Nitrogen Management on Organic Farms

NRCS Animal Waste Management Workshop
April 6, 2010

Nick Andrews
with support from Dan Sullivan
OSU – North Willamette Research & Extension Center
nick.andrews@oregonstate.edu
(503) 678-1264 x149

Topics

- Nitrogen cycle
- Mineralization of organic fertilizers
- Cover crop nitrogen
  - Sampling cover crops
  - Predicting cover crop N-mineralization
- Using the OSU Cover Crop Calculator
- Mineralization of soil organic matter – time permitting

http://efotg.nrcs.usda.gov Oregon

590 OR-Specification

Natural Resources Conservation Service, Oregon — August 2002

NUTRIENT MANAGEMENT SPECIFICATION SHEET

Tract number ____

Client ____ Field number ____

PURPOSE (Check all that apply)			
Budget and supply nutrients for plant production		Utilize manure/organic materials as a nutrient source	
Minimize agricultural non-point source pollution (water quality)		Maintain or improve soil Condition	

Table 1. Field Conditions and Recommendations

CROP SEQUENCE/ROTATION ([x] current crop)	EXPECTED YIELD

CURRENT SOIL TEST LEVELS (ppm or lb/ac)					
N	P	K	pH	S.O.M %	P Index Rating

RECOMMENDED NUTRIENTS/AMENDMENTS TO MEET EXPECTED YIELD					
N	P_2O_5	K_2O	LIME	Other ____	Other ____

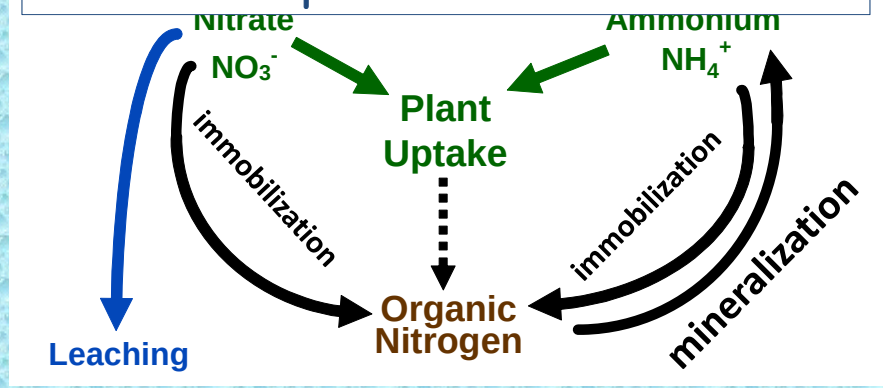
Table 2. Nutrient Sources

Credits	N	P_2O_5	K_2O
	Pounds per acre		
1. Nitrogen credits from previous legume crop			
2. Residual: periodic organic application (previous year)			
3. Irrigation water			
4. Other (e.g., soil test results, mineralization, etc.)			
5. **Total credits**			

Plant-Available Nutrients Applied to Field	N		P_2O_5		K_2O	
(Circle column that is client's decision)	Alt. 1	Alt. 2	Alt. 1	Alt. 2	Alt. 1	Alt. 2
6. Credits (from row 5, above)						
Starter						

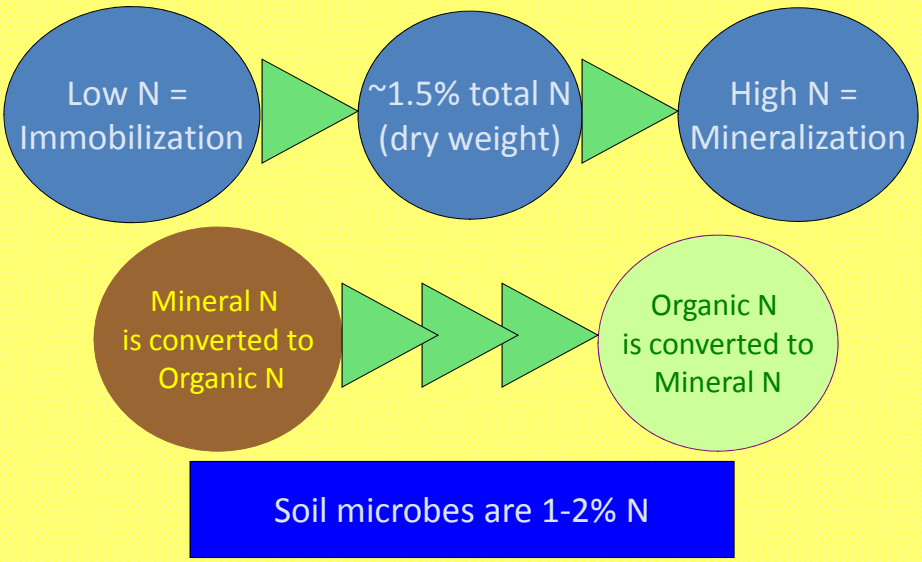
Successful organic farming relies on non-fertilizer sources of nitrogen and microbial decomposition of organic amendments: nitrogen mineralization

It is especially important for organic (little "o" – 'biologically intensive') farmers and their advisors to understand the nitrogen cycle, and have access to tools that predict N-mineralization.



Courtesy of Dan Sullivan OSU Crop & Soil Science

Nitrogen Availability

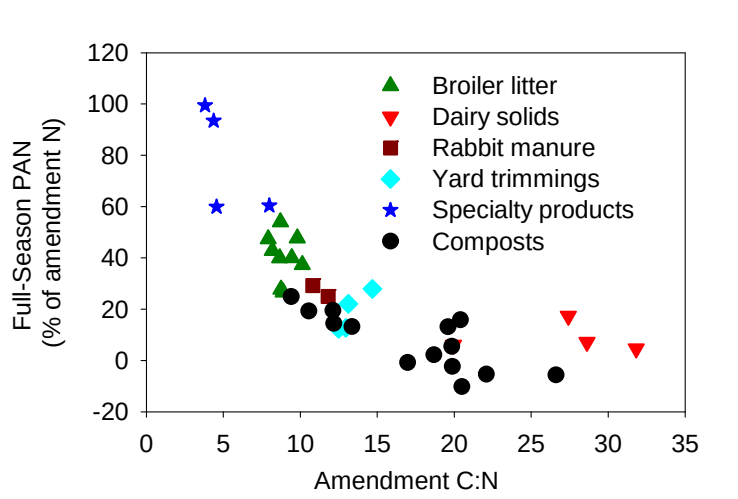


N-mineralization from organic fertilizers

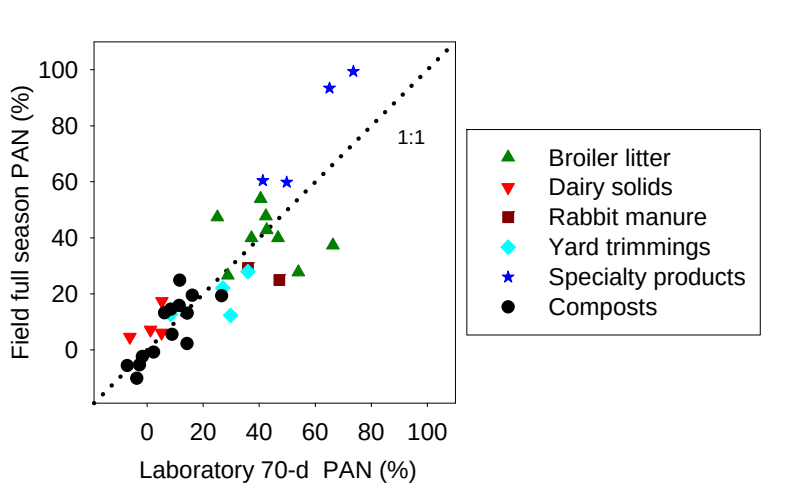
Validation of Organic Fertilizer Calculator Manure, compost and specialty products

Dairy solids	Corn gluten meal
Broiler litter	Feather meal
Rabbit manure	Alfalfa meal
Yard trimmings	Blood meal
Compost	Bone meal
Fish meal	Kelp meal
Fish bone	Soluble seaweed extract
Soybean meal	Seabird guano
Meat and bone meal	Blends of organic materials

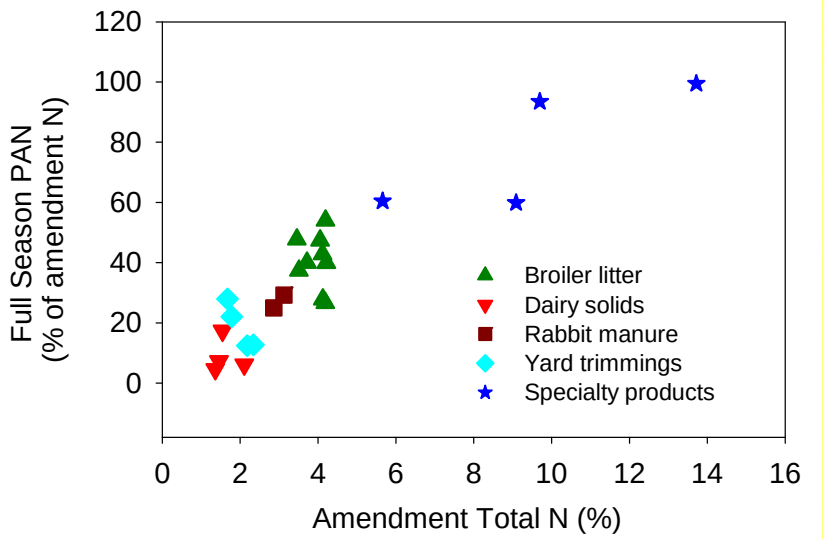
Amendment C:N vs. plant-available N (field)



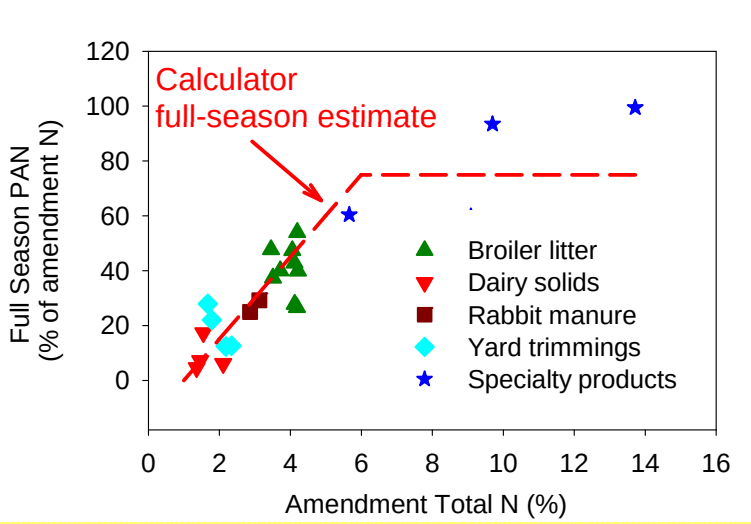
Lab vs. full-season field PAN (4-site yr.)



Amendment total N vs. plant-available N (field)

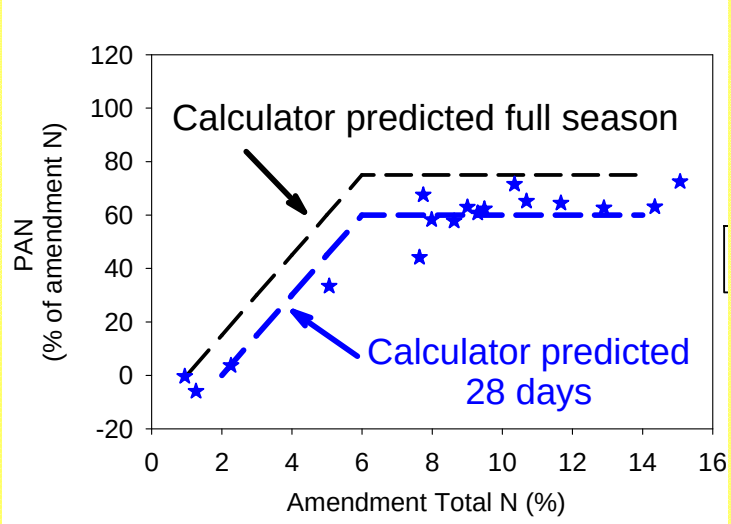


Basis for Organic Fertilizer Calculator



ORGANIC FERTILIZER CALCULATOR. http://smallfarms.oregonstate.edu

Validation of Organic Fertilizer Calculator, Specialty products



"Organic Fertilizer Calculator" Estimates of plant-available N (PAN)

Fresh Amendment total N	Example	Fresh Amendment C:N	PAN 28 days	PAN full season
% dry wt.		Approx.	% of total N	% of total N
1	Solid manure w/bedding	35	< 0	0
2	Dairy solids	18	0	15
4	Broiler litter	9	30	45
6+	Specialty products	less than 6	60	75

"Fertilizer Calculator" Estimates of plant-available N (PAN)

Composted Amendment total N	Composted Amendment C:N	PAN 28 day	PAN full season
% dry wt.		% of total N	% of total N
1	30	0	5
2-3	15 to 10	5	10

N-mineralization from cover crops

***Rhizobium* in nodules**

Fix atmospheric N at room temperature & normal atmospheric pressure.

Häber Bosch process fixes N at about 400°C and 200 atm.

Estimating Cover Crop DM & N

Species	Dry Matter (T/A)	Total N (lb/A)	PAN (lb/A)
Fava beans	3.5	140	50%
Hairy vetch	2.2	140	50%
Common vetch	2-3	120	50%
Sub clover	2.5	115	50%
Crimson clover	3	110	50%
Field pea	1.7	100	50%
Red clover	1.7	85	50%
Rape seed	3	80	0
Small grains	2-3	60	0
Annual rye grass	3	45	0
Cereal rye	2-3+	0	0
Sudhan grass	Very high!	?	?

Using Cover Crops in Oregon: EM 8704

Total N content and PAN contribution from cover crops varies depending on % of legumes, stand maturity and other factors

Oats & vetch
~26" canopy

~110 lbs total N & ~10lbs PAN

Rye, vetch & peas
~20" canopy

~ 155lbs total N & ~60lbs PAN

Common vetch ~ 12" canopy
~155 lbs N, 80 lbs PAN & 4,278 lbs DM

Cereal rye – vetch ~ 26" canopy
~ 203 lbs N, 86 lbs PAN & 6,585 lbs DM

Weedy fallow: sparse canopy
~13 lbs N, 4 lbs PAN & 615 lbs DM

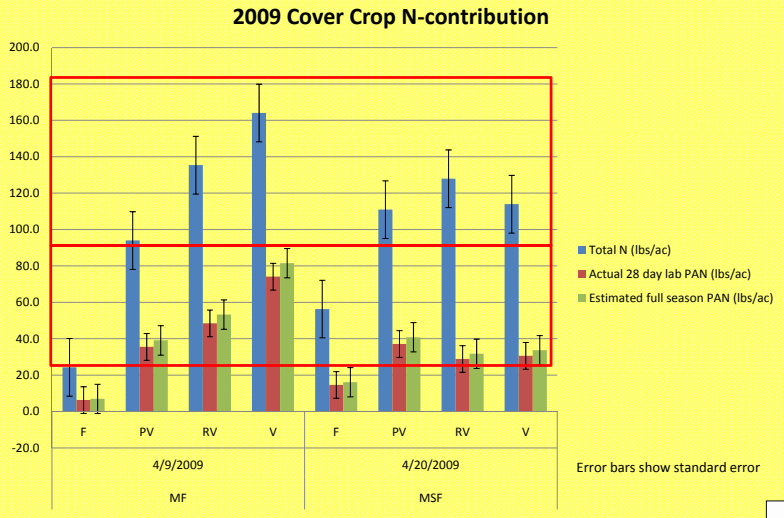
Phacelia (winter killed) – vetch ~ 10" canopy
~60 lbs N, 27 lbs PAN & 1,569 lbs DM

Common vetch ~ 20” canopy
~141 lbs N, 58 lbs PAN & 4,345 lbs DM

Cereal rye – vetch ~ 30” canopy
~ 153lbs N, 37 lbs PAN & 6,059 lbs DM

Weedy fallow ~ 15” canopy
~24 lbs N, 1.5 lbs PAN & 1129 lbs DM

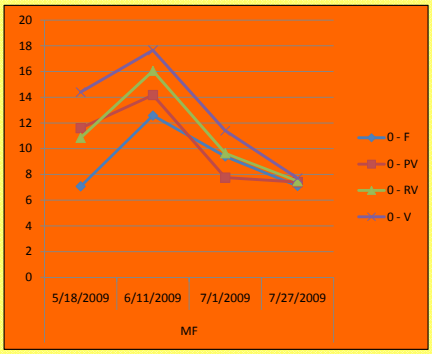
Phacelia – vetch ~ 23” canopy
~ 178 lbs N, 78 lbs PAN & 4,994 lbs DM

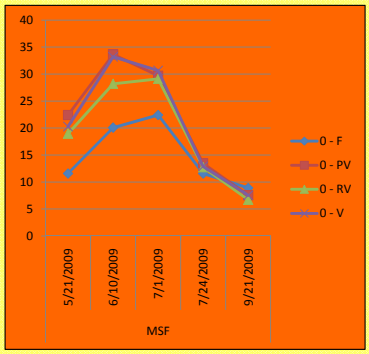


Oregon State University OSU Extension Service

OREGON TILTH

Soil nitrate (ppm) levels following cover crops with no N fertilizer (0-12”)



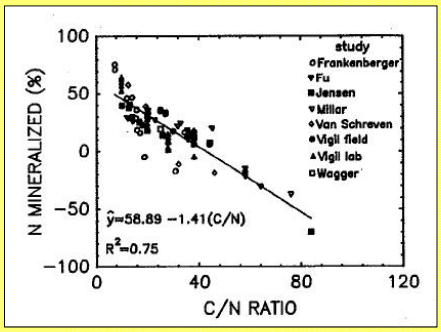


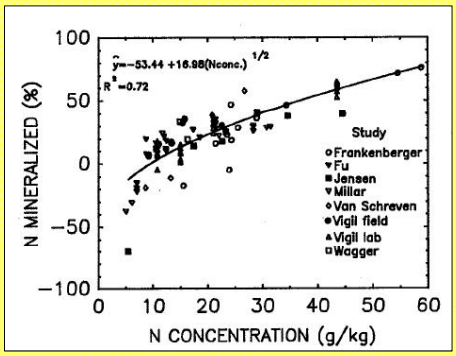
20-30 ppm nitrate is sufficient for most crops

Oregon State UNIVERSITY OSU Extension Service

OREGON TILTH

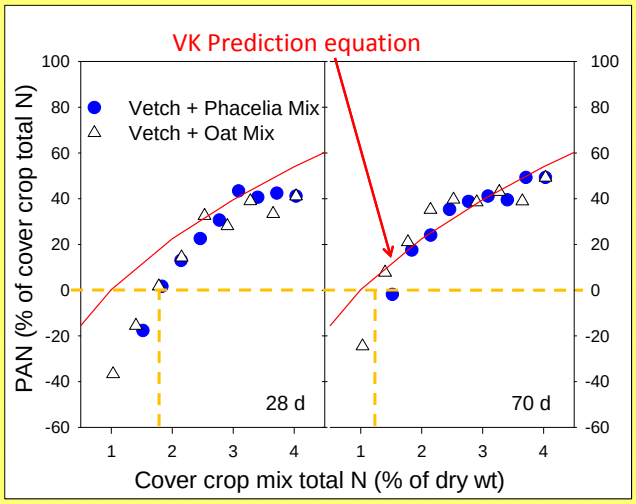
Mineralization of N from crop residues





Vigil and Kissel (1991) SSSAJ 55:757

Validation of cover crop calculator prediction equation (lab)



Equation: Vigil and Kissel (1991) SSSAJ 55:757

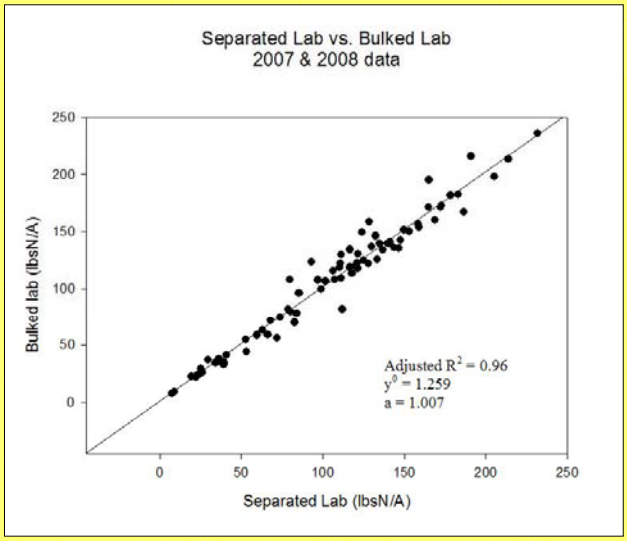
Do we need to separate species?

Total N - Separated spp. vs Bulk spp.

- Grasses
  - 0.8 - 2.0% total N can be a lot of N per acre
  - Grasses immobilize or release small amt's of N: -5% - 20% PAN
- Legumes
  - 2.5-3.8% total N
  - Legumes have 30-50% PAN

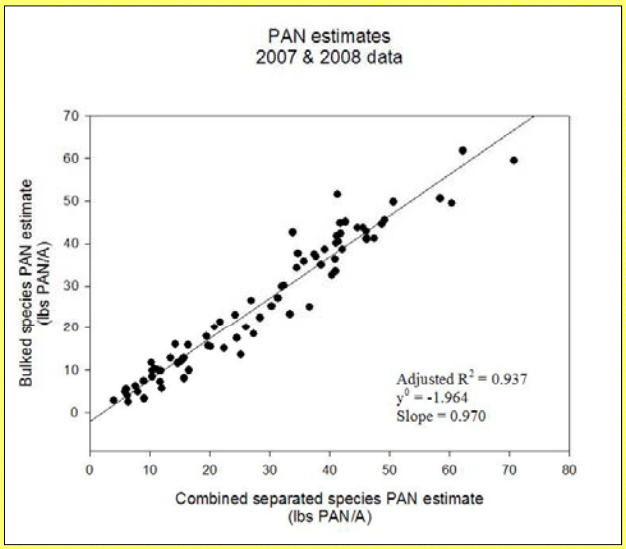
Do we need to separate species?

Total N - Separated spp. vs Bulk spp.



Do we need to separate species?

PAN - Separated spp. vs Bulk spp.



Relative Costs of Nitrogen

Product	$/ton	Total % N	Est'd % PAN	$/lb PAN	$/100 lbs PAN
Urea (not organic)	$500	46%	100%	$0.54	$54
	$1000	46%	100%	$1.09	$109
Processed chicken manure	$200	4%	50%	$5.00	$500
	$250	4%	50%	$6.25	$625

PAN from legume cover crops cost ~ $1-2.00/lb when all costs of cover cropping are attributed to PAN; $0.50-$1.00 if only the legume seed and inoculum are attributed to PAN.

New OSU Cover Crop Calculator

- Predicts PAN from organic fertilizers
- Helps determine balanced and cost effective fertilizer programs
- Uses lab results from cover crop samples taken in the field.
- Predicts total N and PAN release from incorporated cover crops.
- Calculates the cost of managing cover crops and compares the cost of cover crop PAN with fertilizers.
- Based on PAN prediction equation developed in Midwest and verified by our lab and field research in the Willamette Valley.
- Online very soon

Oregon State University OSU Extension Service

Western Region Sustainable Agriculture Research and Education

OREGON TILTH

Cover Crop Calculator has separate mineralization models for:

- Organic fertilizers (online)
- Compost (online)
- Cover crops (online later this week…)

Validated for Willamette Valley (W OR)

http://smallfarms.oregonstate.edu/organic-fertilizer-calculator

Using the Calculator

1. Determine crop nutrient requirements
2. Sample cover crops and submit to lab
3. Input information and use Calculator to determine fertilizer program

2. Sample cover crops in the field

2. Weigh and prepare samples for the analytical lab

- Cut up large plants and remove soil
- Mix the whole sample thoroughly
- Weigh the total sample
- Take about a 1 gallon grab sample
- Ready for the lab

2. Send sample to your soil testing lab

EM-8677

NUTRIENT MANAGEMENT guide

EM 8677
Revised June 2006

Laboratories Serving Oregon

Soil, Water, Plant Tissue, and Feed Analysis

J. Hart

- % moisture
- Total N analysis

Western Region Sustainable Agriculture Research and Education

Oregon State University OSU Extension Service

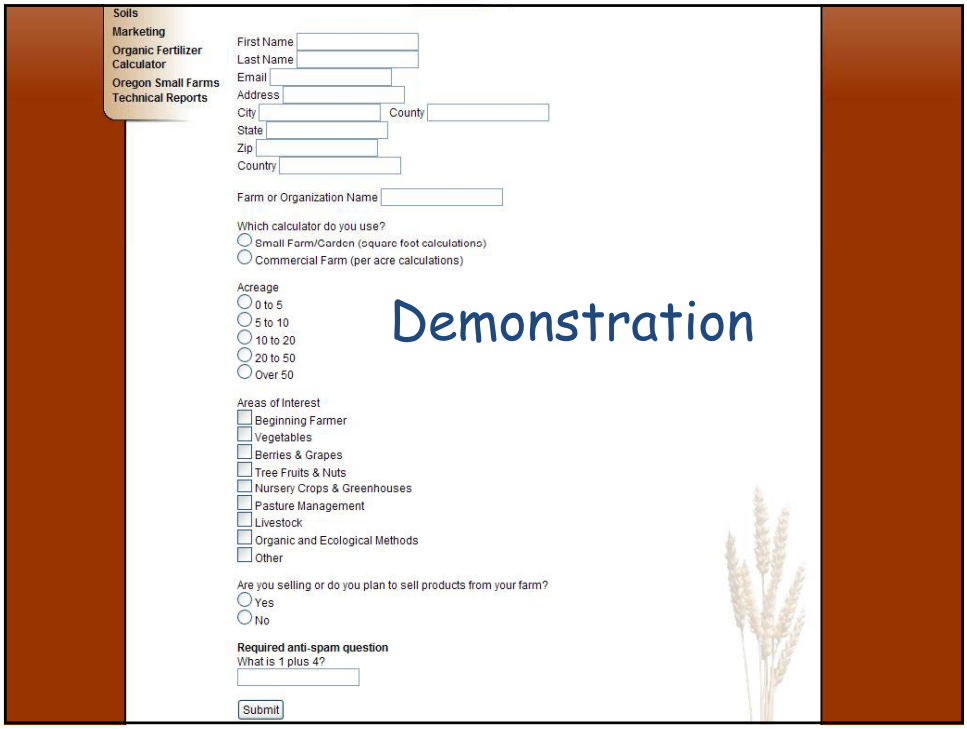
OREGON TILTH

RECORDS SHEET: OSU COVER CROP CALCULATOR
INPUT

Information	Source of information	Units & accuracy	Your values	Calculator Sheet
Nutrient information				
Nutrient requirement	Fertilizer guides and soil tests N-P-K plus other nutrients	lb/ac		Nutrients provided
Fertilizer analysis	Fertilizer label or suppliers N-P-K plus other nutrients	x.x %		Fertilizer analysis
Fertilizer % dry matter	Supplier, manufacturer or oven dry test	x %		Fertilizer analysis
Fertilizer app'n rates	Determined by using the Calculator	lb/ac		Nutrients provided
Cover crop area sampled	Calculation: [size of quadrat (ft^2) x no. of quadrats sampled]	ft^2		Cover crop analysis
Fresh weight of field sample	Measured weight of cleaned field sample (oz x 0.063 = lbs)	x.x lbs		Cover crop analysis
% moisture of subsample	Value from lab	x.x %		Cover crop analysis
Total % N	Value from lab	x.x % of dry wt		Cover crop analysis
Economic information				
Fertilizer cost	Farm records	$/lb		Cost comparisons
Seed cost	Farm records	$/lb		Your costs
Inoculant cost	Farm records	Total $		Your costs
Labor cost	Farm records	$/hr		Your costs
Fuel Cost	Farm records	$/gal		Your costs
Tractor size	Farm records	hp		Your costs
Implement width	Farm records	ft		Your costs
Speed travelled	Tractor manual (gear, rpm and wheel size)	mph		Your costs

RECORDS SHEET: OSU COVER CROP CALCULATOR OUTPUT

Information	Source	Units & accuracy	Your results	Calculator Sheet
Nutrient information				
Fertilizer nutrients provided	Calculations	lb/ac		Nutrients provided
Fertilizer PAN	Model prediction	lb/ac		Fertilizer analysis
Acreage sampled	Calculation	Factor		Cover crop analysis
Dry matter	Calculation	x.x %		Cover crop analysis
Fresh weight	Calculation	lb/ac		Cover crop analysis
Dry weight	Calculation	lb/ac		Cover crop analysis
Total N	Calculation	lb/ac		Cover crop analysis
Cover crop total N & PAN	Model prediction	lb/ac		Cover crop analysis
Economic information				
Fertilizer cost	Calculation: by nutrient and by fertilizer	$/lb		Cost comparisons
Cover crop seed & inoculant cost	Calculation	$/ac		Your costs
Cover crop management and fertilizer application cost	Calculation: includes labor, fuel and straight line depreciation	$/ac		Your costs
Cover crop PAN cost	Calculation from model output	$/lb		Cost comparisons
Total cost	Calculation	$/ac		Cost comparisons



Organic matter

"The best single overall strategy for nutrient management… is to enhance soil organic matter levels in soils" (Magdoff & van Es)

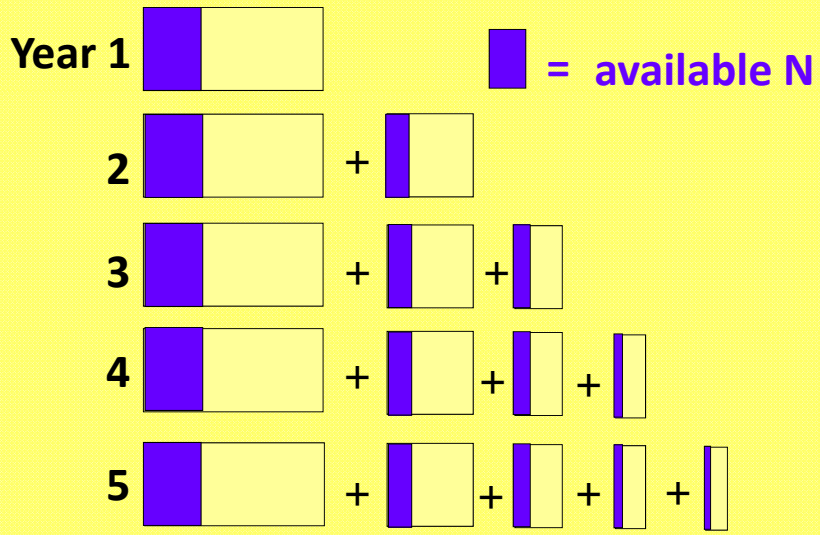
OM increases CEC (holds onto K, Ca and Mg), mineralizes N, P, S and B, and chelates micronutrients (i.e. Zn, Cu, Mn), keeping them plant available.

Oregon State University OSU Extension Service

SOM is Compositionally and Functionally Heterogeneous

Pool	Size/Age (yrs)	Functions
Biologically Active	Small/1-5	The Meat: nutrient mineralization, macro-aggregation, disease suppression
Protected	intermediate/ 5-30	The Bones: soil structure, porosity, water relations
Stable	Large/ 50-10,000	Micro-aggregation, CEC, fate of ionic and non-ionic compounds, color

Cumulative available N from an organic source



Courtesy of Dan Sullivan OSU Crop & Soil Science

Organic equilibrium

- Organic C&N accumulate over time
- Soil Nmin potential increases over time
- Nmin potential can be estimated using frequent soil nitrate tests

MAINTENANCE PHASE

SOIL BUILDING PHASE
2-4 years or more

9-year annual cropping trials

(MD, PA, OH, IA, WI, CA)

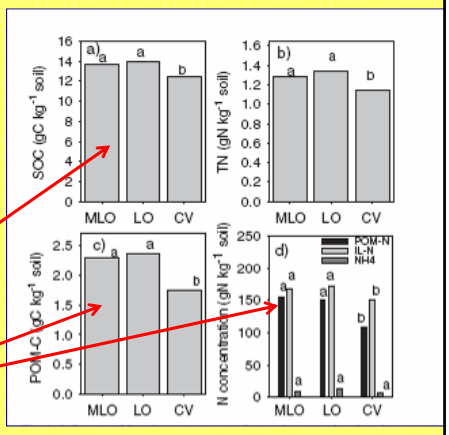
MLO=manure org, LO=legume org, CV=conventional

Legume system ≈ manure system

Organic management increased:

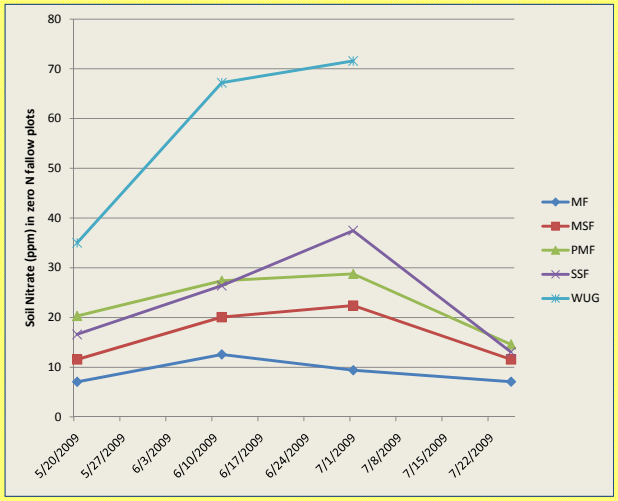
SOC (ave 10yr) 14%

POM C & N 30-40%



(Marriott & Wander, 2006)

Predicting N from organic matter



Predicting N from organic matter

Estimating Nitrogen Mineralization in Organic Potato Production

D.M. Sullivan, J.P.G. McQueen, and D.A. Horneck

EM 8949-E
January 2008

This bulletin is one of a series on organic potato production developed by "OSPUD." OSPUD is a collaboration among Oregon State University personnel and 11 farmers operating diversified organic vegetable farms. The purpose of OSPUD is to improve potato quality and profitability through a participatory learning process and on-farm, farmer-directed research. The first 2 years of OSPUD were supported by Western SARE Grant SW05-091. For more information on OSPUD, visit ospud.org.

Potatoes require adequate nitrogen to produce quality tubers and high yields. Organic farming practices are designed to build soil nutrient levels gradually. In organic systems, nitrogen (N) enters the soil in the form of crop residue and amendments (e.g., manures, composts, and specialty products).

Much of the N added to the soil is held in organic forms not immediately available for crop uptake. A soil with 3 percent organic matter in the top foot contains about 5,000 lb N per acre. However, only a small fraction of soil organic N is released in plant-available forms each year through a process

Predicting N from organic matter

FS 334-E • January 2006

Using the Nitrogen Mineralization Soil Test to Predict Spring Fertilizer N Rate

Soft White Winter Wheat Grown in Western Oregon

J.M. Hart, N.W. Christensen, M.E. Mellbye, and M.D. Flowers

Soft white winter wheat grown in western Oregon requires a spring application of nitrogen (N) fertilizer for optimum production. Determining the amount of N to apply has been a challenge for growers because wheat is produced in numerous rotations that provide varying amounts of N to the wheat crop. Inadequate N results in reduced yield. However, excess N causes lodging, higher-than-desired grain protein, and added expense.

Wheat obtains N from two sources: soil and fertilizer. Soil N is provided in available mineral form (nitrate or ammonium-N) and as mineralizable N (nitrogen that will become available during the growing season). Nitrate and ammonium-N supply only 5 to 15 percent of the total N requirement. Miner-

conventional tillage and direct seeding to establish stands.

Using the mineralizable N soil test for irrigated winter wheat, spring wheat, or other crops is not recommended. *Current research, through January 2006, has calibrated the Nmin test only for use in western Oregon winter wheat. It is not intended for use with any other crop.*

Using the mineralizable nitrogen test (Nmin)

Taking a sample

The first step is to collect a composite soil sample from the 0- to 12-inch depth using a soil sampling tube. The sample should include a minimum of 20 soil cores representing the area to be fertilized. The best time to take soil samples

Through more than 10 years of research, Neil Christensen, OSU soil scientist, developed the Nmin test for wheat, a method for accurately predicting the spring fertilizer N requirement.