INMP Budgets & AR Metrics:

Nitrogen Mineralization for soil amendments, organic fertilizers and other BMPs

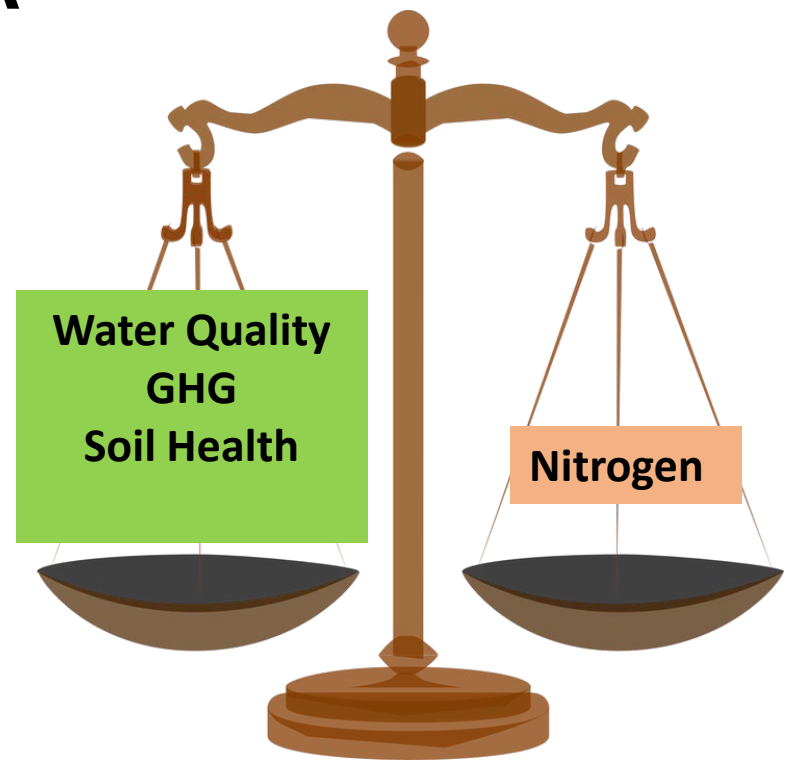
Compost & Soil N testing: Jocelyn Bridson, Director Environmental Science & Resources, Rio Farms / Chair, Science Advisory Panel CDFA

Organic Fertilizers: Ramy Colfer, Senior Agronomist, True Organic Products Inc

Mineralization & carbon amendments: Richard Smith, Farm Advisor, Vegetable Crop Production & Weed Science UC Cooperative Extension

Compost is a stormwater BMP listed by the EPA

- "Compost retains a large volume of water, thus helping to prevent/reduce erosion, reduce runoff, and establish vegetation.
- Compost improves downstream water quality by retaining pollutants such as heavy metals, nitrogen, phosphorus, oil and grease, fuels, herbicides, and pesticides.
- Nutrients and hydrocarbons adsorbed and/or trapped by compost are decomposed by naturally occurring microorganisms.
- Compost improves soil structure and nutrient content, which reduces the need for chemical fertilizers.
- **Compost-based BMPs remove as much or more sediment from stormwater as a traditional perimeter."**



Direct quote from US Environmental Protection Agency
https://www.epa.gov/sustainable-management-food/reducing-impact-wasted-food-feeding-soil-and-composting

C: N ratio of compost	Compost rates funded in HSP	Percent of N available
C:N < 11	3-5 tons/acre	10%
C:N > 11	6-8 tons/acre	5%

https://www.cdfa.ca.gov/oefi/healthysoils/

Proposed Solution:

1. Growers should only report Mineralized / Plant Available Nitrogen

- This is what Farmers & Certified Crop Advisors were already taught in the UCANR Nitrogen Management Trainings
- This is what is written in the ESJ Order MRP:
  - *The applied organic soil amendments include compost and manure and should be reported as **the amount of nitrogen available to the plant during the growing period in pounds per acre**. Available nitrogen may be measured by testing the applied compost or manure materials or estimated using reference materials that are available for estimating nitrogen content.* (Attachment B, page 37)
- This makes sense: Nitrate is the form of N that is:
  - Available for plants uptake – growers concern.
  - Available to leach/runoff – water quality concern.

Proposed Solution: 2. create a real incentive for compost:

March 2019 STAFF REPORT:
"Staff recommends incorporating an incentive for the use of compost, which can increase soil health and water holding capacity and decrease nitrate leaching. This incentive may come in the form of a factor that reduces the amount of compost nitrogen used in the A-R compliance calculations."

Suggested Change:
The Water Board will require growers to report plant available nitrogen (PAN) from compost. To acknowledge that the water quality benefits may outweigh the negligible nitrogen contribution of compost, we will encourage the use of this best management practice by not including compost sources of nitrogen in the A-R compliance calculations (Discharge Targets, Limits or Outlier designations).

Simple Steps for a Grower to calculate and report PAN

1. Send compost sample to lab
2. Determine % N – use wet basis for easy calculations
3. Determine C:N ratio, > or < 11?
4. Calculate total PAN

Nutrients-Primary + Secondary	Units	Wet wt. Basis	Dry wt. Basis	TMECC Method
Total Nitrogen:	%	1.1	1.5	4.02-D
Ammonia (NH_4-N):	mg/kg	360	500	4.02-C
Nitrate (NO_3-N):	mg/kg	140	200	4.02-B
Organic Nitrogen (Org.-N):	%	1.0	1.4	Calc.
Phosphorus (as P_2O_5):	%	0.57	0.80	Calc.
Bulk Density :	lb/cu ft	41	29	SCL
Carbonates (as $CaCO_3$) :	lb/ton	110	150	04.08-A
Organic Matter:	%	27.8	38.6	05.07-A
Organic Carbon:	%	14	19	4.01
Ash:	%	44.3	61.4	3.02
C/N Ratio	ratio	12.7	12.7	calc.
Moisture:	%	27.9	0	3.09
AgIndex	ratio	4.7	4.7	SCL

To Calculate lbs/ton: (%Nutrient) x (20)
To Calculate lbs/ton: (mg/kg Nutrient/10,000) x (20)
To Calculate lbs/cu yd: (%Nutrient/100) x B.D. x 27
To Calculate lbs/cu yd: (mg/kgNutrient/1,000,000) x B.D. x 27

Analyst: Assaf Sadeh

What Percent Nitrogen is Available from Compost in Year 1?

It is complicated, but a lot of research has been done.

1. **5-10% CDFA White Paper**
   https://www.cdfa.ca.gov/oefi/efasap/docs/CompostApplicationRate_WhitePaper.pdf
2. **Use PAN, UCANR** Nitrogen Management Training for Certified Crop Advisors: "Where the material applied is mature compost or weathered corral manure, the N credit will be small, possibly negligible" Module 5: Nitrogen budgeting "cheat sheet" with definitions & formulas (handout) http://ciwr.ucanr.edu/files/205050.pdf
3. **5-10%, CDFA Grower N Mgmt Training: 5-10%** CDFA Grower Nitrogen Management Training for Grower Nitrogen Management Plan Self-Certification
   https://www.cdfa.ca.gov/is/ffldrs/frep/pdfs/Grower_N_TrainingPresentation.pdf
4. **5-10%** Hartz, T. 2009. Nutrient Value of Compost Presentation
   https://vric.ucdavis.edu/events/2009_osfm_symposium/UC%20Organic%20Symposium%20010609%2005b%20Hartz.pdf
5. **10-15%** (New England soils) University of Massachusetts:
   UMASS Amherst Extension, 2014. Interpreting Your Compost Test Results
   https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/compost_analysis_and_interpretation_with_test.pdf
6. **20% Colorado State,** Calculating a Compost Application Rate based on Fertilizer Needs.
   http://www.extsoilcrop.colostate.edu/Soils/powerpoint/compost/Calculating_compost_application_rate.pdf

Calculating Compost N contribution for Nitrogen Budgets

1.10%	% total N wet weight basis
4	tons/acre applied
2000	pounds per ton
88	Total lb N/land acre applied (organic & inorganic) via compost
12.7	C:N ratio
5%	% available year 1: C:N > 11, mineralization = 5% C:N < 11, mineralization = 10%
4.4	**PAN:** Total lb N/land acre expected to be mineralized in year 1 (inorganic N)
2	average # crops per year
2.2	**PAN:** Total lb N/crop acre expected to be mineralized in year 1 (inorganic N)

Is N released in future years significant?

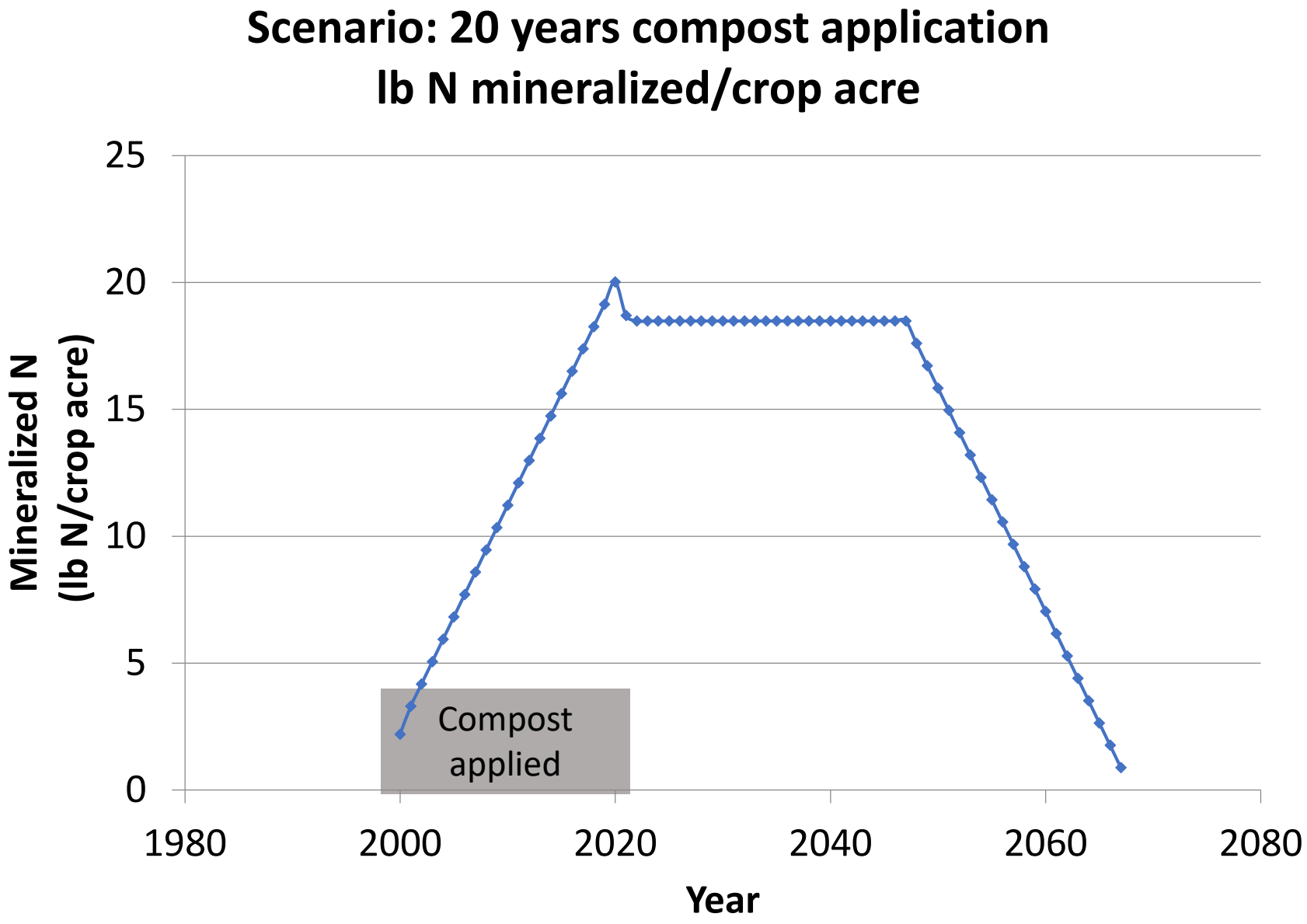
(Extreme) Scenario: Apply same compost 4 tons/acre for 20 years assuming 2 crops/year and no losses. Use CDFA guidance.

Set up spreadsheet:

Year	2000	2001	2002	2003	2004
2000	4.4				
2001	2.2	4.4			
2002	1.76	2.2	4.4		
2003	1.76	1.76	2.2	4.4	
2004	1.76	1.76	1.76	2.2	4.4
2005	1.76	1.76	1.76	1.76	2.2
2006	1.76	1.76	1.76	1.76	1.76
2007	1.76	1.76	1.76	1.76	1.76

Questions:

- **How many lbs N/crop acre are mineralized each year?**
- **How long does it take all of the N in the first year of application to get used up?**
- **Is this a major contribution to crop N budgets?**


Scenario: 20 years compost application
lb N mineralized/crop acre
Mineralized N
(lb N/crop acre)
25
20
15
10
5
0
1980
2000
2020
2040
2060
2080
Year
Compost
applied

Scenario Results

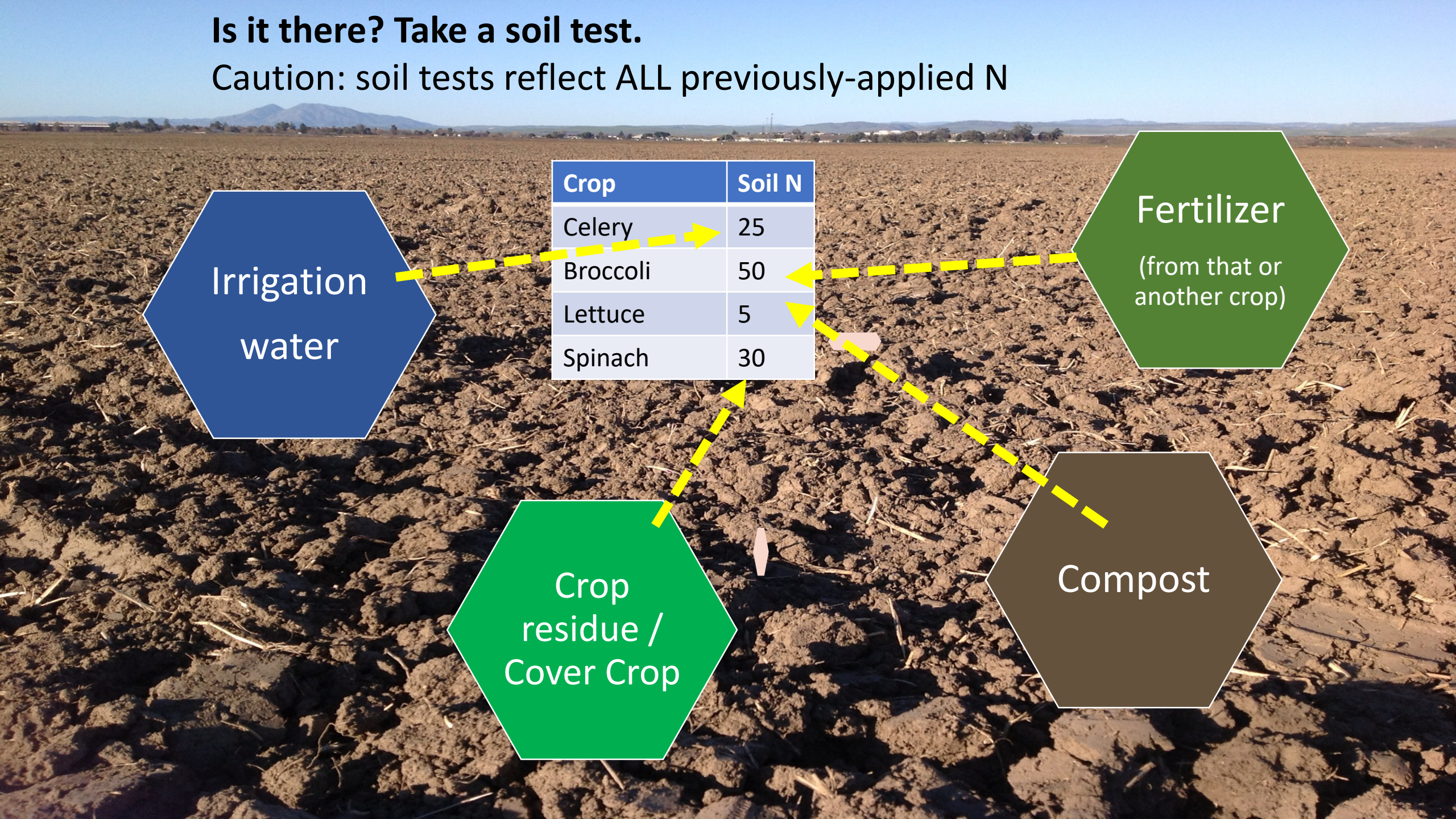
- How many lbs N available to each crop each year?
  Min = 2.2 lb N/crop acre (Year1)
  Max = 20 lbs N/crop acre (Year 20)

- How long does it take all of the N in the first year of application to get used up?
  - **It takes 47 years for all 88 lbs N from Y1 application to be mineralized (assuming nitrogen isn't recalcitrant, no losses)**

- Is this a major contribution to crop N budgets ?
  - **No.**
  - **In 2020, the cumulative max N available = 20 lb N/crop acre, or 5-15% of total crop N needs, not significant**
  - **Note, the cumulative N release of 20 years of compost application is only 46% of total N applied in one year (20/44).**

Is it there? Take a soil test.

Caution: soil tests reflect ALL previously-applied N

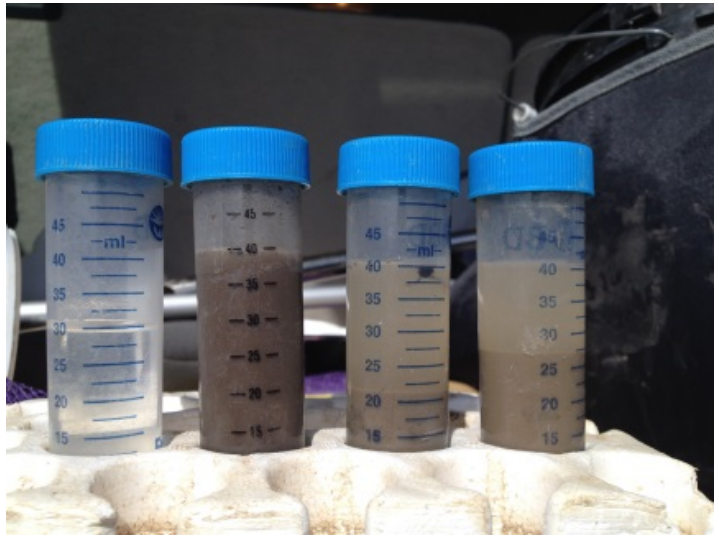


Proposed Solution:

3. Require that growers take soil samples but do not include for final Discharge Targets, Limits or Outlier calculations

Why?

- Avoid double counting: The N is already accounted for in another part of the report
- Ag Order 3.0 “new nitrogen applied” language
  - Soil N is not applied
  - Soil N is not new
- ESJ INMP Summary Report – does not require reporting soil results to Water Board



Organic Fertilizers

Ramy Colfer, Senior Agronomist,
True Organic Products Inc

Organic Farming Sector in California Agriculture is Substantial and Growing

- Organic sales in the U.S. totaled a new record of $49.4 billion in 2017, up 6.4% from 2016 (OTA).
- Organic farms in the United States produced and sold $7.6 billion worth of organic products in 2016, up 23% from 2015 (CCOF).
- California produced 38% of total U.S. farm commodity value for organics, with $2.9 billion in organic crops, poultry, livestock, and dairy products sold in 2017 (CCOF).

California County	Value of Organic Crops (2017)	Acres of Organic Farm Land (2017)
Monterey County	$390,295,000	40,859
Santa Cruz County	$109,058,000	6,702
San Benito County	$56,511,500	46,802
Ventura County	$197,386,000	8,851
Imperial County	?	45,216

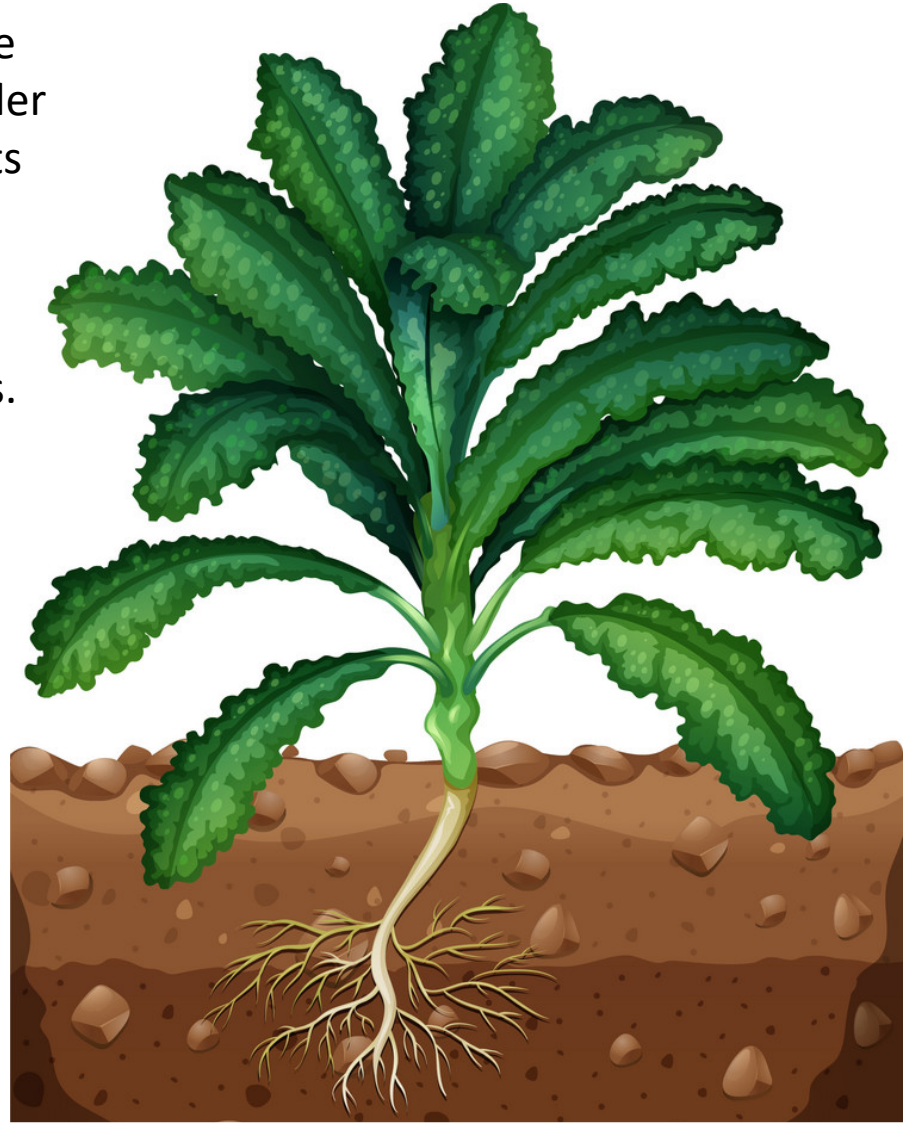
Organic Farming Practices Generally Reduce Surface and Groundwater Contamination

- No synthetic pesticides (such as pyrethroids, neonicotinoids, organophosphates, & carbamates)
- No synthetic fertilizers.
- Use farming practices & inputs that improve soil health (compost applications and cover crop use). These practices have been shown to reduce nitrate leaching, surface nutrient discharges, and soil erosion.
- The CCRWQCB has the opportunity to incentivize these practices for both organic and conventional growers.

Organic Pelleted Fertilizer

Organic fertilizer and amendments require decomposition by microbial activity in order to make nitrogen and most other nutrients available for crop uptake.

Organic fertilizer is food for soil microbes which, in turn, provides nutrients to crops.



Nitrogen in crude protein and other biomolecules are decomposed by microbial activity

Percentage of Nitrogen is mineralized through microbial decomposition and converted to Ammonium (NH4) & Nitrate (NO3) which is available for crop uptake

Carbon and other nutrients in biomolecules enter soil where they are decomposed via microbial activity, making Phosphorus and Potassium and other nutrients available to crops

Nitrogen not mineralized may remain in soil indefinitely as soil organic matter

Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board to protect groundwater

- Discharge Limit $A_{FER} + A_{IRR} - R$ = TBD lbs/ac/ranch/year
- Application Limits A_{FER} cannot exceed TBD lbs/ac/crop
- Ranches that repeatedly exceed the numeric discharge limit per the time schedule may be limited or prohibited from applying A_{FER}.
  - A_{FER} is the amount of nitrogen applied in fertilizers, compost, and other amendments
  - A_{IRR} is the amount of nitrogen applied through the irrigation water based on the groundwater nitrate concentration
  - $A_{FER} + A_{IRR}$ = the total amount of nitrogen applied
  - R is the amount of nitrogen removed through harvest, pruning, or other methods, plus the nitrogen sequestered in perennial crop permanent wood

Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board to protect groundwater

Problem for Organic Leafy Green Production:

- In contrast to conventional agriculture where 100% of total nitrogen applied (TNA) will be in mineralized forms during cropping cycle (as NH4 or NO3), only a fraction of total nitrogen applied in organic fertilizer and organic amendments by organic growers is converted to mineralized nitrogen during the cropping cycle.
- Mineralization rates of organic amendments and fertilizers vary greatly but are generally below 60% in laboratory studies.
- **This will mean organic growers will have to grow crops with 40-70% less mineralized nitrogen than conventional growers.**
- **Ag Order 4.0 will disproportionally penalize organic farming.**

From R. Smith, UCCE
Monterey Co. Farm Advisor

Laboratory Incubations of Fertilizer Materials
Percent N Mineralized – High N fertilizers provide more nitrate to plants than low N fertilizers.

Material	2 weeks	4 weeks	8 weeks
2.5-2.0-2.5	4.0	5.8	13.6
4-4-2	28.8	30.5	37.5
8-5-1	47.2	43.5	58.5
10-5-2	43.8	49.3	58.8
12-0-0	48.7	56.5	59.3

Organic Fertilizers. Less than 60% of Total Nitrogen Applied is available to crop over 8 week period.

Material	Total Fertilizer Applied (Lbs.)	Total Nitrogen Applied (Lbs.)	Total Mineralized Nitrogen Available to Crop (Lbs.) over 8 weeks
2.5-2.0-2.5	8000	200	27.2
4-4-2	5000	200	75
8-5-1	2500	200	117
10-5-2	2000	200	117.6
12-0-0	1667	200	118.6

Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board to protect groundwater

As proposed, Ag Order 4.0 will disproportionally penalize organic farming:

- The Ag Order 4.0 constraint on organic farming fertility programs could be very detrimental to organic farming on the Central Coast.
- If fertility rates are cut by 40-60%, organic crop yields and quality would be devastated, and organic leafy greens farming may not be financially viable.
- Indeed, this may force some growers to go from organic production back to conventional production due to this Ag Order 4.0 constraint.

Solutions to help promote organic farming and meet rules proposed for Ag Order 4.0

Proposed Solution:

1. Growers should report only Mineralized (Plant Available Nitrogen) for organic fertilizers.
    - For each organic fertilizer, growers would use a scientifically measured mineralization rate (**M**) determined by UC fertility specialists.
    - **M***AFER= mineralization rate multiplied by the total nitrogen applied in fertilizer.

      Example: UCCE found 38% of 4-4-2 is mineralized (75/200 = 37.5%)
      5000 lbs 4-4-2 applied = 200 lb N total * 38%(M) = 75 lb N mineralized to be reported
    - Regional water board staff have already proposed that compost use be incentivized due to soil health benefits. Other organic fertilizers (being high in labile carbon) should also be incentivized.

From R. Smith, UCCE
Monterey Co. Farm Advisor

Carbon Content of Various Fertilizers

Fertilizer	% Carbon	Source
4-4-2	27.9	Poultry Manure, Meat and Bone Meal
12-0-0	46.1	Feather (+Meat and Bone) Meal
10-5-2	42.0	Meat, Bone and Feather meals & K_2SO_4
8-5-1	36.9	Meat, Bone, and Feather meals & poultry
7.5-5-7.5	37.2	Meat, Bone and Feather meals
2.5-2-2.5	25.2	Poultry manure
14-0-0	42.7	Hydrolyzed soybean

From R. Smith, UCCE
Monterey Co. Farm Advisor

Input of Carbon

Material	Biomass lbs/A	Carbon content percent	Total carbon lbs/A
Compost	10,000[1]	29%	2,146
Cover crop	6,000	44%	2,640
4-4-2 2 baby crops @ 3000 each	5,400[2]	29%	1,566
8-5-1 1 broccoli crop	5,000[3]	41%	2,050

1 – 10,000 lbs/A @ 74% oven dry weight
2 – 6000 lbs/A (2 baby crops @ 3000 lbs/A each) @ 90% oven dry weight;
3 – 5650 lbs/A @ 90% oven dry weight

Solutions to help promote organic farming and meet rules proposed for Ag Order 4.0

Proposed Solution:

2. Encourage management practices that reduce residual nitrate remaining in the soil at the end of the growing season.

- Winter cover cropping (October-March) can reduce nitrate leaching on average by 75% in lettuce production on the central coast (Smith et al. 2005).
- An autumn application of high C:N ratio amendment (C:N ratio greater than 50:1) has the potential to reduce nitrate leaching by immobilizing residual soil nitrate, potentially preventing >75% soil nitrate from leaching (Muramoto et al. 2019).

Solutions to help promote organic farming and meet rules proposed for Ag Order 4.0

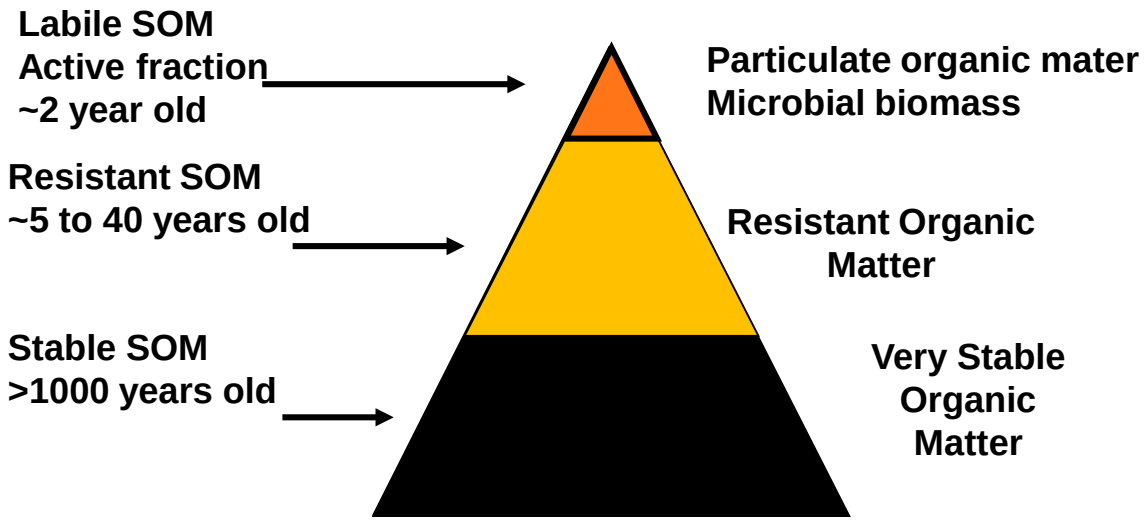
Proposed Solution:

3. CCOF (California Certified Organic Farmers) wants to create a water quality enhancement program that would supplement the existing organic certification and qualify an operation for **the lowest tier of regulation**. The certification would verify additional, quantifiable standards focused on nutrient management and erosion control.

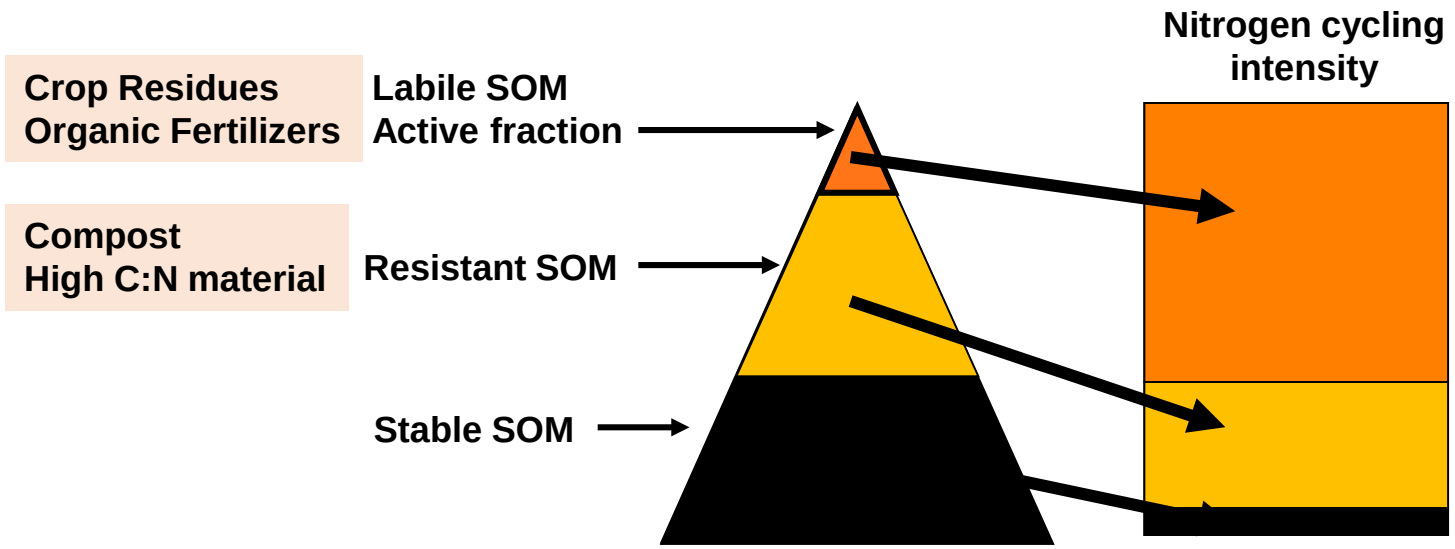
Mineralization & carbon amendments

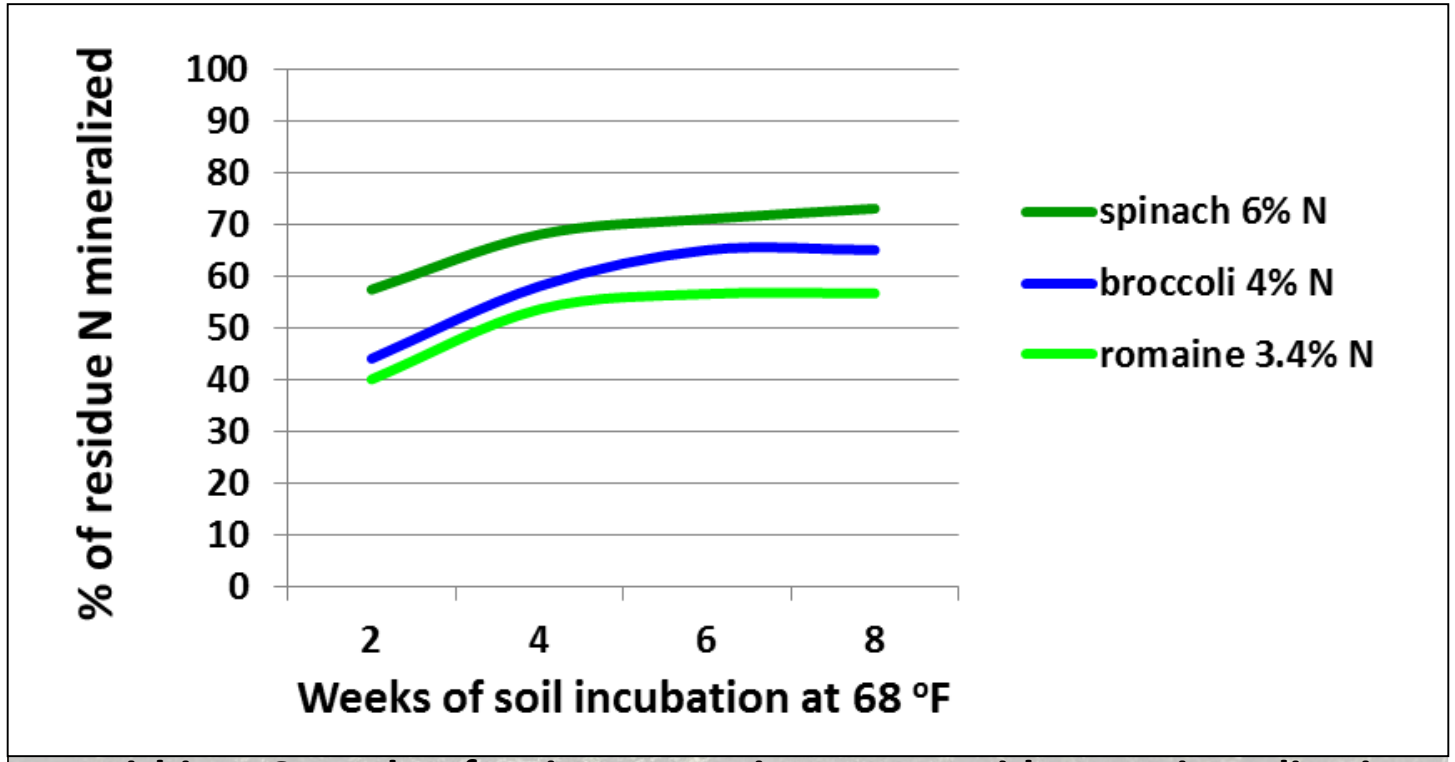
Richard Smith, Farm Advisor, Vegetable Crop Production & Weed Science UC Cooperative Extension

A Model for Understanding Soil Organic Material



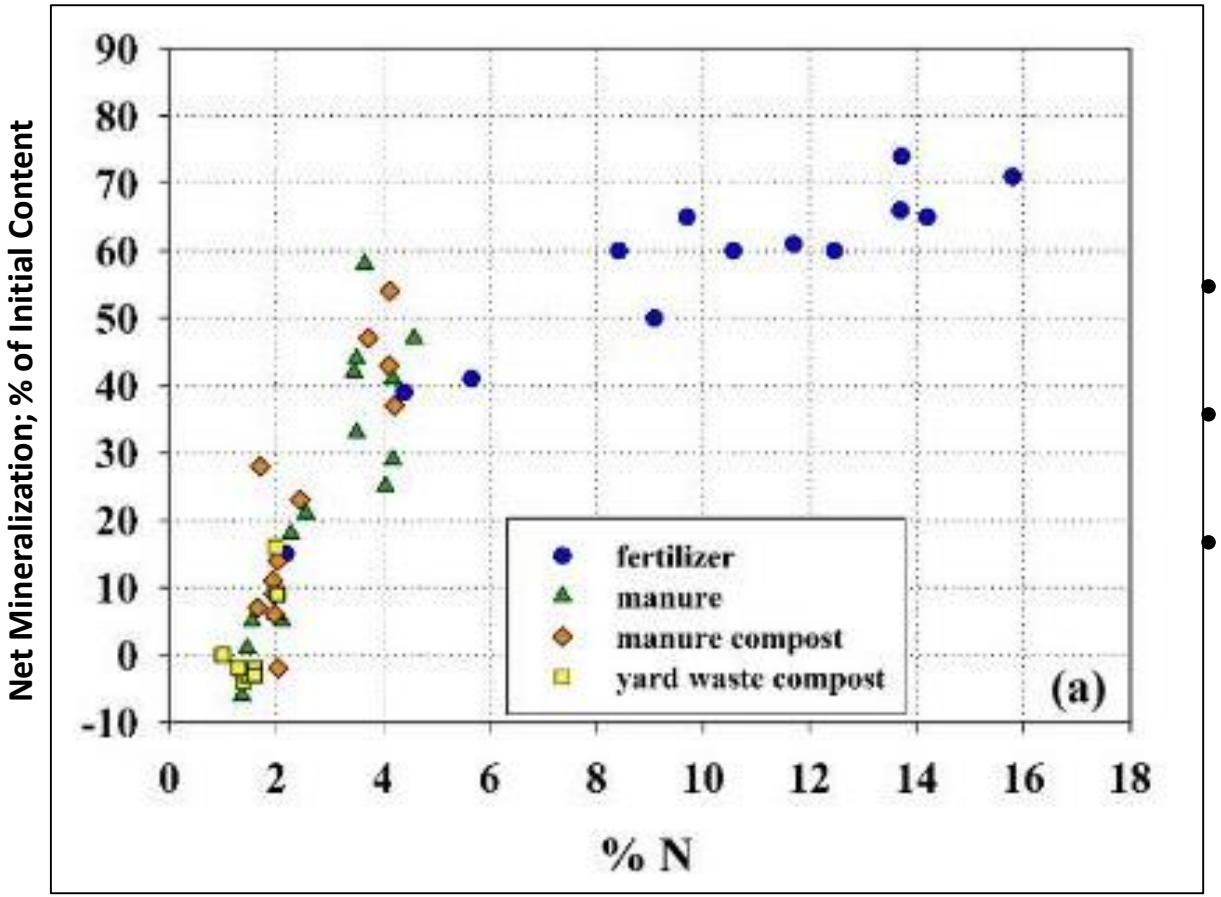
Contribution of soil organic pools to nitrogen availability





- Within 4-6 weeks after incorporation, crop residue N mineralization slows down
- Even these succulent tissues have two-phase mineralization (decomposition) – rapid then slow
- In the second phase, the rate of breakdown is similar to soil organic matter

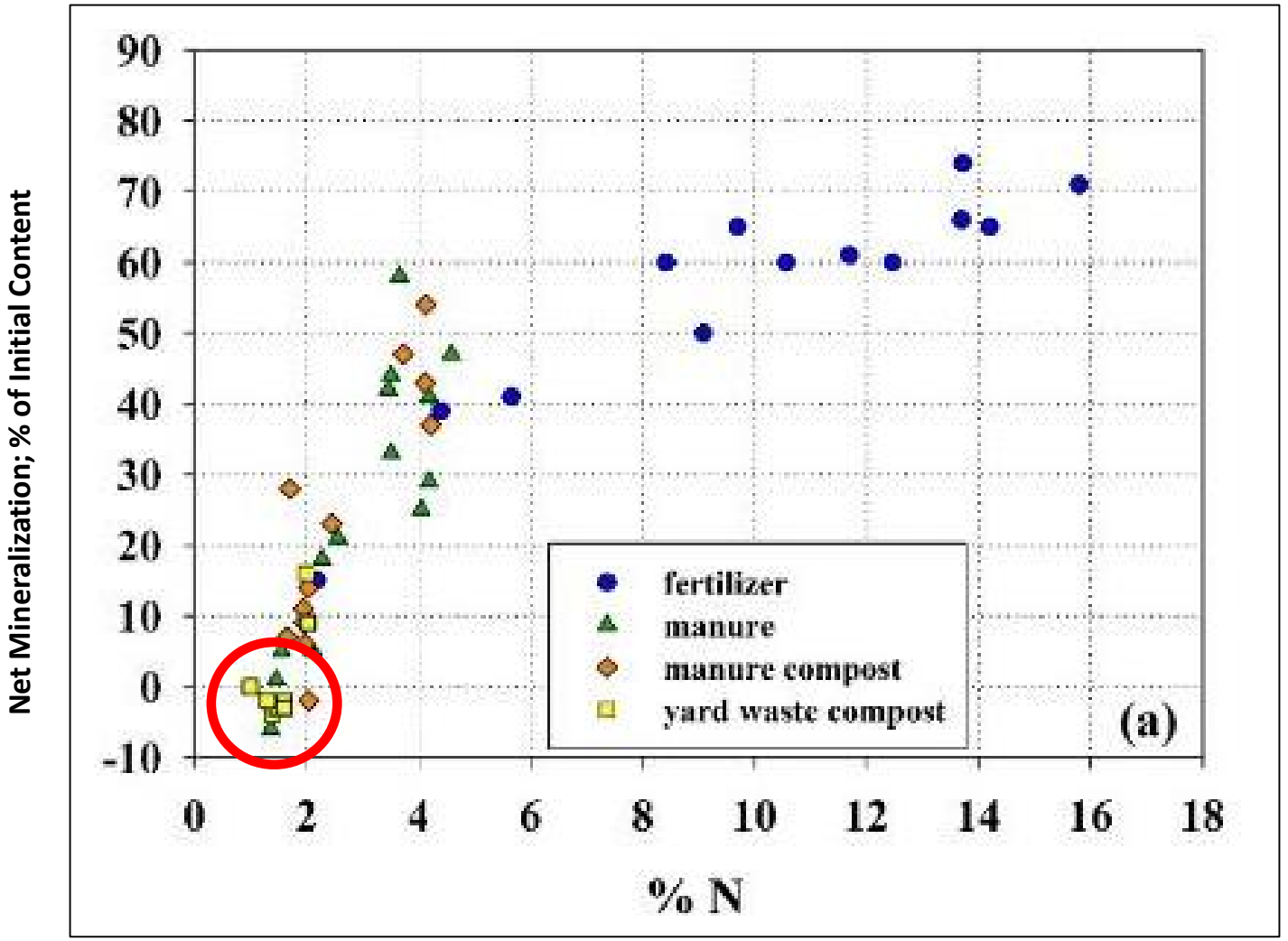
Net Mineralization (% of Initial N Content) of Various Organic Materials



- N concentration is the best predictor of N availability because N concentration drives the C:N ratio
- Materials ≤ 2% N provide little, if any, N
- Low N containing materials immobilize N
- Higher N content materials release a greater percent of initial N content - none release 100%

Tim Hartz

Immobilization of Nitrate
A Tool to Improve Nitrogen Use Efficiency



Immobilization of Winter Fallow Nitrate: 2018 Trial

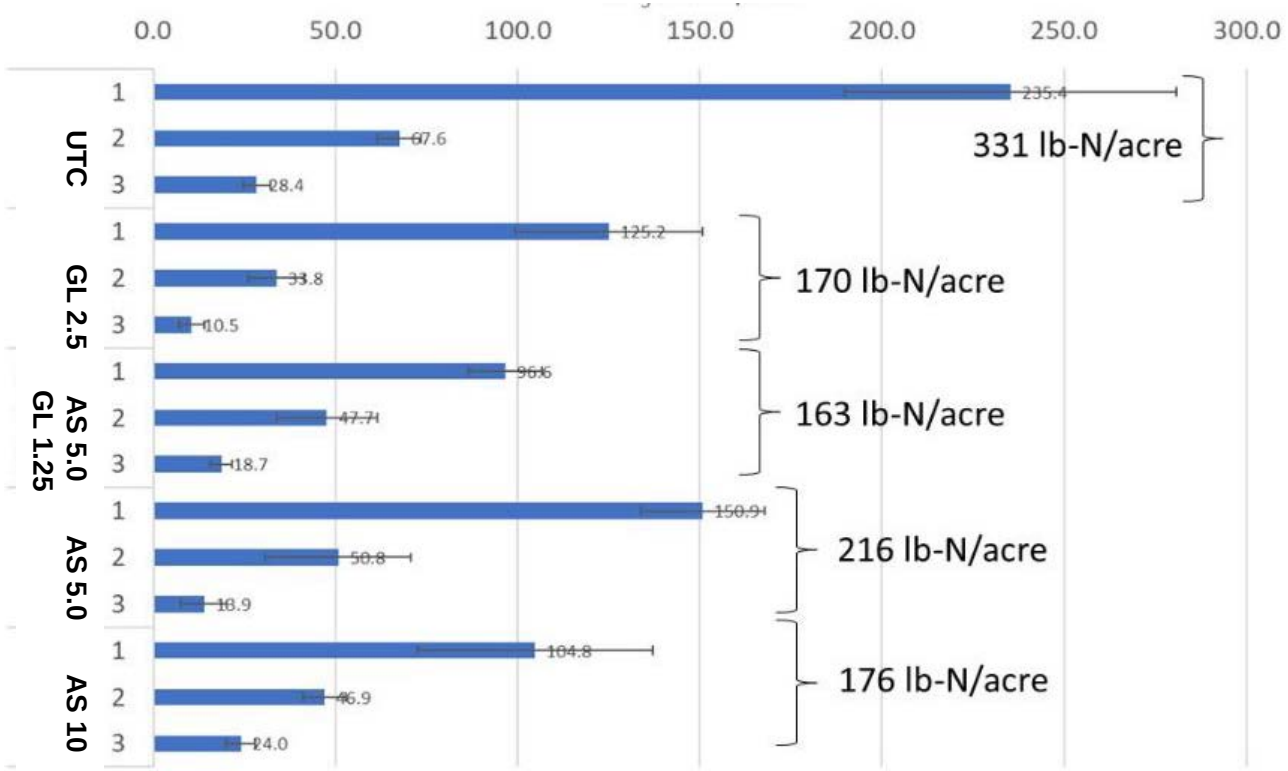
Almond Shells C:N = 70.3

Shells ground to 2 mm

Commercial Application
@ 5.0 and 10.0 T/A

Trial before incorporation

Total Load of Nitrate in Top 3 Feet of Soil



Nitrate Immobilization

Reduce Nitrate Leaching in Winter Fallow

Coarse High Carbon

Finer but lower in Carbon

- Ground almond shells and glycerol are effective but are too expensive
- Research is needed on locally sourced, high C:N compost that is be able to sequester nitrate in a similar fashion

Summary

- **The breakdown of organic inputs (compost, fertilizers, crop residues) depends on the concentration of N (which drives the C:N ratio)**
  - **Need coefficients to credit the net N mineralization from organic fertilizers and amendments (some are currently available)**
- **The breakdown is two-phased: Rapid (labile) and slow-steady (recalcitrant)**
- **Immobilization occurs with low N content materials; it can be used to reduce nitrate leaching in the fall and is undoubtedly occurring with current composting practices that utilize compost made from yard waste**