NITROGEN MANAGEMENT IN ORGANIC VEGETABLES

Nick Andrews
Organic Extension Program
OSU Center for Small Farms
Nick.andrews@oregonstate.edu
http://smallfarms.oregonstate.edu/calculator
503-913-9410

Some questions

1. How much plant-available N (PAN) is supplied from non-fertilizer sources?
2. How much plant-available N (PAN) is needed from fertilizers?
3. How much of the total N (fertilizer label) from organic fertilizers is released during the period of crop N uptake?
4. How do you get a ratio of PAN, P_2O_5 and K_2O in organic fertilizers that matches crop requirements?

Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

Step-by-step guide to determining an organic nitrogen fertilizer rate:

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	
2	Additional soil organic matter contribution		
3	Cover crop nitrogen contribution		
4	Site specific nitrogen recommendation		
5	Fertilizer PAN estimate & fertilizer application rate		
6	Adjust nitrogen rates		

Crop N requirement: Nutrient Mgt Guides

Table 1. Nitrogen requirement of vegetable crops based on seasonal nitrogen uptake		
Low Total N Need <120 lb/acre	**Medium Total N Need <120-200 lb/acre**	**High Total N Need >200 lb/acre**
Baby greens	Carrot	Broccoli
Beans	Corn, Sweet	Cabbage
Cucumbers	Garlic	Cauliflower
Radish	Lettuce	Celery
Spinach	Melons	Potato
Squashes	Onion	
	Peppers	
	Tomatoes	

— Gaskell et al. 2006, Soil Fertility Management for Organic Crops

Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

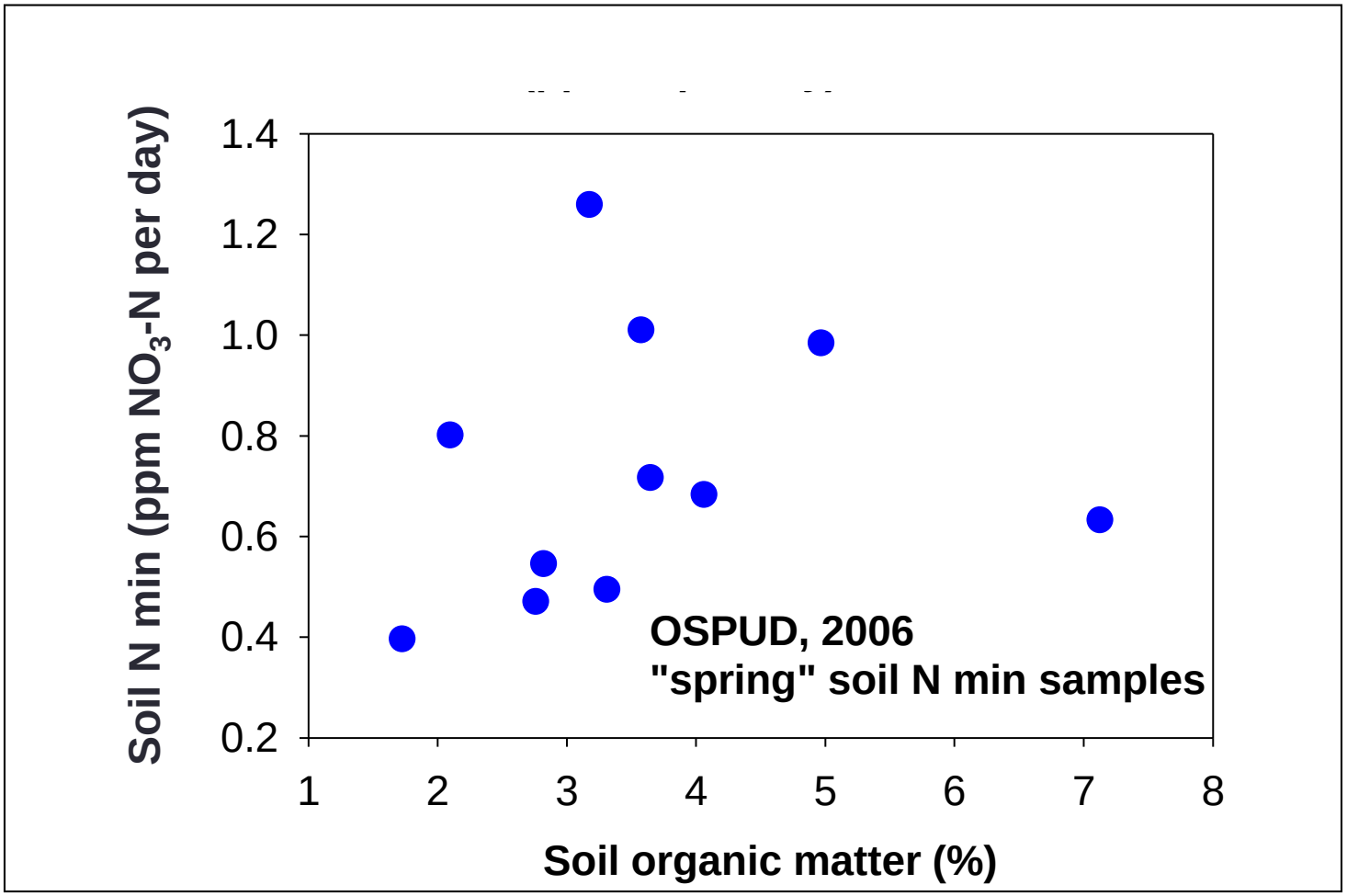
Step-by-step guide to determining an organic nitrogen fertilizer rate:

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	200lbs PAN/ac
2	Additional soil organic matter contribution	Estimate from previous soil building practices	
3	Cover crop nitrogen contribution		
4	Site specific nitrogen recommendation		
5	Fertilizer PAN estimate & fertilizer application rate		
6	Adjust nitrogen rates		

Types of Soil Organic Matter

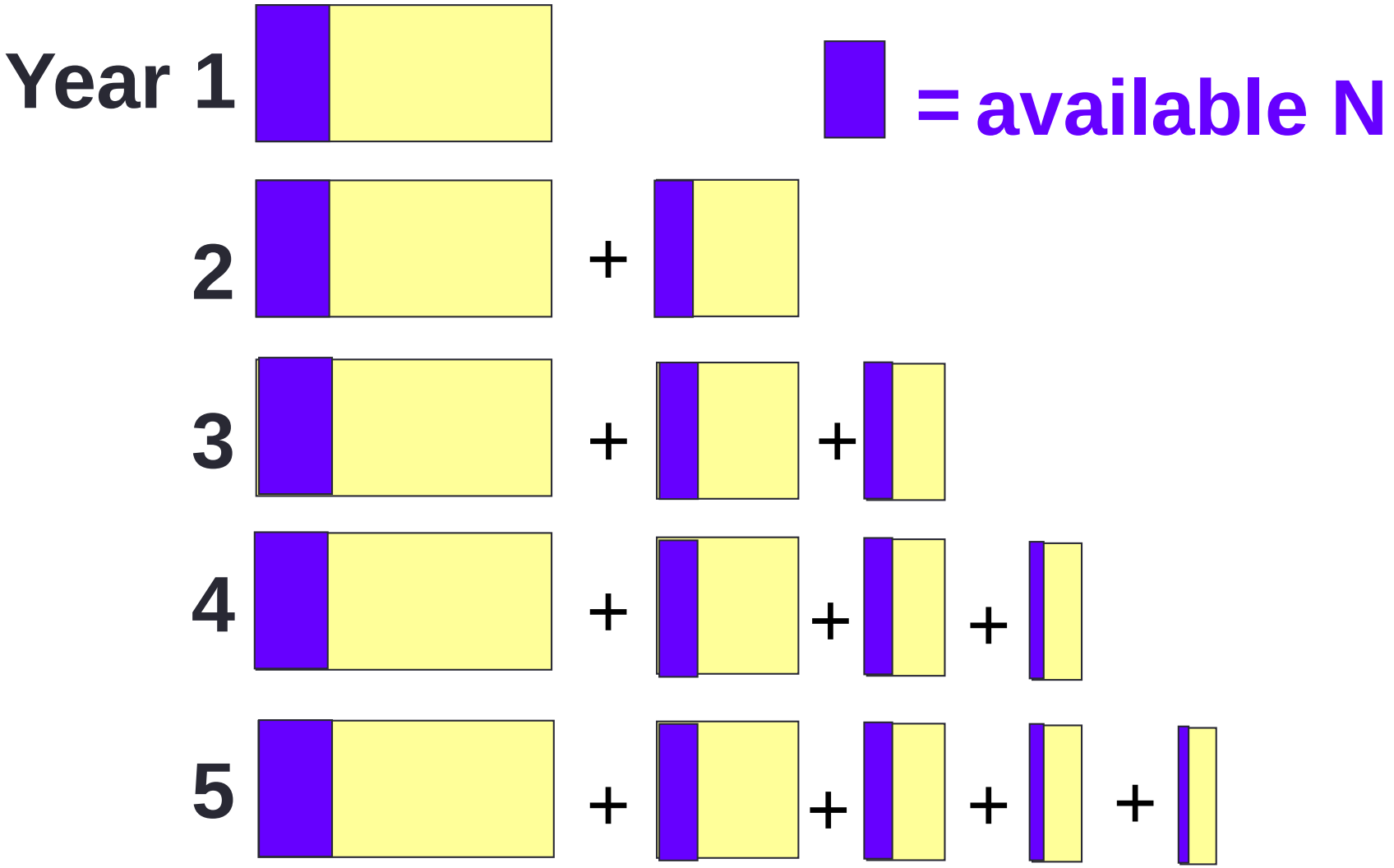
Pool	Size/Age (years)	Functions
Biologically Active	Small 1-5	**Meat:** nutrient mineralization, macro-aggregation, disease suppression
Protected	Intermediate 5-30	**Bones:** soil structure, porosity, water relations
Stable	Large 50-10,000	Micro-aggregation, CEC, fate of compounds, color

Total soil organic matter vs anaerobic N mineralized (ppm NO_3-N per day)



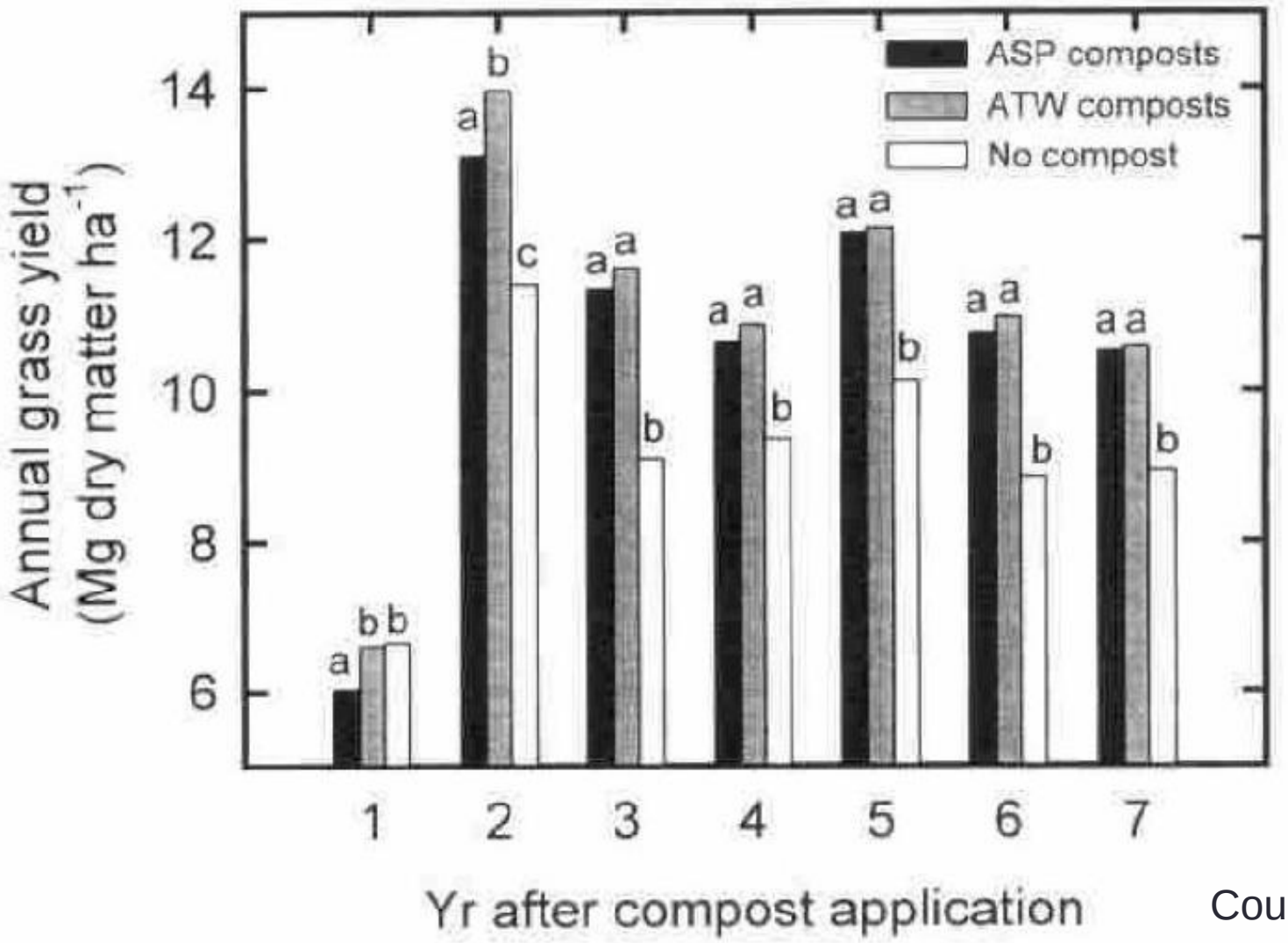
Courtesy Sullivan

Cumulative PAN from an organic source



Courtesy of Dan Sullivan OSU Crop & Soil Science

N mineralization from compost



Courtesy Sullivan

Estimating PAN from soil organic matter

Field history [1]	Description (modest tillage)	Nitrogen credit [2] (lbs/ac)
0	No additional organic matter	0
1	3-7 yrs covers; some compost/manure	25-75
2	5-10 yrs covers + compost/manure	75-200

[1] Field history: estimate your level of “soil building”.
[2] Estimated amount to subtract from older University fertilizer guides

Currently in PNW we recommend monitoring soil nitrate levels to check this estimate

Low risk of summer leaching in Oregon

May not be appropriate in regions with heavy summer rains

Doug Collins (WSU) evaluating pre-season tests to predict N mineralization potential

- Haney Test
  - from air dried soil (Solvita & Weak Acid Extracted mineral N)
- Aerobic incubation
  - From fresh soil: 7d, 14d, 21d, 42d at 22C and 35C
- Anaerobic incubation
  - From air dried soil: 7 d
- Others also working on this so look for new research findings

Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

Step-by-step guide to determining an organic nitrogen fertilizer rate:

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	200lbs PAN/ac
2	Additional soil organic matter contribution	Estimate from previous soil building practices	50lbs PAN/ac
3	Cover crop nitrogen contribution	OSU Organic Fertilizer & Cover Crop Calculator	
4	Site specific nitrogen recommendation		
5	Fertilizer PAN estimate & fertilizer application rate		
6	Adjust nitrogen rates		

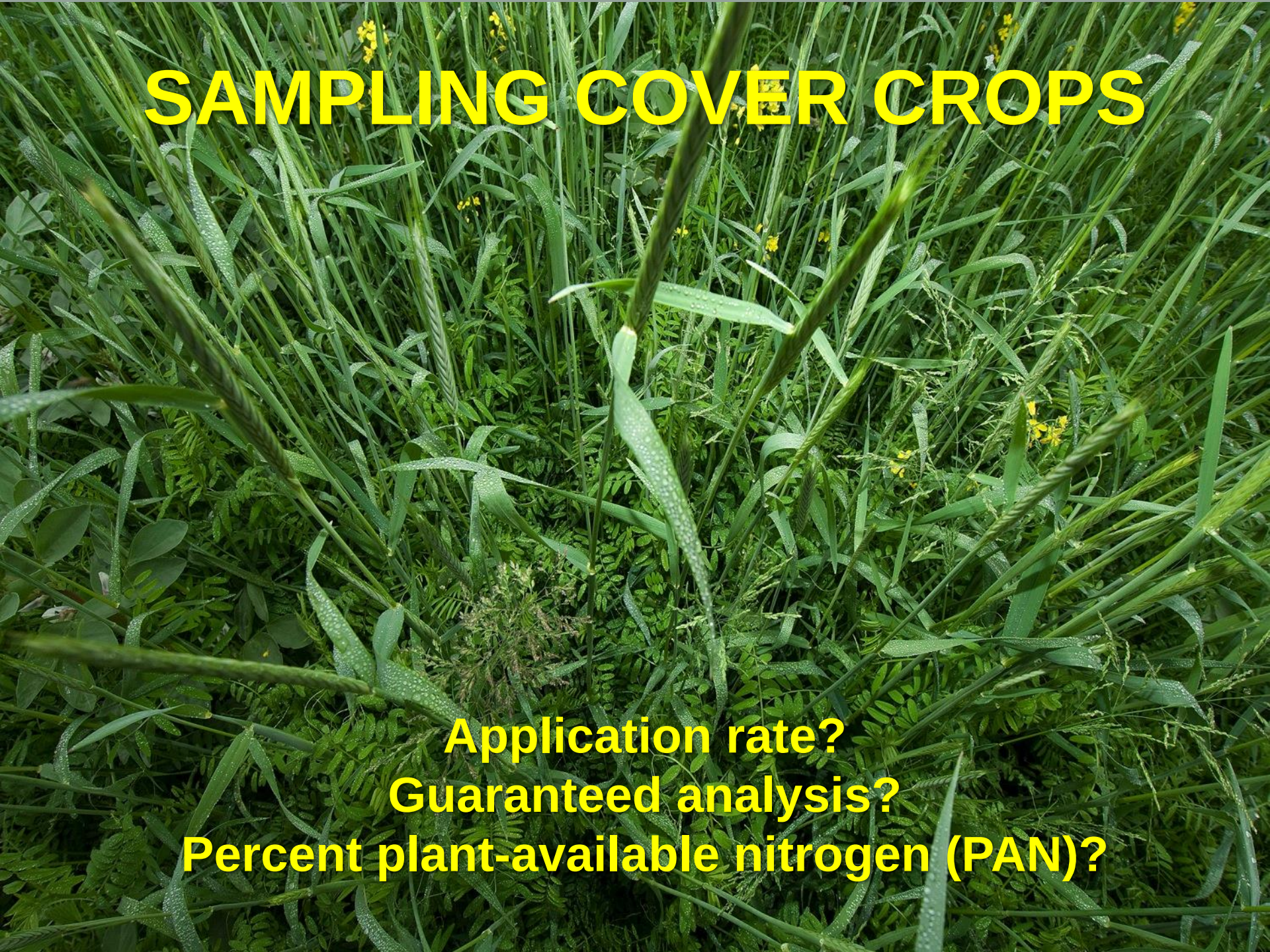
PNW 636 • November 2012

Estimating Plant-Available Nitrogen Release from Cover Crops

D.M. Sullivan and N.D. Andrews

Highlights

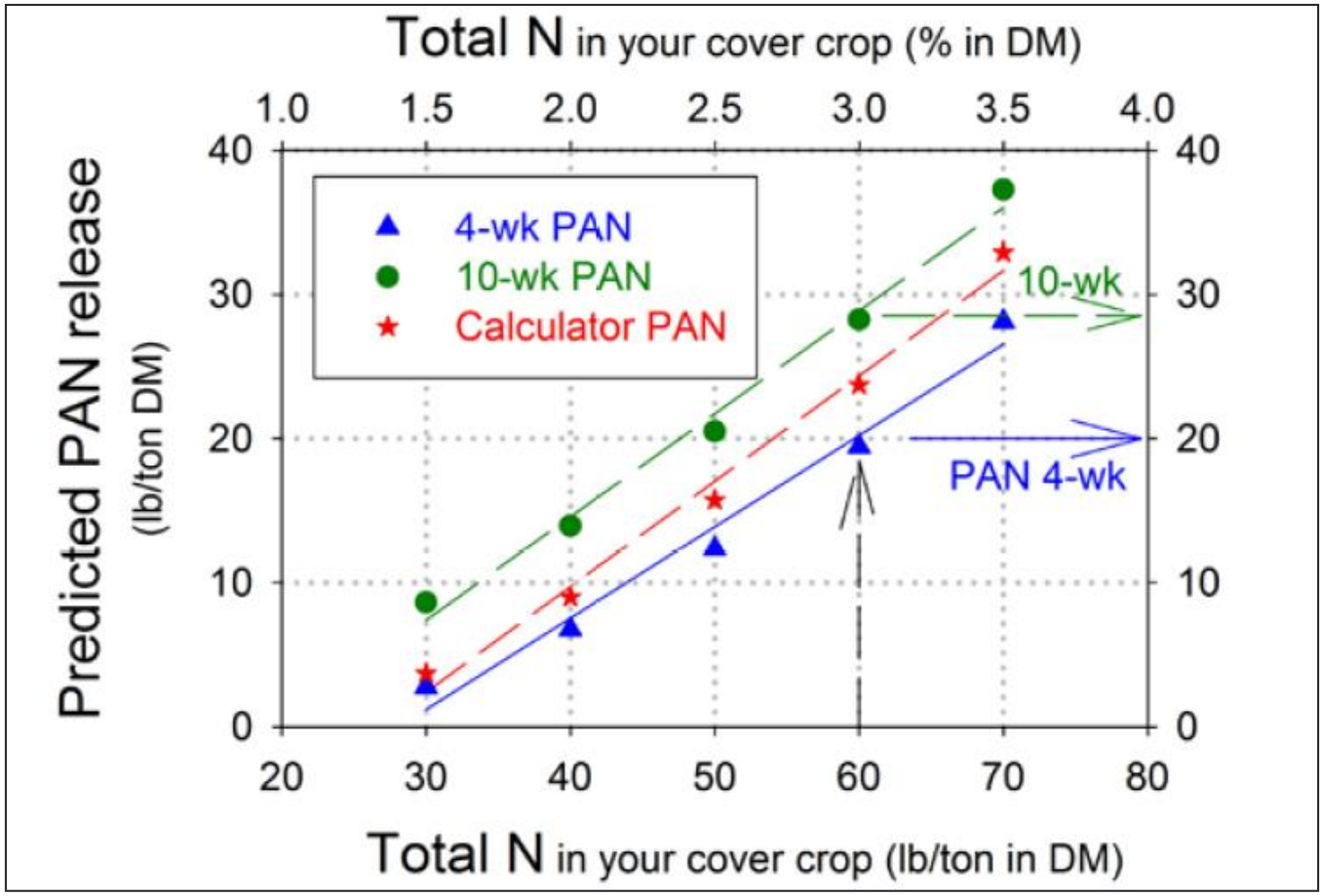
- Legume cover crops provide up to 100 lb PAN/a. To maximize PAN contribution from legumes, kill the cover crop at bud stage (early May).
- Cereal cover crops immobilize up to 50 lb PAN/a. To minimize PAN immobilization from cereals, kill the cover crop during the early stem elongation (jointing) growth stage (early April).
- Legume/cereal cover crop mixtures provide a wide range of PAN contributions, depending on legume content. When cover crop dry matter is 75 percent from cereals + 25 percent from legumes, PAN is usually near zero.


SAMPLING COVER CROPS
Application rate?
Guaranteed analysis?
Percent plant-available nitrogen (PAN)?

Ask lab to dry and grind whole sample and analyze:

- % dry matter
- total % N

Cover crop PAN (PNW 636)



Cover Crops tested at mid vegetative and flowering GS
Oats
Cereal Rye
Phacelia
Common Vetch
Crimson Clover

Soils tested: Amity silt loam (Mollic), Aloha silt loam, Canderly sandy loam

http://smallfarms.oregonstate.edu/calculator

Cover Crop PAN: OSU Calculator

	A	B	C	D	E	F	G	H	I	J
1	***ENTER YOUR COVER CROP INFORMATION FROM THE FIELD AND THE LAB***									
2	***Enter your information in yellow cells. Results are in green cells.***									
3	OREGON TILTH / OSU Oregon State University Extension Service	**Area sampled (ft^2)**	**Fraction of acre sampled**	**Fresh weight of field sample (x.x lb)**	**% N from lab (x.x%)**	**% dry matter from lab (xx.x%)**	**fresh weight (lbs/A)**	**Total dry weight (lb/A)**	**Total N (lb/A)**	**PAN (lb/A)**
4	**COVER CROPS**									
5	Common vetch	16	0.000367	8.0	3.5	22.0	21780	4792	168	79
6	Rye vetch	16	0.000367	8.0	2.5	22.0	21780	4792	120	38
7	Common vetch (seed only)	16	0.000367	8.0	3.5	22.0	21780	4792	168	79
8	**Comments to:** nick.andrews@oregonstate.edu									

Fertilizer Analysis | **Cover Crop Analysis** | Your Costs | Cost Comparisons | Nutrients Provided

Cover Crop PAN: UH Calculator

CRATE

College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

Cover Crop Calculator for Plant Available N

Follow instruction in Sheet #1 to fill in cells in **Step 2**. Best time to terminate an annual cover crop in Hawaii is about 2-3 months after planting.

Date: 3/13/2017

1. Use row with your location and soil order

2. Enter your information in white cells

3. Results are in the orange cells

Location and soil			Your sample info.				Dry wt. & total N			28 Day PAN		70 Day PAN	
Island	Location	Soil Order	Area sampled (ft^2)	Fresh wt of field sample (x.xlbs)	Total % N from lab (x.x%)	% dry matter from lab (xx.x%)	Fraction of acre sampled	Dry Weight (lb/Acre)	Total N (lb/A)	PAN (%)	Actual PAN (lb/A)	PAN (%)2	Actual PAN (lb/A)
Oahu	Poamoho	Oxisols					0.00000	0	0	0.0	0	0.0	0
Oahu	Waimanalo	Mollisols					0.00000	0	0	0.0	0	0.0	0
Oahu	Kunia	Oxisols					0.00000	0	0	0.0	0	0.0	0
Hawaii	Waimea	Andisols	16	8.00	3.50	17.00	0.00037	3703	130	52.2	68	61.3	79
Maui	Alae	Andisols					0.00000	0	0	0.0	0	0.0	0
Maui	Kula	Andisols					0.00000	0	0	0.0	0	0.0	0
Maui	Waiakoa	Mollisols					0.00000	0	0	0.0	0	0.0	0
Molokai	Hoolehua	Inceptisols					0.00000	0	0	0.0	0	0.0	0

Total N requirement for your crop (lb/acre):	150.0
Enter PAN available from your cover crop (column L or N):	79.0
Estimated N fertilizer for next crop (lb/acre):	71.0

This doesn't account for additional N from soil organic matter

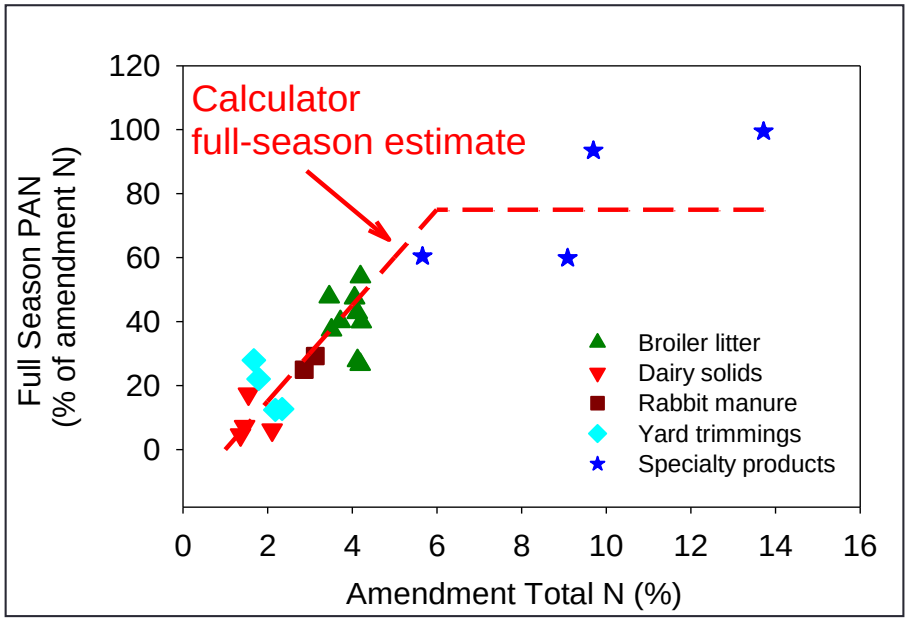
Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

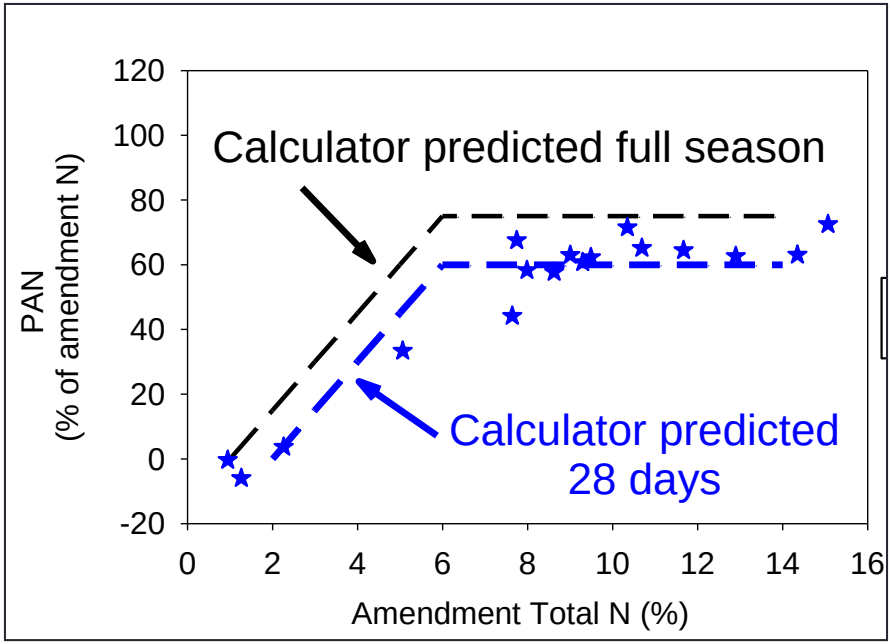
Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	200lbs PAN/ac
2	Additional soil organic matter contribution	Estimate from previous soil building practices	50lbs PAN/ac
3	Cover crop nitrogen contribution	OSU Organic Fertilizer & Cover Crop Calculator	80lbs PAN/ac
4	Site specific nitrogen recommendation	Line 1 – line 2 – line 3	200-50-80=70
5	Fertilizer PAN estimate & fertilizer application rate	OSU Organic Fertilizer & Cover Crop Calculator	
6	Adjust nitrogen rates based on monitoring		

Fertilizer N Mineralization



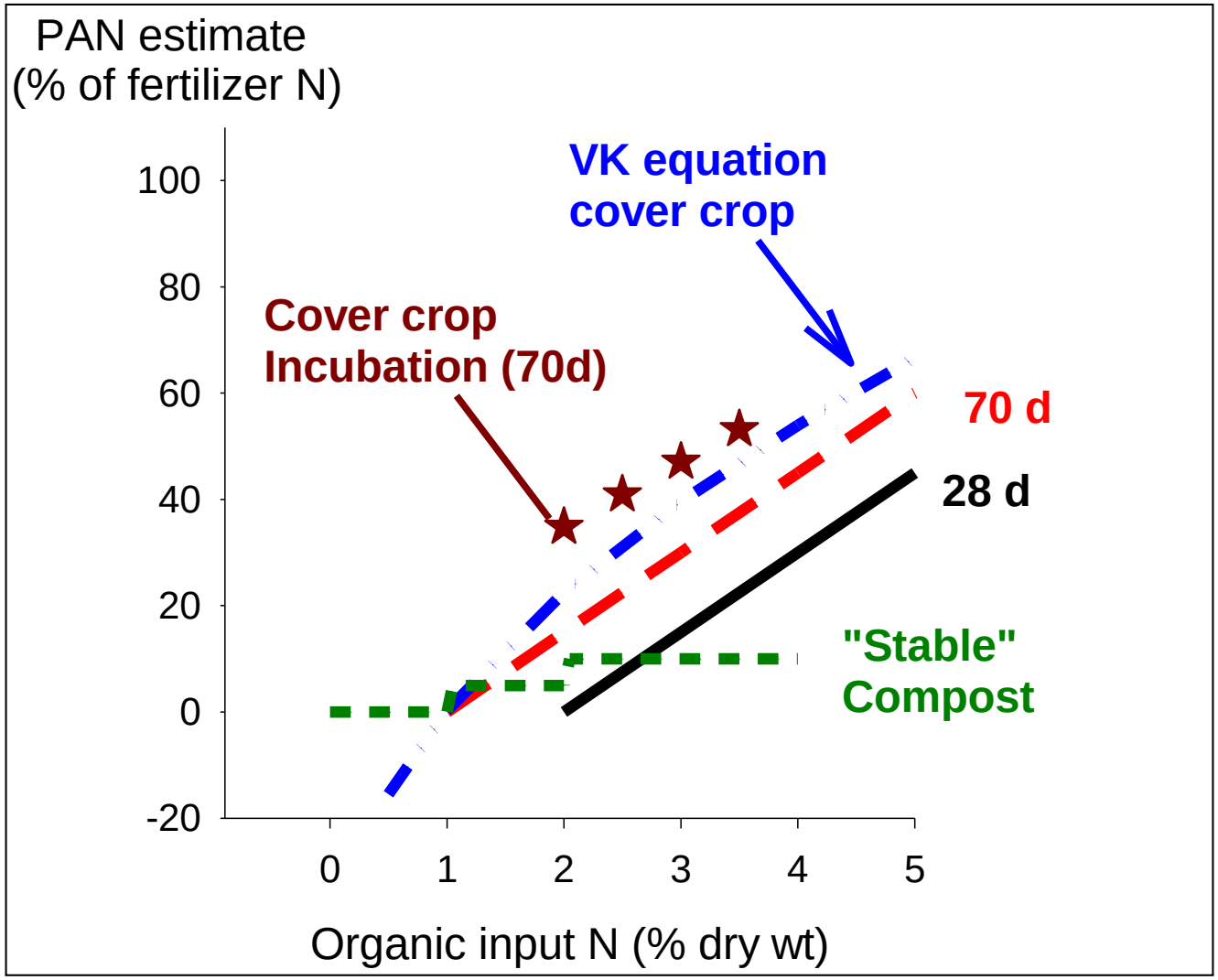


Gale et al. (2006). J Env Qual 35:2321-2332

Specialty products tested with incubation studies		
Fish meals	Alfalfa meal	Fish bone meal
Soybean meal	Blood meal	Meat & bone meal
Corn gluten meal	Kelp meal	Bone meal
Feather meal	Sol. Seaweed Extract	Seabird guano

OSU Calculator Equations

http://smallfarms.oregonstate.edu/calculator

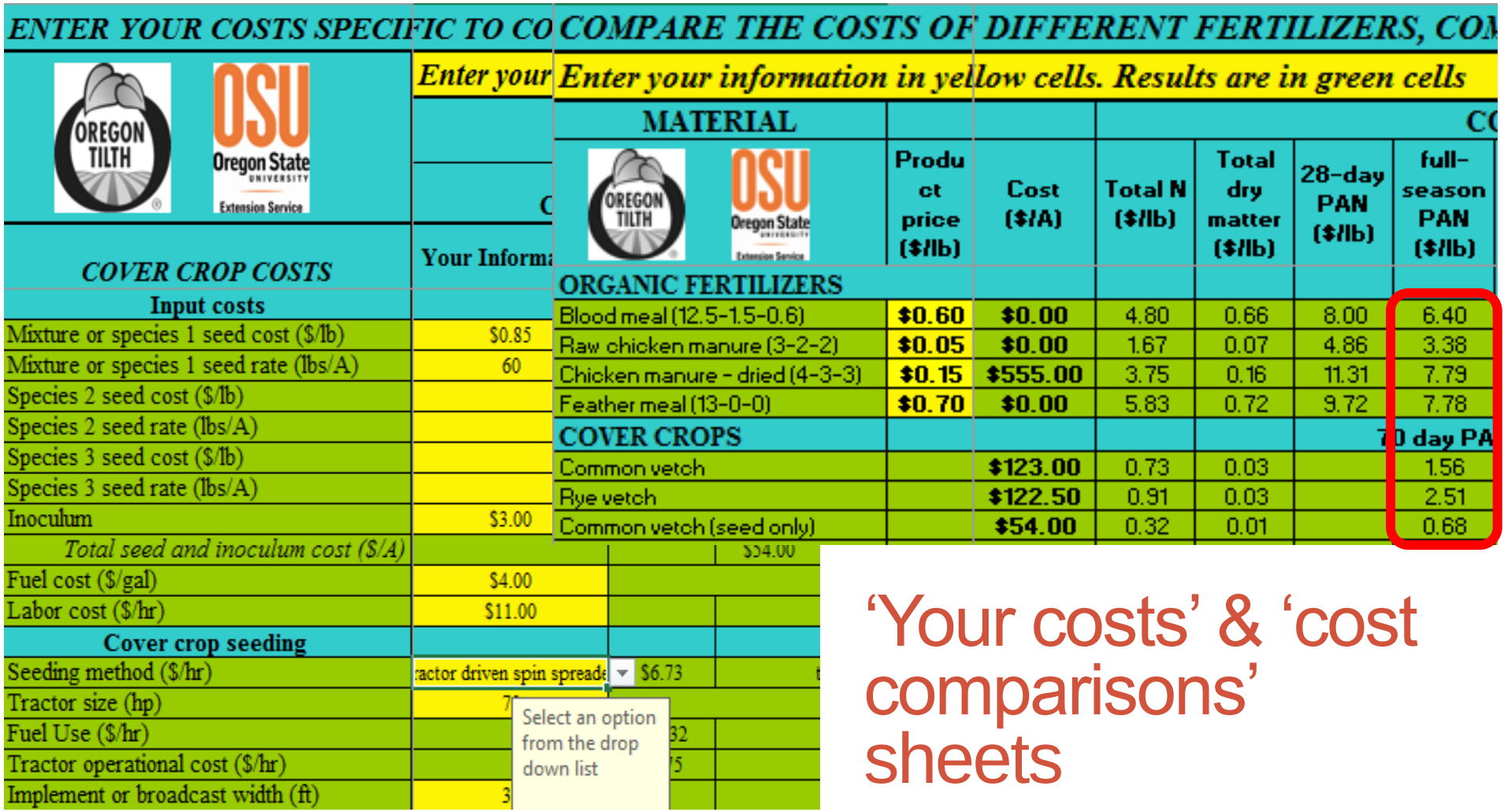


Cover Crop PAN = 79 lbs (OSU Calculator)

	A	B	C	D	E	F	G	H	I	J
1	***ENTER YOUR COVER CROP INFORMATION FROM THE FIELD AND THE LAB***									
2	***Enter your information in yellow cells. Results are in green cells.***									
3	OREGON TILTH / OSU Oregon State University Extension Service	**Area sampled (ft^2)**	**Fraction of acre sampled**	**Fresh weight of field sample (x.x lb)**	**% N from lab (x.x%)**	**% dry matter from lab (xx.x%)**	**fresh weight (lbs/A)**	**Total dry weight (lb/A)**	**Total N (lb/A)**	**PAN (lb/A)**
4	**COVER CROPS**									
5	Common vetch	16	0.000367	8.0	3.5	22.0	21780	4792	168	79
6	Rye vetch	16	0.000367	8.0	2.5	22.0	21780	4792	120	38
7	Common vetch (seed only)	16	0.000367	8.0	3.5	22.0	21780	4792	168	79
8	**Comments to:**	nick.andrews@oregonstate.edu								

Fertilizer Analysis | **Cover Crop Analysis** | Your Costs | Cost Comparisons | Nutrients Provided

Accounting for cover crops



ENTER YOUR COSTS SPECIFIC TO CO

Enter your

COVER CROP COSTS	Your Informa
Input costs	
Mixture or species 1 seed cost ($/lb)	$0.85
Mixture or species 1 seed rate (lbs/A)	60
Species 2 seed cost ($/lb)	
Species 2 seed rate (lbs/A)	
Species 3 seed cost ($/lb)	
Species 3 seed rate (lbs/A)	
Inoculum	$3.00
Total seed and inoculum cost ($/A)	$54.00
Fuel cost ($/gal)	$4.00
Labor cost ($/hr)	$11.00
Cover crop seeding	
Seeding method ($/hr)	ractor driven spread $6.73
Tractor size (hp)	7
Fuel Use ($/hr)	32
Tractor operational cost ($/hr)	75
Implement or broadcast width (ft)	3

Select an option from the drop down list

COMPARE THE COSTS OF DIFFERENT FERTILIZERS, CO

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

MATERIAL	Product price ($/lb)	Cost ($/A)	Total N ($/lb)	Total dry matter ($/lb)	28-day PAN ($/lb)	full-season PAN ($/lb)
ORGANIC FERTILIZERS						
Blood meal (12.5-1.5-0.6)	$0.60	$0.00	4.80	0.66	8.00	6.40
Raw chicken manure (3-2-2)	$0.05	$0.00	1.67	0.07	4.86	3.38
Chicken manure - dried (4-3-3)	$0.15	$555.00	3.75	0.16	11.31	7.79
Feather meal (13-0-0)	$0.70	$0.00	5.83	0.72	9.72	7.78
COVER CROPS						0 day PA
Common vetch		$123.00	0.73	0.03		1.56
Rye vetch		$122.50	0.91	0.03		2.51
Common vetch (seed only)		$54.00	0.32	0.01		0.68

'Your costs' & 'cost comparisons' sheets

70 lbs more PAN needed

‘Nutrients provided’ sheet: adjust fertilizer rates to get the right amount of N-P-K and other nutrients.

COMPARE THE NU

Enter your informatio

MATERIAL	App'n rate "as-is" basis (lb/ac)	Total N applied (lb/ac)	Total dry matter applied (lb/ac)	Estimated PAN after 28 days (lb/ac)	Estimated PAN after full season (lb/ac)	P_2O_5 (lb/ac)	K_2O (lb/ac)
Raw chicken manure (3-2-2)		0	0	0	0	0	0
Chicken manure - dried (4-3-3)	1700	68	1615	23	33	51	51
Feather meal (13-0-0)	450	54	437	32	41	0	0
Raw chicken manure (3-2-2)		0	0	0	0	0	0
COVER CROP FIELD							
Common vetch	21780	168	4792		79		
Total applied		290	6843	55	152	51	51
Fertilizer recommendation					150	50	50
Balance		290	6843	55	2	1	1

Cost comparisons

MATERIAL	Product price ($/lb)	Cost ($/A)				($/lb)		
ORGANIC FERTILIZERS								
HI: fish tankage (10-2.5-1)	$0.21	$0.00	2.10	0.23	3.50	2.80	8.40	21.00
OR: Raw chicken manure (3-2-2)	$0.05	$125.00	1.67	0.07	4.86	3.38	2.50	2.50
OR: Dry chicken manure (4-3-3)	$0.15	$0.00	3.75	0.16	11.31	7.79	5.00	5.00
Feather meal (13-0-0)	$0.70	$245.00	5.38	0.72	8.97	7.18	0.00	0.00
Fertilizer application cost		$5.34						
Total cost of fertilizer and application		$375.34						
COVER CROPS						70 day PAN		
Common vetch		$123.00	0					
Rye vetch		$122.50	0					
Common vetch (seed only)		$54.00	0.32	0.01		0.68		

$375 + $123 = $498

Program	Fertilizer rate	Nutrients app'd (lbs/ac)	Est. Cost ($/ac)
OR Raw chicken manure	5 Tons	148-200-200	$500
HI tankage + sulfate of potash	1 Ton + 70lbs	150-50-50	$457
Raw chicken + feather meal	1.25 T + 1200lbs	154-50-50	$970
Vetch cover + chicken + feather	1.25T + 350lbs	150-50-50	$498
Rye-vetch + HI tankage + bone + sulfate of potash	1400+100+70lbs	150-50-50	$508

Cost of organic fertilizer N

Source	Analysis	Price ($/ton)	Cost ($/lb PAN)
Urea (not organic)	46-0-0	$400	$0.43
Chicken litter	Variable (~3-4-3)	$75	~$1.65
Processed chicken manure	4-3-2	$250	$6.49
ProNatural (feather + blood)	13-0-0	$1300	$7.22
Phyta-grow	7-1-2	$800	$7.62
Veggie mix	8-4-4	$730	$6.08
Phytamin (liquid fish)	3-2-0		$26.80
Organic fertilizer range			**$2-27+**

Cost estimates: OSU Organic Fertilizer & Cover Crop Calculator

http://smallfarms.oregonstate.edu/calculator

Cost of Organic PAN (2017 est.)

Source	Range (price or biomass.)	Dry wt. (T/ac)	PAN (lb/ac)	PAN Cost ($/lb PAN)
Urea	$400/ton			$0.43
	$800/ton			$0.87
Chicken litter	$50/ton			$1.11
	$100/ton			$2.22
Processed chicken manure	$250/ton			$6.49
	$300/ton			$7.79
Feather meal	$1200/ton			$6.67
	$1400/ton			$7.78
Common vetch: total cost	High	3	100	$1.23
	Low	0.8	26	$4.70
Common vetch: seed only	High	3	100	$0.54
	Low	0.8	26	$2.06
Rye/vetch: total cost	High	3.4	70	$1.75
	Low	0.8	16	$7.61

Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	200lbs PAN/ac
2	Additional soil organic matter contribution	Estimate from previous soil building practices	50lbs PAN/ac
3	Cover crop nitrogen contribution	OSU Organic Fertilizer & Cover Crop Calculator	80lbs PAN/ac
4	Site specific nitrogen recommendation	Line 1 – line 2 – line 3	200-50-80=70
5	Fertilizer PAN estimate & fertilizer application rate	OSU Organic Fertilizer & Cover Crop Calculator	4000lbs ch manure or 800lbs feath meal
6	Adjust nitrogen rates based on monitoring		

Raw chicken litter

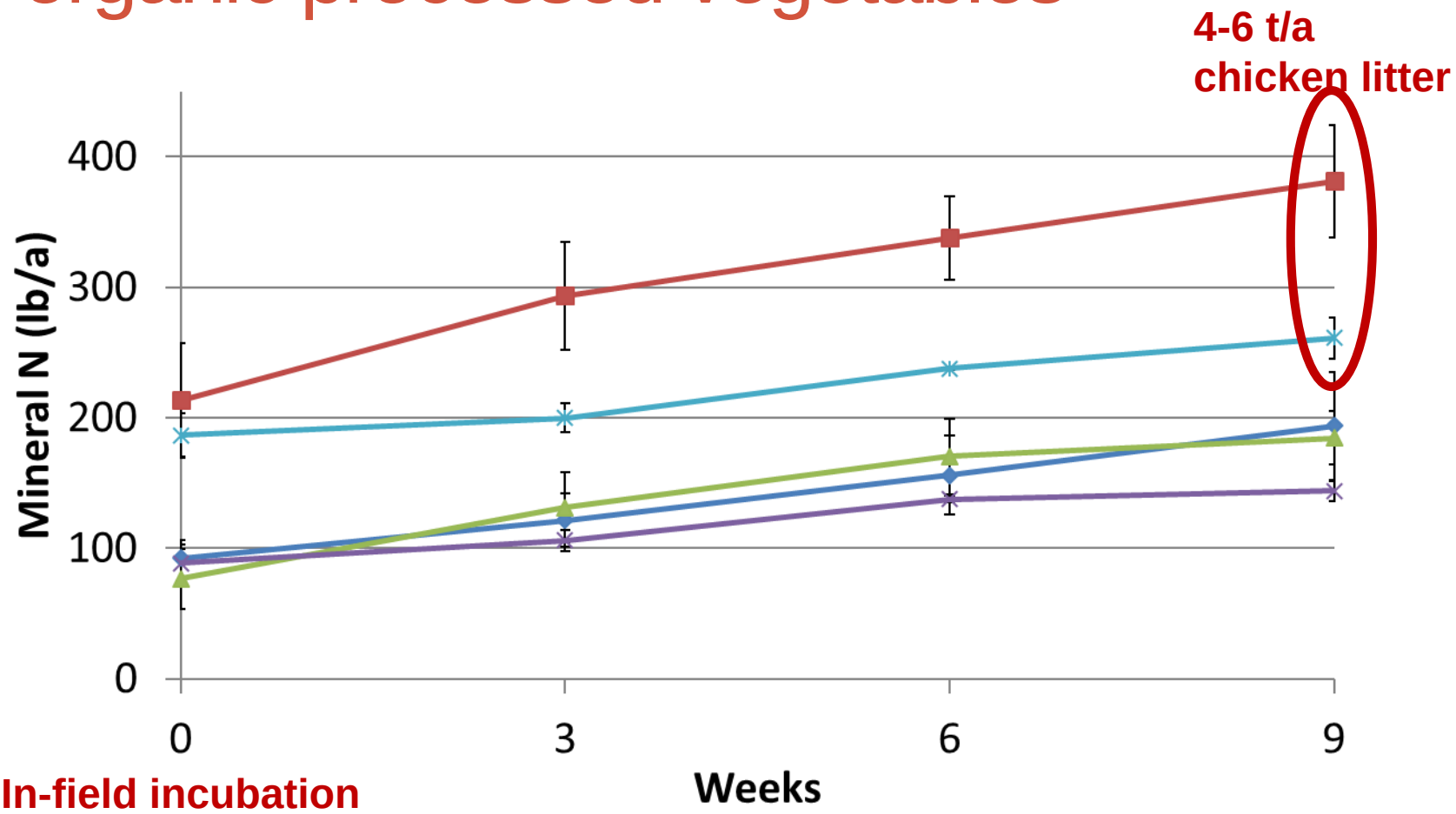
Pros

- Low cost
- Utilizing local resources

Cons

- Limited supply
- Harder to apply accurately
- Potential FSMA concerns
- High P and K relative to N
- A 5 t/a application of 3-4-3 would supply:
  - **100 lb PAN/acre**
  - **400 lb P_2O_5/acre**
  - **300 lb K_2O/acre**

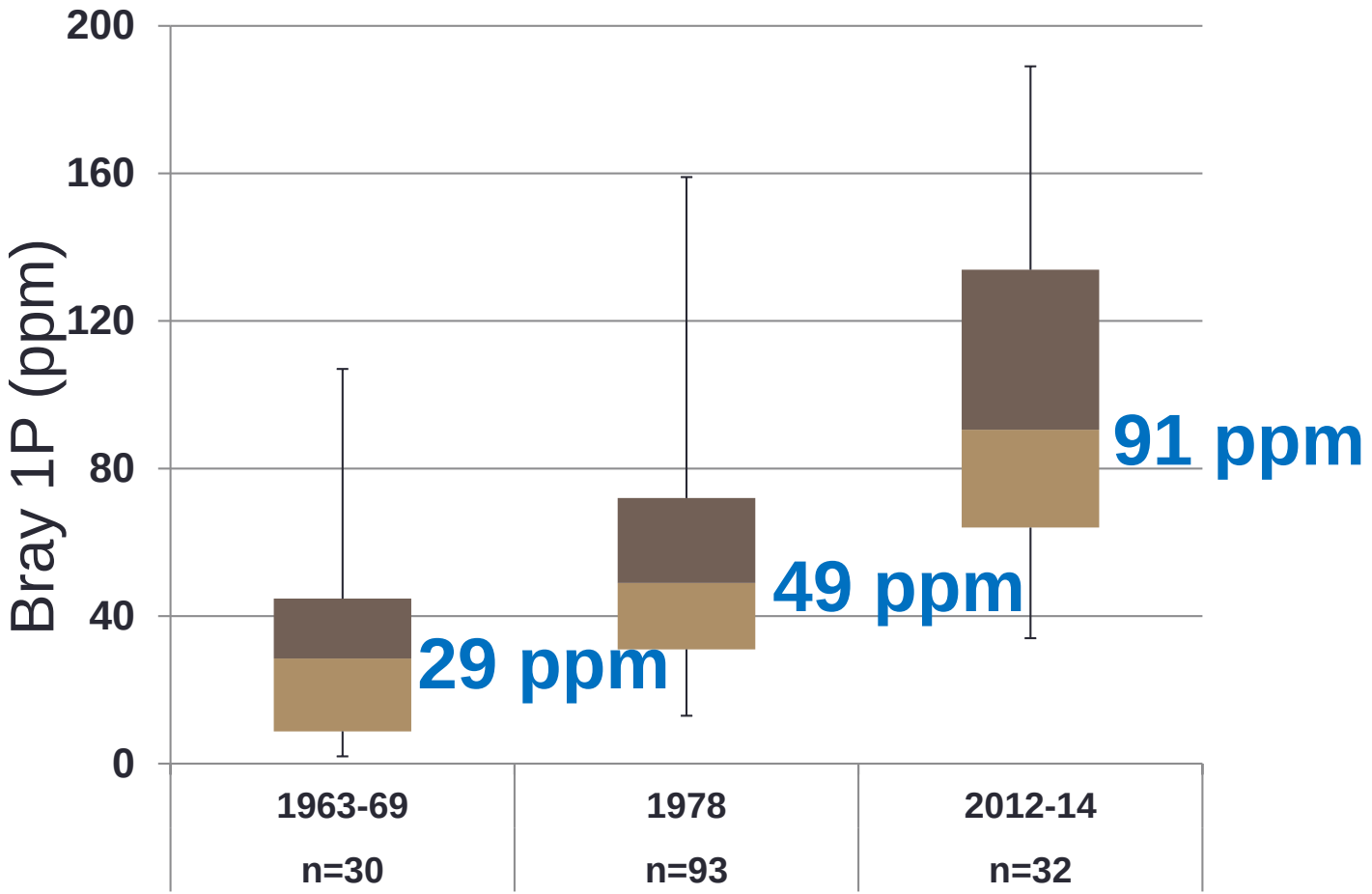
2016 Nmin data for fields growing organic processed vegetables



- **In-field incubation**
- **Nmin from SOM + winter cover crops + applied fertilizer**

Courtesy Sullivan & Heinrich

Increasing P levels on Willamette Valley processed vegetable farms



Courtesy Sullivan & Heinrich

Nitrogen & phosphorus

	CROP UPTAKE (lbs/ac)		
	N	P_2O_5	K_2O
beans	100	40	150
cabbage	220	75	300
carrot	140	50	170
cauliflower	220	90	300
cucumber	110	45	110
onion	160	45	140
radish	100	50	100
tomato	160	60	170
peas	100	40	70
Mean	***146***	***55***	***168***
Mean nutrient ratio	***2.6***	***1.0***	***3.1***

	PAN	P_2O_5	K_2O
Vegetable crop	150	60	170
3.5 tons chicken manure	145	210	210

	ORGANIC AMENDMENTS (%)		
	Total N	P_2O_5	K_2O
Dairy manure & bedding	0.5	0.2	0.5
Poultry manure & litter	2.8	2.3	1.7
Pelleted chicken manure	4.0	3.0	3.0
Composted poultry manure	0.9	2.0	1.2
Composted dairy manure	0.6	0.6	1.3
Mean	***1.7***	***1.6***	***1.5***
Mean nutrient ratio	***1.1***	***1.0***	***1.0***

Low P options

	Specialty Products		
	Total N	P_2O_5	K_2O
Feather meal	12.0	0.0	0.0
Blood meal	12.0	0.0	0.0
Fish meal	10.0	6.0	2.0
Soybean meal	7.0	2.0	1.0
Sulfate of potash	0.0	0.0	22.0
Muriate of potash	0.0	0.0	60.0
Bone meal	2.0	15.0	0.0
Rock phosphate	0.0	2.0	0.0
Legume cover crop	3.0	-	-

Cover crops

Pros

- Low cost source of nitrogen and OM
- Doesn’t increase P and K
- Soil protection, water holding capacity, infiltration, etc.

Cons

- Time sensitive field operations
  - If late, too much biomass or reduced N min
- May not be compatible with early planting dates
  - Delayed entry to fields
  - 3 wk interval between incorporation and planting

Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers

Collins, WSU

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW646

	Steps	Information source	Broccoli
1	General crop nitrogen recommendation	University nutrient management guides	200lbs PAN/ac
2	Additional soil organic matter contribution	Estimate from previous soil building practices	50lbs PAN/ac
3	Cover crop nitrogen contribution	OSU Organic Fertilizer & Cover Crop Calculator	80lbs PAN/ac
4	Site specific nitrogen recommendation	Line 1 – line 2 – line 3	200-50-80=70
5	Fertilizer PAN estimate & fertilizer application rate	OSU Organic Fertilizer & Cover Crop Calculator	2000lbs ch manure or 800lbs feath meal
6	Adjust nitrogen rates based on monitoring	Soil tests and observe crop performance	Monitor soil Nitrate-N

PNW early soil nitrate-N (12” depth): is there enough N?

- Early season plantings (May – June):
  - “Pre side-dress nitrate test” for spring and early summer planted crops
  - Just before period of rapid N-uptake
- Mid to late season plantings (July – Sept):
  - Pre plant nitrate test
- 25-30ppm NO_3-N is sufficient during early crop growth – side-dress or top dress if needed

PNW late soil nitrate-N (12” depth): was there enough N?

Around time of harvest, before winter rain

	NO_3-N (ppm)
Low	<10
Medium	10-20
High	20-30
Excessive	>30

N MANAGEMENT IN ORGANIC VEGETABLES

Nick Andrews
Organic Extension Program
OSU Center for Small Farms
Nick.andrews@oregonstate.edu
http://smallfarms.oregonstate.edu/calculator
503-913-9410