
Will Release N	4.0	Legumes

Availability of N from cover crops

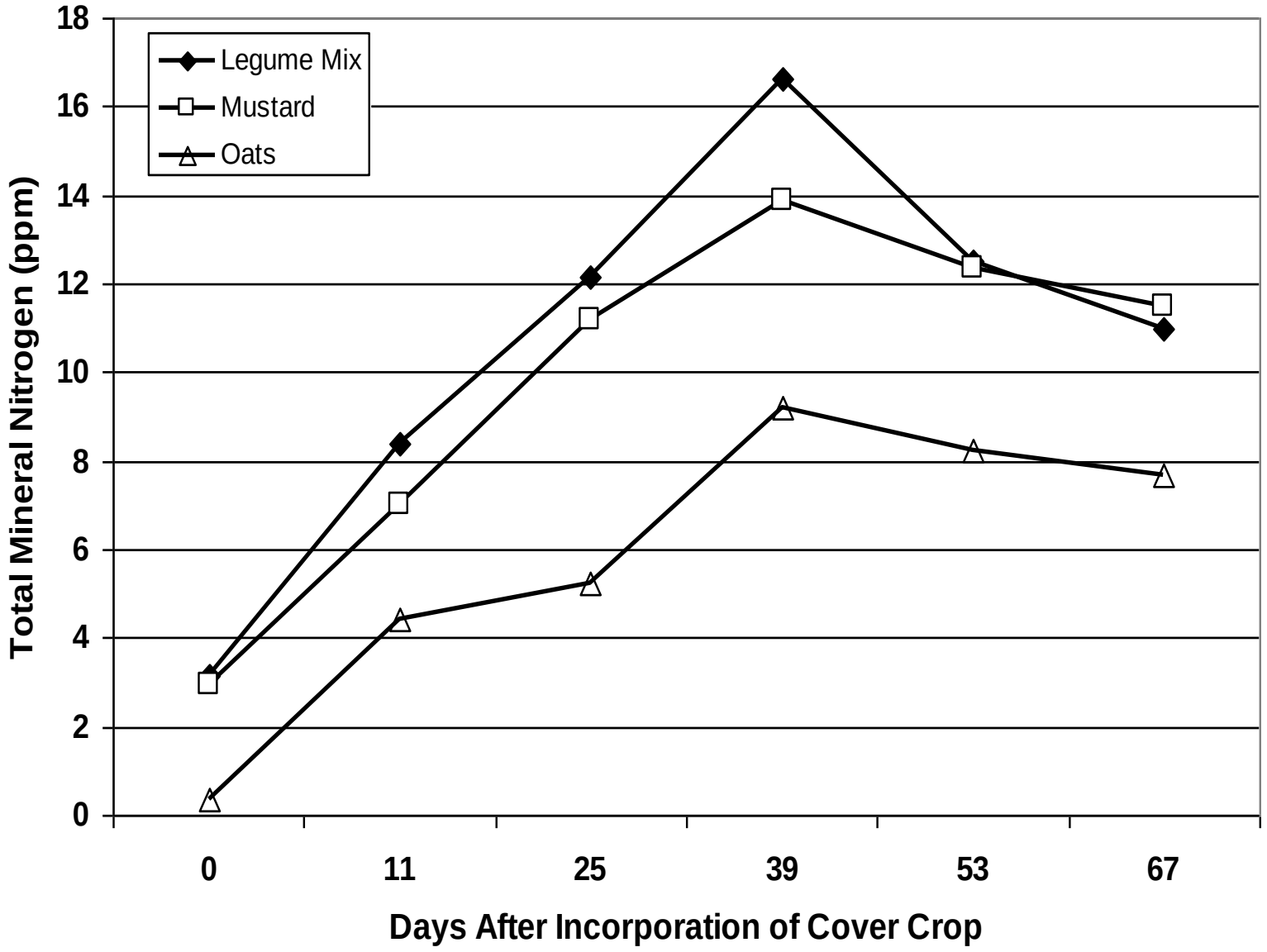
N fixation estimates for common legumes

Common name	Lb N ac^{-1} yr^{-1}
Berseem clover	243-357
Subterranean clover	143-175
Lana woolypod vetch	230
Medic	85-131
Australian winter pea	150

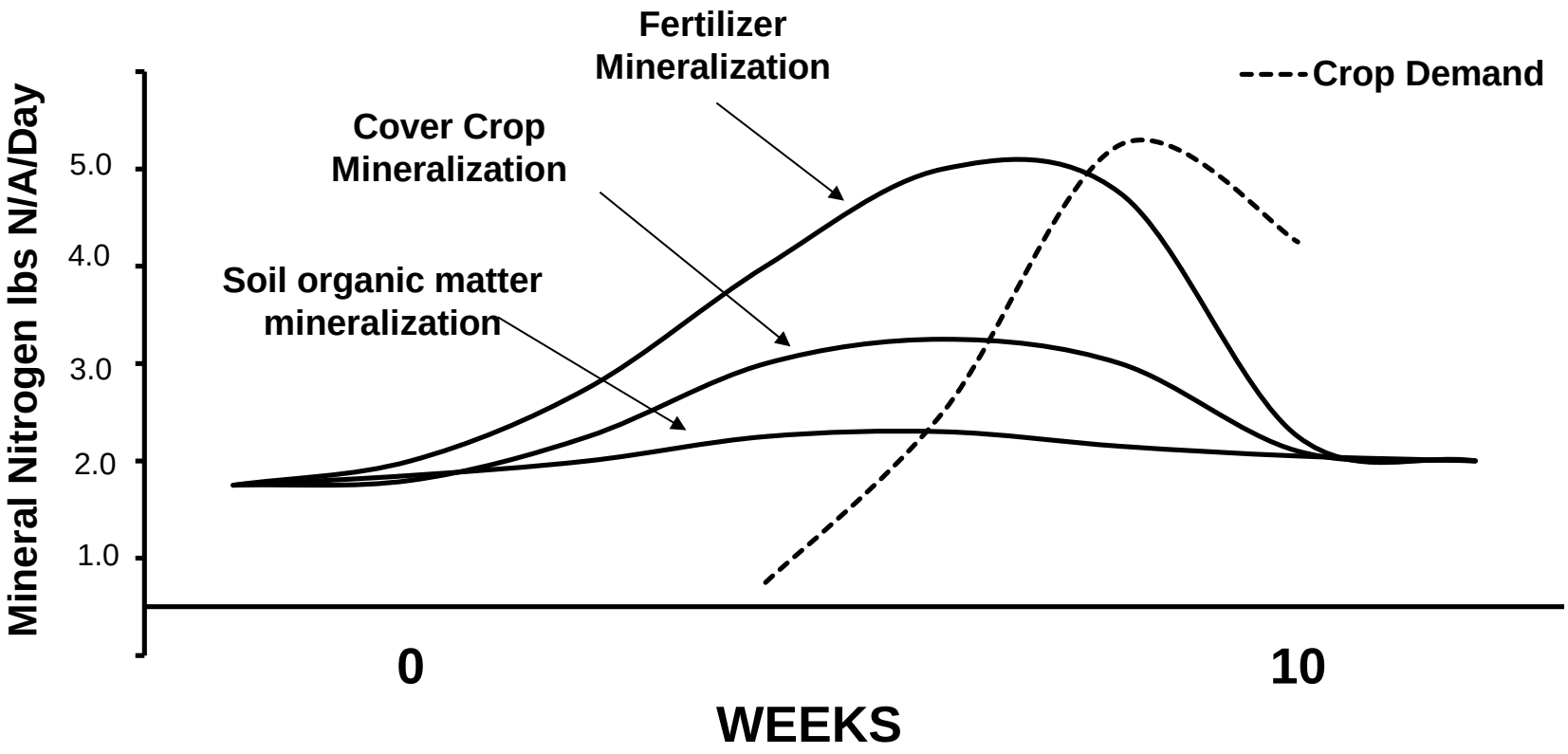
4-30% of nitrogen in a cover crop is directly used by the subsequent crop (Jackson, 2000)

The overall fertilizer replacement value of a cover crop is often 50-100 lbs/acre

N Release Pattern from Cover Crops



Timing of N Mineralization



Cover Crop Nutrition

- Grasses require additional N
- Legumes may require P, S
- Avoid N fertilizers on legumes and grass/legume mixes
- Max. N contribution is at flowering
- 80% of N is in above-ground parts;

  20% in roots

Nitrate Cycling by Cover Crops
-Comparison of Families

Average % Reduction

in Nitrate Leaching:

Legumes – 23%

Grasses – 60%

Brassicas – 60-75%

Carbon-to-Nitrogen Ratios

RESIDUE	C/N RATIO
Legume	15:1 to 20:1
Brassica	20:1 to 30:1
Grass	40:1 to 80:1

N Management in Organic Production

- The higher the total N, the higher rate of mineralization
- Compost mineralizes N slower than manure
- Legume cover crops release most N in the first 8 weeks
- Delayed N release from compost and cover crops
  - Most N stored in organic matter
- Organic matter additions could release 50-100 lbs. N/acre/year

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Can Gypsum Improve Your Soil?

Yes

If soil is impermeable due to excess Na,
Or due to low Ca:Mg ratio

Probably Not

If soil is impermeable due to fine texture, compaction, or hardpan

Definitely Not

If soil is permeable and water penetrates well

Equivalency to 1 Ton Pure Gypsum

Amendment	Application equivalent to 1 ton of pure gypsum
	tons
Gypsum	1 ton applied = 1 ton gypsum
Sulfur	0.19 ton applied = 1 ton gypsum
Sulfuric acid	0.61 ton applied = 1 ton gypsum
Ferric sulfate	1.09 tons applied = 1 ton gypsum
Calcium chloride	0.86 ton applied = 1 ton gypsum
Calcium nitrate	1.06 tons applied = 1 ton gypsum
Lime sulfur	0.78 ton applied = 1 ton gypsum

Source: UC ANR pub. 8519 (2015)

Materials for Changing Soil pH

Raising pH	Lowering pH
Limestone	Soil sulfur
Hydrated lime	Ammonium-based fertilizers
Oyster shell lime	
Dolomite	
Wood ash	

Gypsum does not change soil pH!

Resources

University of California:

- Solution Center for Nutrient Management
- Organic Vegetable Production Manual (#3509)
- Cover Cropping for Vegetable Production (#3517)
- Organic Soil Amendments and Fertilizers (#21505)
- Reclaiming Saline, Sodic, and Saline-Sodic Soils (#8519)

Oregon State University

- OSU Organic Nutrient Calculator (spreadsheet)