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Soil Management in Organic Orchards

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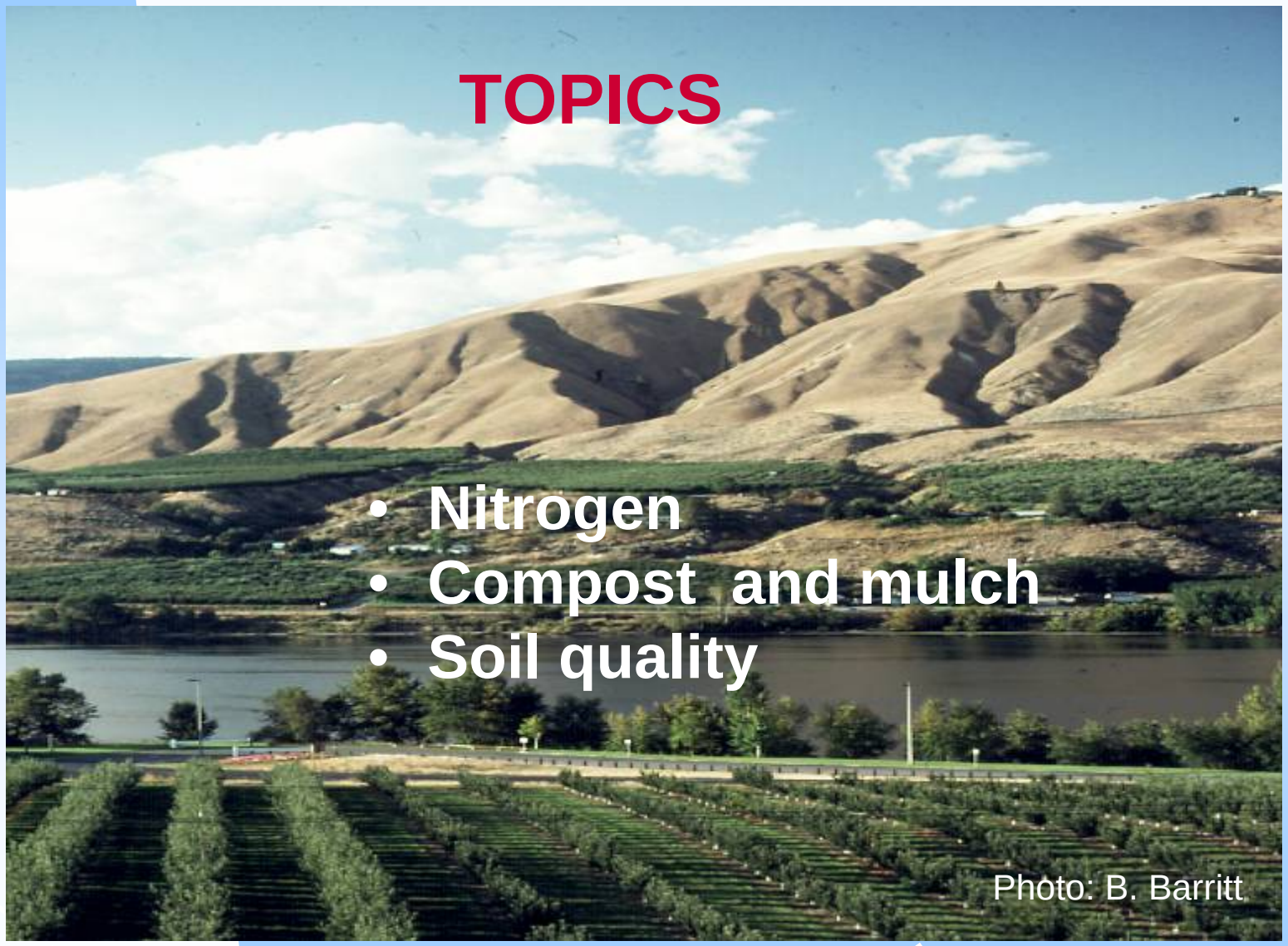
TOPICS



- Nitrogen
- Compost and mulch
- Soil quality

Photo: B. Barritt

Soil Organic Matter

6” soil = 2 million lb/acre

1% organic matter = 20,000 lb

SOM 2-5% N = ~1,000 lb

Annual N turnover 2-4% = 20-40 lb

Amendments, crop residues may tie up N if C:N>20

Influences on SOM

Climate – temperature, moisture
Soil texture – sand < --- > clay
Vegetation – perennial vs. annual; grass
Management – tillage, fertilization, crop removal, amendments

Soil Organic Matter

Pool	Size / Age (yr)	Functions
Biologically active	**Small / 1-5**	***The Meat:*** **nutrient mineralization, macro aggregation, disease suppression**
Protected	**Medium / 5-30**	***The Bones:*** **soil structure, porosity, water relations**
Stable	**Large / 50-10,000**	**Micro aggregation, CEC, AEC, color**

(A. Stone)

Organic matter is not uniform !

Organic Nutrient Management

Soil biota (microbes, collembola, worms, etc.) are the 'engine'

Satisfy microbial needs to provide nutrients to plants

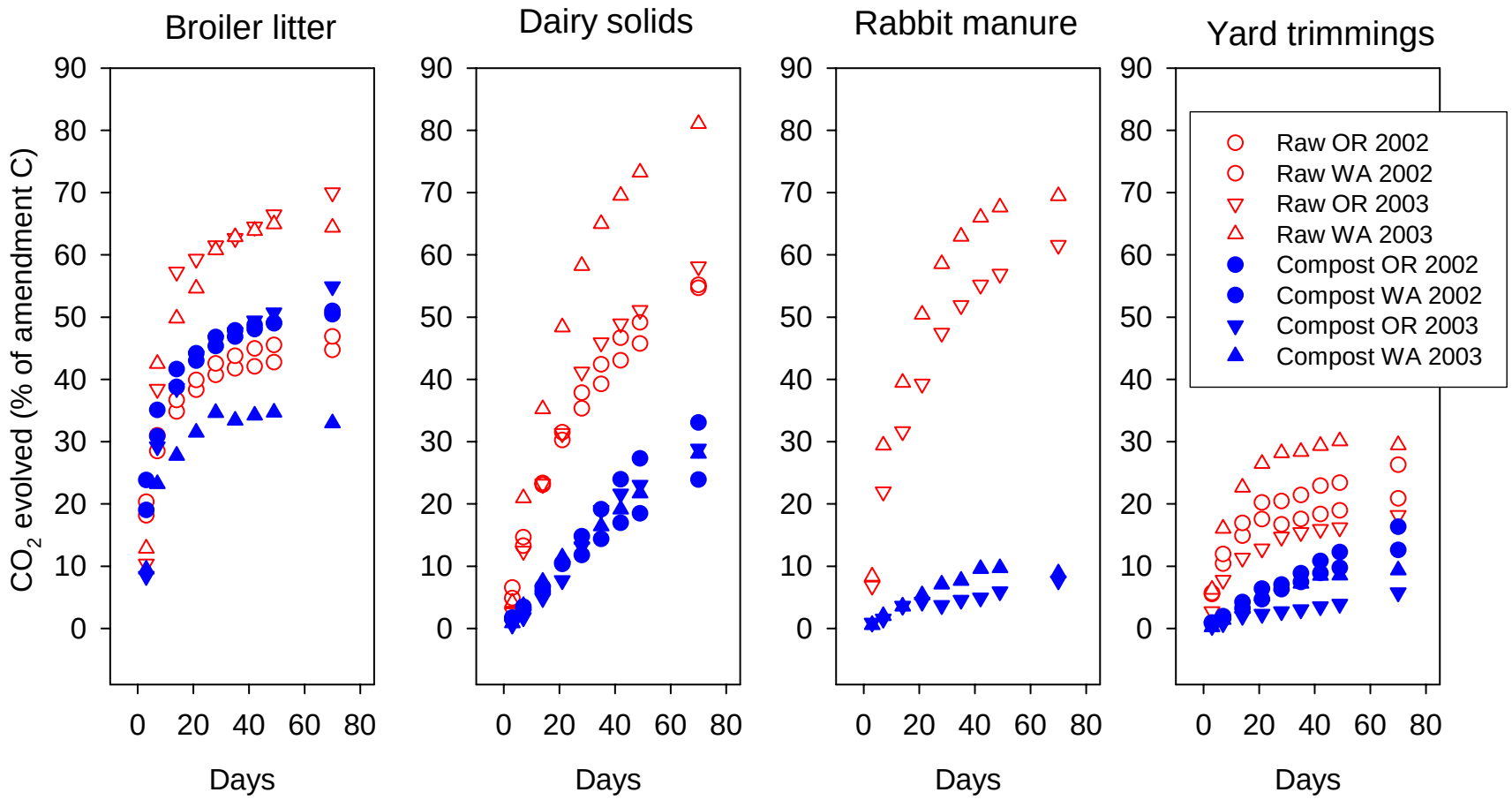
'Feed the soil'

Balance short and long term soil needs – e.g. tillage

Soil C:N is stable, 10-12:1 – lose C, lose N

Nutrients in organic compounds generally not available for plants – microbes convert or 'mineralize' them

Amendment Decomposition



(Gale, Sullivan, & Cogger)

Plant Available Nitrogen (PAN) from Amendments

Amendment	C:N	NH4-N	PAN (%) Field	PAN (%) Lab
Dry broiler litter	9	6.3	41	45
Composted	9	7.3	38	45
Dairy solids	27	1.5	9	1
Composted	20	0.6	5	8
Yard trimmings	13	3.0	19	25
Composted	17	0.7	5	5
BioGro	5	1.1	77	57
Canola meal	8	0.1	60	41
Feather meal	4	2.0	99?	74
Mint slugs	10	0.4	7	3

(Cogger et al.)

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Recommended (tentative) application rates (in dry tons/acre) to release 50 lbs mineral N/acre in first year

	Poultry compost	Dairy compost	Ogogrow	Alfalfa hay	Fishmeal fert.
% N (start)	**4.8**	**1.0**	**1.5**	**3.7**	**9.2**
% N released	**47**	**29**	**31**	**47**	**82**
Tons/acre to yield 50 lbs N/acre	**1.1**	**8.5**	**5.5**	**1.5**	**0.4**
lbs N/acre if add 25 t/acre	**1136**	**147**	**227**	**862**	**n.a.**

(T. Forge, PARC)

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Guidelines for PAN

Nitrogen %	C:N ratio	% N Available
Fresh Material		
1	35	0
2	18	15
3	12	30
4	9	45
5	7	60
6+	<6	75
Composts		(Cogger et al.)
1	25-35	5
2-3	10-15	10

Year 2 PAN – 5-10% of total initial N

Compost – 2%/yr N mineralization from Yr 4 on

Est. Cost of Organic Nitrogen

Product	Analysis	% H2O	lb N/ton as is	Cost $/lb N dry	% PAN	Price per ton	Cost for 50 lb PAN
Bloodmeal	12-0-0		240	5.62	90	1350	281
Feathermeal	13-0-0		260	3.13	70	815	157
Canola meal	6-1-1	10	108	5.55	50	600	278
Alfalfa meal	2.5-.2-2	10	45	4.44	45	200	222
Chicken compost	3.5-2-2	30	49	1.51	40	74	76
Nature Intent	9-3-4		180	4.66	50	838	233
NutriRich	4-3-3	9	73	3.42	40	249	171
NutriRich	8-2-4		160	5.15	50	825	258

$$\text{Cost: \$/lb N dry} = \frac{\text{Price per ton as is}}{2000 \text{ lb} \times \text{dry matter} \times \% \text{ total N}}$$

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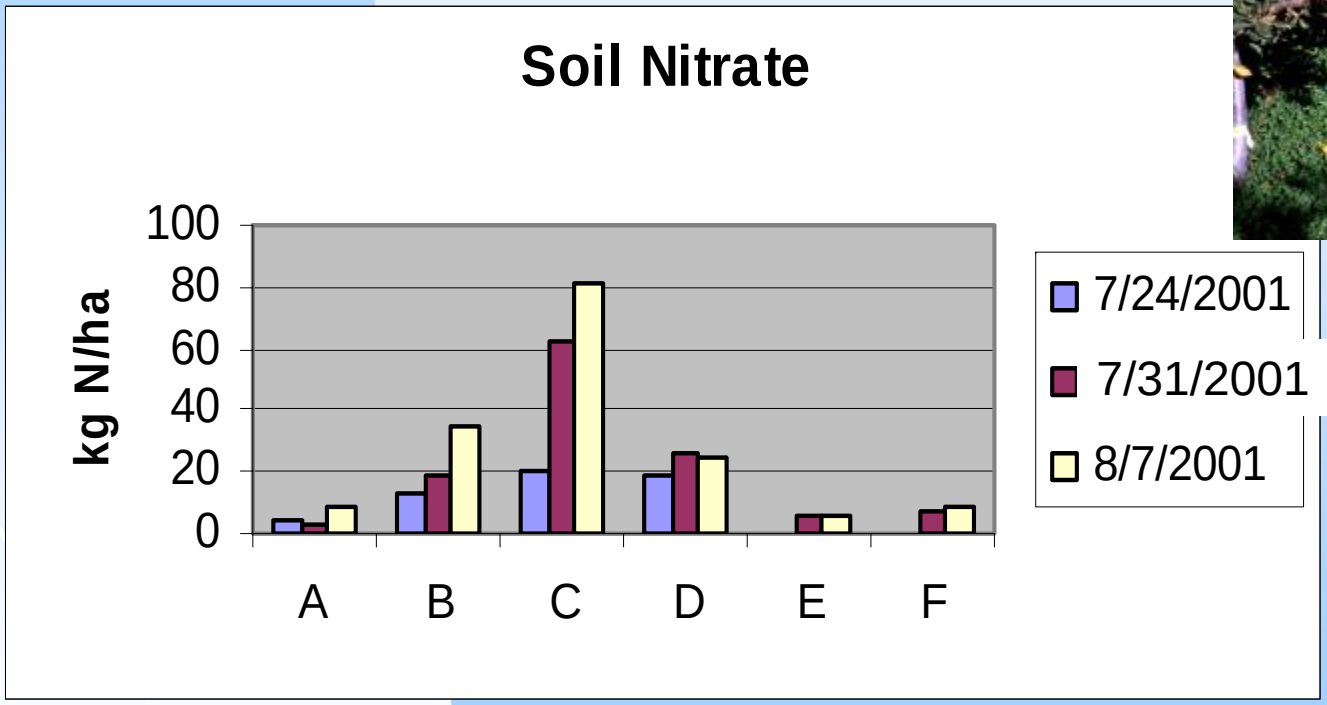
Grow Your Own N

Nitrogen release over 2 weeks from ambient soil with and without clover, root exclusion tubes, and tube covers.



46% of clover N mineralized

A – control plot; tube + cover; no clover

B – control plot; tube + cover; clover clippings added.

C – clover plot; tube + cover, clover clippings added

D – clover plot; tube – cover, clover clippings added

E – control plot; no tube

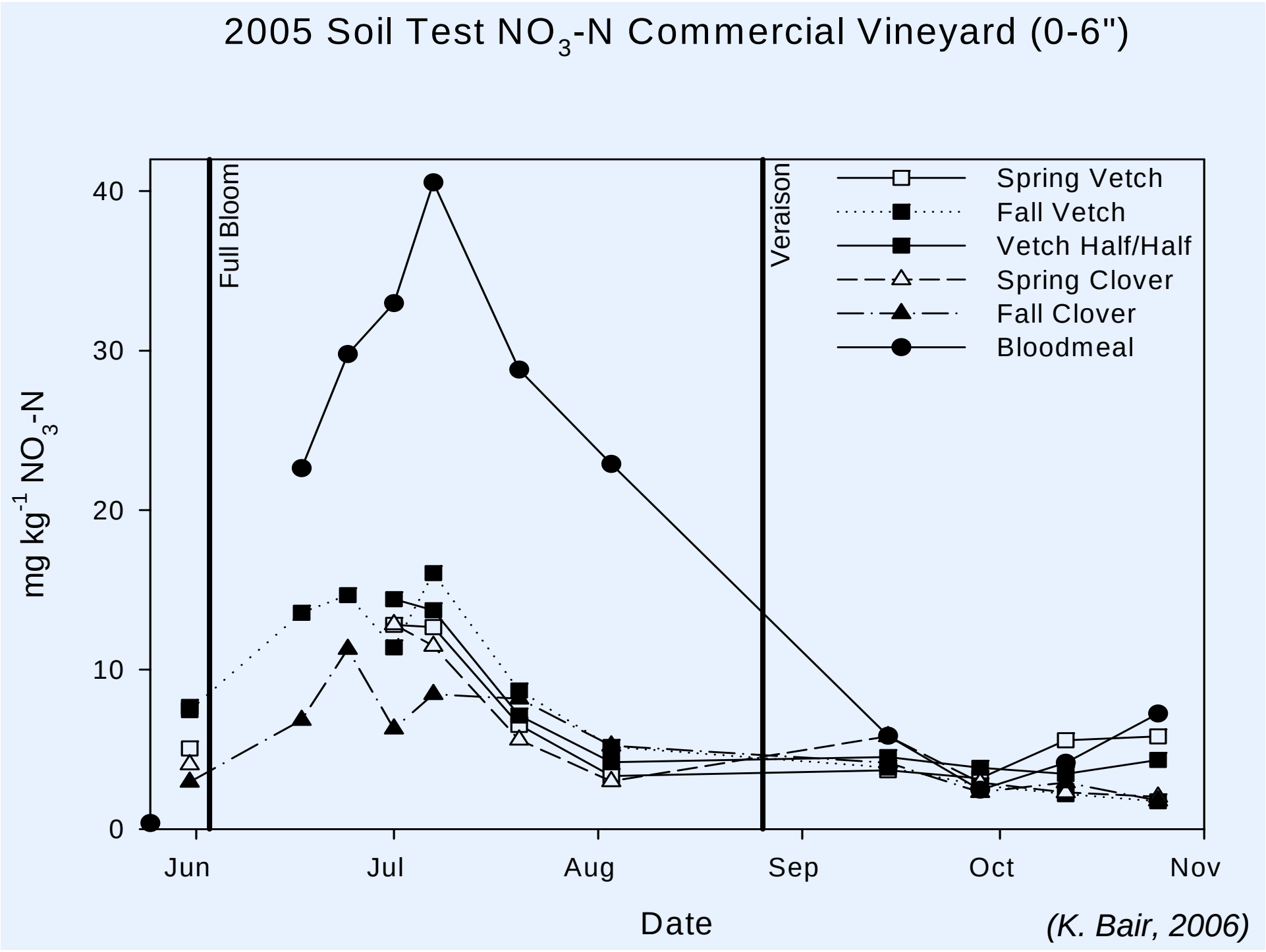
F – clover plot, no tube

Legume Cover Crops - Argentina

	Leaf N (%)	TCSA (cm^2)	Fruit Yield (tons/ha)
Strawberry Clover	1.98a	113a	54a
Alfalfa/fescue	1.85b	108a	58a
Vetch	2.00a	105a	57a
Control	1.86b	94b	45b

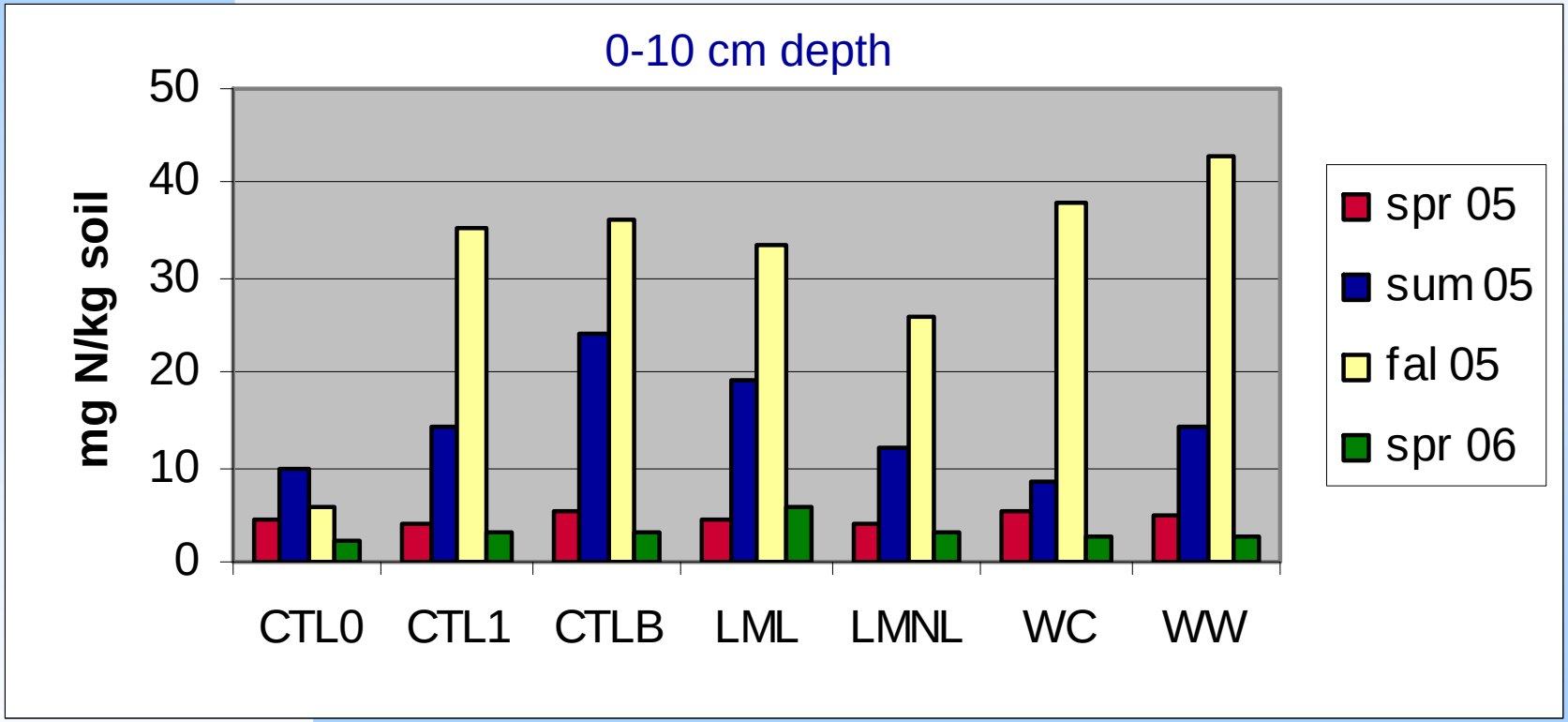
2 tons/ha 5-5-5 fertilizer

(Sanchez et al. 2007)


2005 Soil Test NO3-N Commercial Vineyard (0-6")
Full Bloom
Veraison
Spring Vetch
Fall Vetch
Vetch Half/Half
Spring Clover
Fall Clover
Bloodmeal
mg kg-1 NO3-N
0
10
20
30
40
Jun
Jul
Aug
Sep
Oct
Nov
Date
(K. Bair, 2006)

Soil Nitrate

IMM Trial, E. Wenatchee



(Courtesy L. Hoagland)

There's more than N…

To get 50 lb PAN:

Alfalfa – 2.5% N, 0.24% P, 1.97% K
- **At 50% PAN, need ~2 tons/acre dry**
- **Also get 10 lb P, 80 lb K**

Chicken compost – 3.0% N, 1.7% P, 2.5% K
- **At 40% PAN, need 2100 lb/acre wet**
- **Also get 26 lb P, 39 lb K**

Also get Ca, Mg, Na, Mn, B, Zn, Cu, Fe

Nutrient Content of WA Composts

Parameter	Chicken (3)	Cow (4)	Yard (3)
Org. Matter (%)	4-78	30-50	30-50
pH	6.3-8.3	6.1-8.9	6.3-7.6
E.C. (mmho/cm)	25-30	7-25	2-13
C:N	10-38	10-32	13-23
Total N (%)	1.1-4.2	0.9-1.9	0.8-2.0
NO_3-N (ppm)	162-2460	36-2081	8-1421
NH_4-N (ppm)	3600-9780	16-306	17-50
Total P (%)	0.9-1.8	0.2-0.8	0.2-0.3
Total K (%)	0.6-2.5	0.3-1.4	0.4-1.1

(Granatstein, 1996)

Compost Costs

	$/wet ton FOB	$/wet ton Freight	$/dry ton Delivered	$/lb N dry
Chicken manure compost	40	30	107	1.31
Dairy manure compost	24	17	80	1.74
Yard debris compost	14	26	70	2.69

Value $/wet ton

	Total Nutrient	Available Nutrient
Chicken compost (4% N)	$41-53	$13-14
Yard debris compost (2% N)	$20-23	$5

Includes N, P, K, Ca, S, Zn

(37¢lb N; 40-90¢/lb P; 21¢/lb K; 9¢/lb Ca; 11¢/lb S; $1.40/lb Zn)

Based on fertilizer prices of 2/98.

Estimating Change in EC

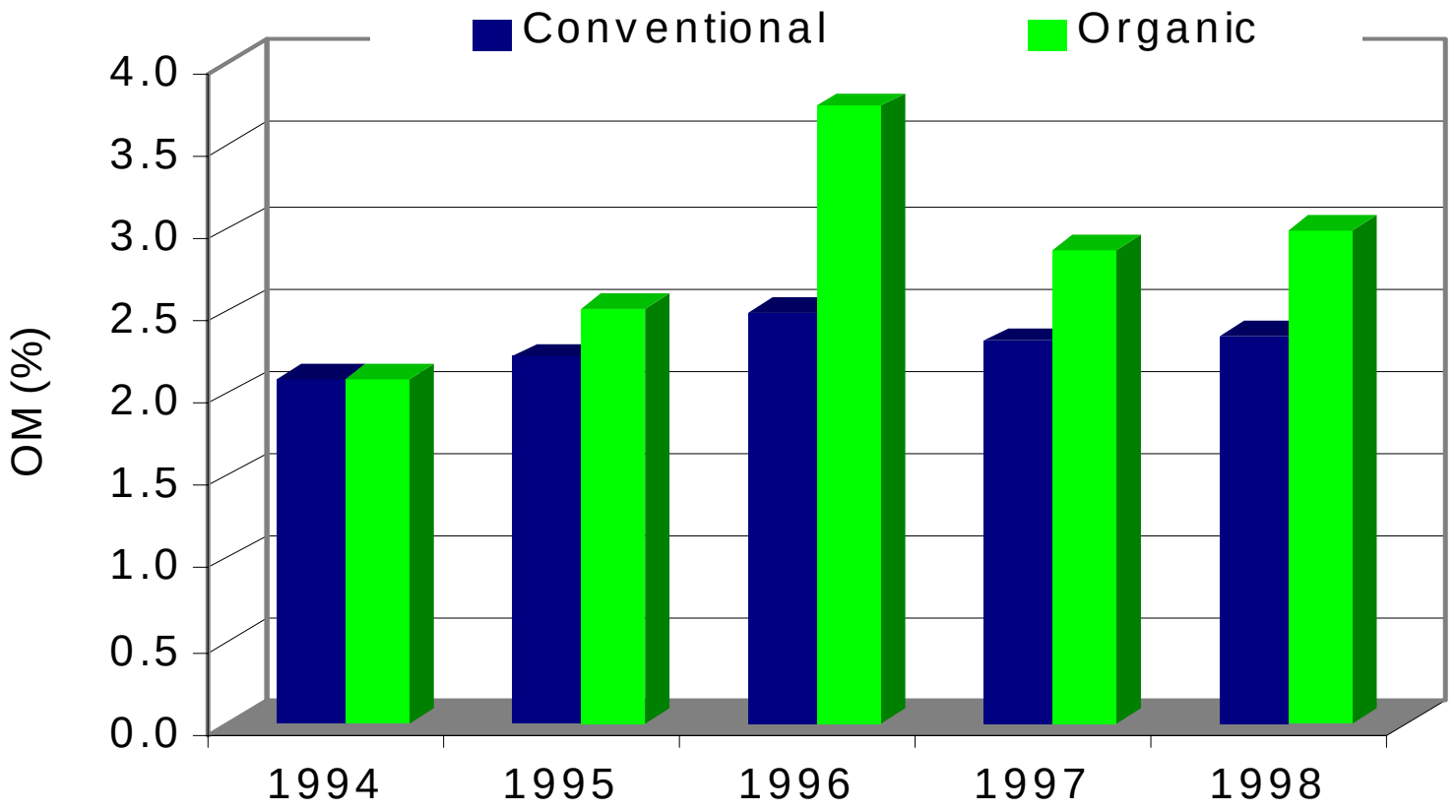
- **Depends on soil EC, amendment EC, amendment rate**
- **Short-term – potential damage to plants**
- **Long-term – depends on leaching, amendment composition**
- **Use weighted average to calculate dilution**
- **Apple, pear – root damage above EC 1.7**

Soil Quality Index for 1998
WSU Orchard Systems Trial – Zillah, WA

	Orchard System		
Function	**Conventional**	**Integrated**	**Organic**
Water entry	**0.09**	**0.14**	**0.17**
Water transfer	**0.17 b**	**0.19 a**	**0.17 b**
Resist degrad.	**0.14 b**	**0.20a**	**0.16 ab**
Sustain product.	**0.13 b**	**0.34 a**	**0.36 a**
Total	**0.71 b**	**0.87 a**	**0.86 a**

(Glover et al., 1998)

WSU Orchard Systems Trial - Zillah, WA
Soil Organic Matter Content (0-15 cm)



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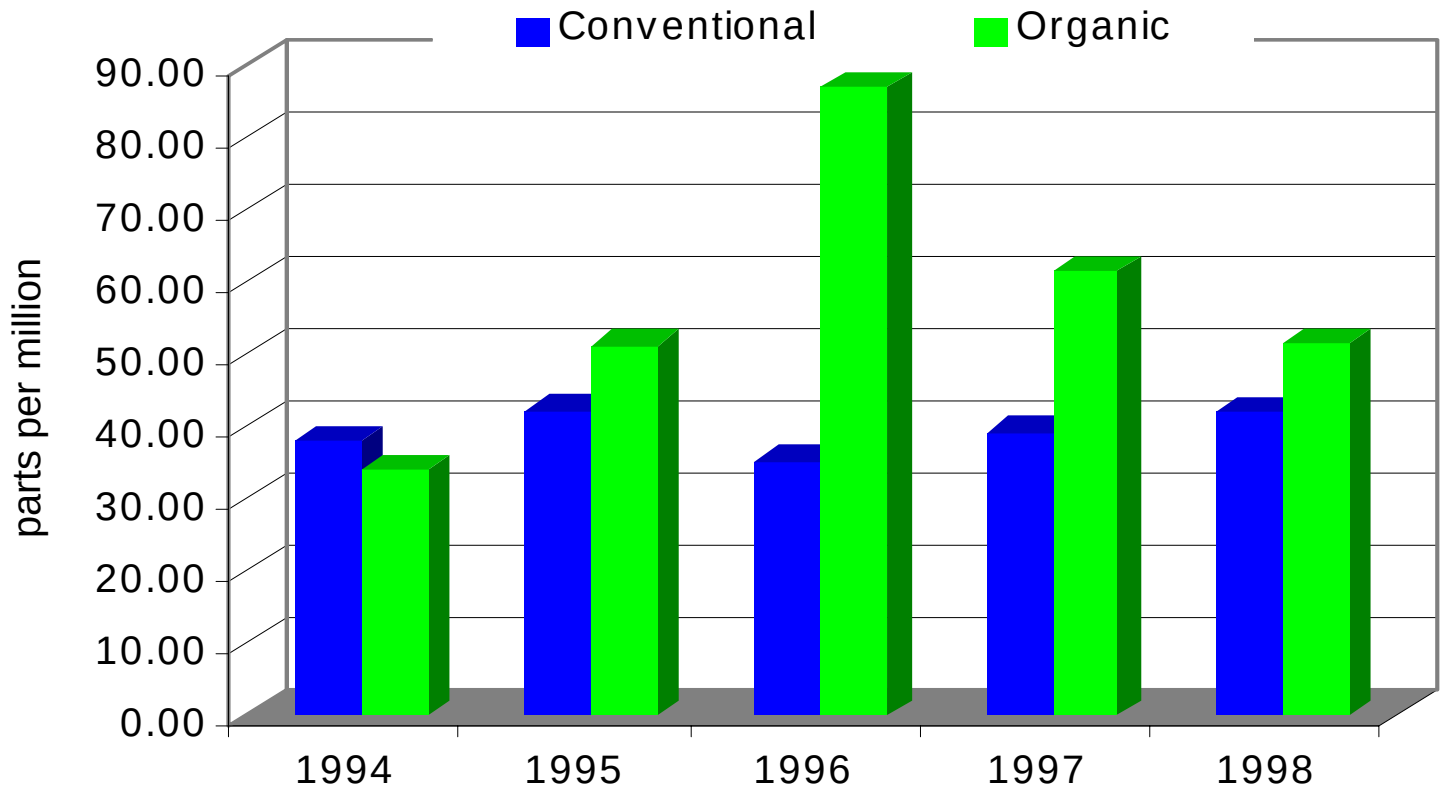
WSU Orchard Systems Trial - Zillah, WA
Soil Phosphorus Content (0-15cm)



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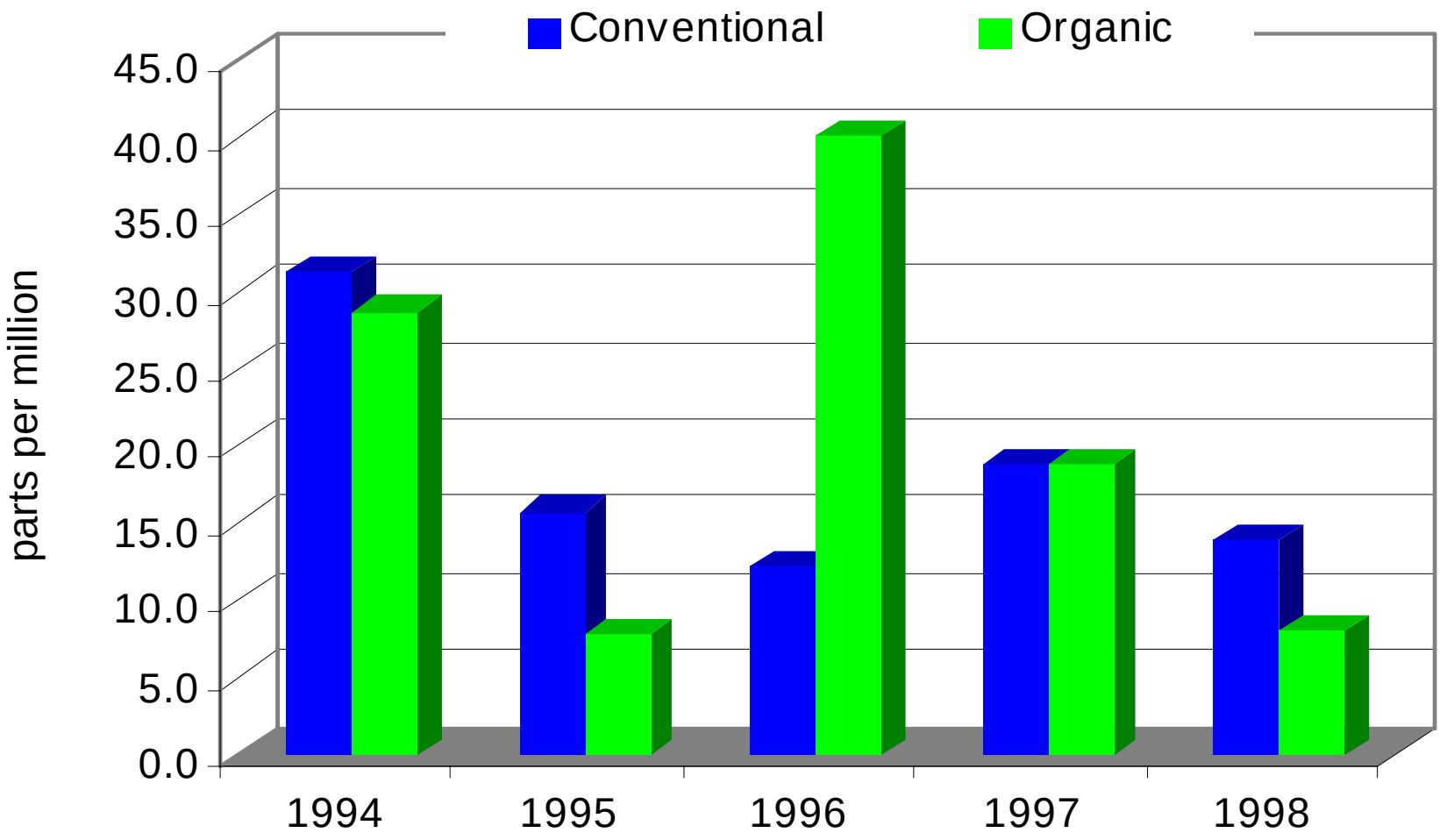
(Glover et al., 1998)

WSU Orchard Systems Trial - Zillah, WA
Soil Nitrate-N Content (0-15 cm)



(Glover et al., 1998)

Examples of SOM Levels in Organic Orchards

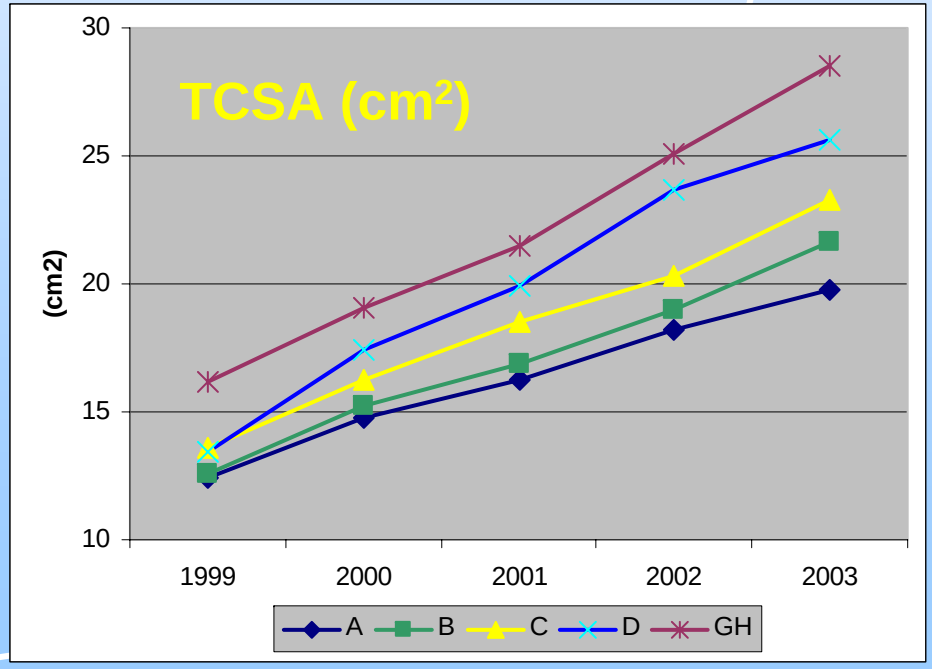
Okanogan	**4-5%**
Chelan	**1.5-4.0%**
Mattawa	**native 0.3%; orchard 1.1-1.6%**
Yakima	**from 0.8-1.5% to 2.3-3.6% over 15 yr** **from 2.1% to 3% over 5 yr**
Wenatchee	**from 1% to 3% over 15 yr**
Hood River	**nearly 50% decline in tree row over 10 yr**

	4-Yr % Increase TCSA	Cum. Yield 3-Yr (kg/tree)
Alfalfa (D)	90 a	66
Clover (GH)	75 b	61
Wood chip (B)	74 b	48
Paper (C)	72 b	52
Mustard	70 b	55
Rye	60 c	53
Control (A)	59 c	50

Tree Growth and Yield

Red Delicious/M26

Wenatchee, WA



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Orchard Mulching Trials – Summerland, BC


Spray-on paper mulch

6th Leaf Spartan / M.9

	TCSA (mm^2)	Roots ($g/0.018m^3$)	Yield (kg/tree)
1. Check (glyphosate)	1011 b	11.3 c	10.3 c
2. Biosolids (Vancouver)	1052 b	16.9 bc	11.2 bc
3. Paper mulch	1565 a	28.7 abc	13.0 ab
4. 2 + 3	1490 a	41.8 a	13.9 a
5. Composted biosolids + 3	1406 a	38.7 a	14.9 a
6. Alfalfa hay	1203 b	35.2 ab	14.0 a
7. Geotextile	1125 b	19.1 bc	12.7 abc

(Hogue et al., 2000)

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Orchard Floor Management – New York
Soil Changes Over 5 Years

Treatment	SOM (g/kg soil)	NO_3-N (kg/ha)	P (kg/ha)	K (kg/ha)
Mowed sod	5.6	6.3	5.7	209
Straw mulch	6.2	37.6	28.5	1230
Glyph. 5’ strip	4.9	8.3	6.4	201
Tilled	4.5	53.2	4.7	188
LSD(.05)	1.0	30.1	12.0	163

(Merwin & Stiles, 1994)

WW Trial results 2006

TRT	2005			2006				
	Fruit yield	Fruit Size 80-88	Gross Fruit Value*	Fruit Yield	Fruit Size 80-88	Gross Fruit Value*	TCSA increase	Canopy volume
	kg/tree	%	$/acre	kg/tree	%	$/acre	cm^2	cu. ft./5 trees
Wood chip	22.4	15.5 a	14,354	14.7	39.0	11,032	3.7 a	1531 a
Control mow	20.4	6.6 b	12,003	14.3	33.5	9,748	3.0 b	1286 ab
Cultivator Z 3x	17.6	7.0 b	9,556	13.3	22.0	10,162	2.3 c	1059 b
p=	0.150	0.014		0.805	0.076		0.001	0.008

Case Study:
Mint Compost for Mulch

Step 1. Volume of vine row layer.

13’ row spacing = 16 rows/acre 9’ x 208’ = 3328 lineal ft of row per acre

4’ weed strip x 3328’ x 0.083 (1” depth) = 40.9 cu. yd. per acre

Case Study:
Mint Compost for Mulch

Step 1. Volume of tree row layer.

13’ row spacing = 16 rows/acre 9’ x 208’ = 3328 lineal ft of row per acre

4’ weed strip x 3328’ x 0.083 (1” depth) = 40.9 cu. yd. per acre

Step 2. Tons of mulch per 1” layer.

Bulk density: Mint compost = 1200 lb/cu. yd. @ 45% moisture

41 cu. yd. x 1200 lb = 24.6 tons wet x 0.55 dry matter = 13.5 tons/acre dry

Case Study:
Mint Compost for Mulch

Step 3. Nutrient additions.

- Need analysis of product; wet or dry basis

Mint compost (dry basis) – 13.5 dry tons / acre 1” depth

2.76% N	745 lb	49 ppm Zn	1.3 lb
0.36% P	100 lb	215 ppm Mn	6.0 lb
2.30% K	620 lb	18 ppm Cu	0.5 lb
0.21% S	57 lb	35 ppm B	0.9 lb
1.73% Ca	470 lb		
0.93% Fe	250 lb		

Case Study:
Mint Compost for Mulch

Step 4. Nitrogen release.

- Need lab and/or field N mineralization estimate.

Mint compost:

7% (research trial)	745 lb x 0.07 = 52 lb
50% (vendor estimate)	745 lb x 0.50 = 370 lb
20% (researcher estimate)	745 lb x 0.20 = 150 lb

- N release can be season long.
- Will be N contribution in future years as well.

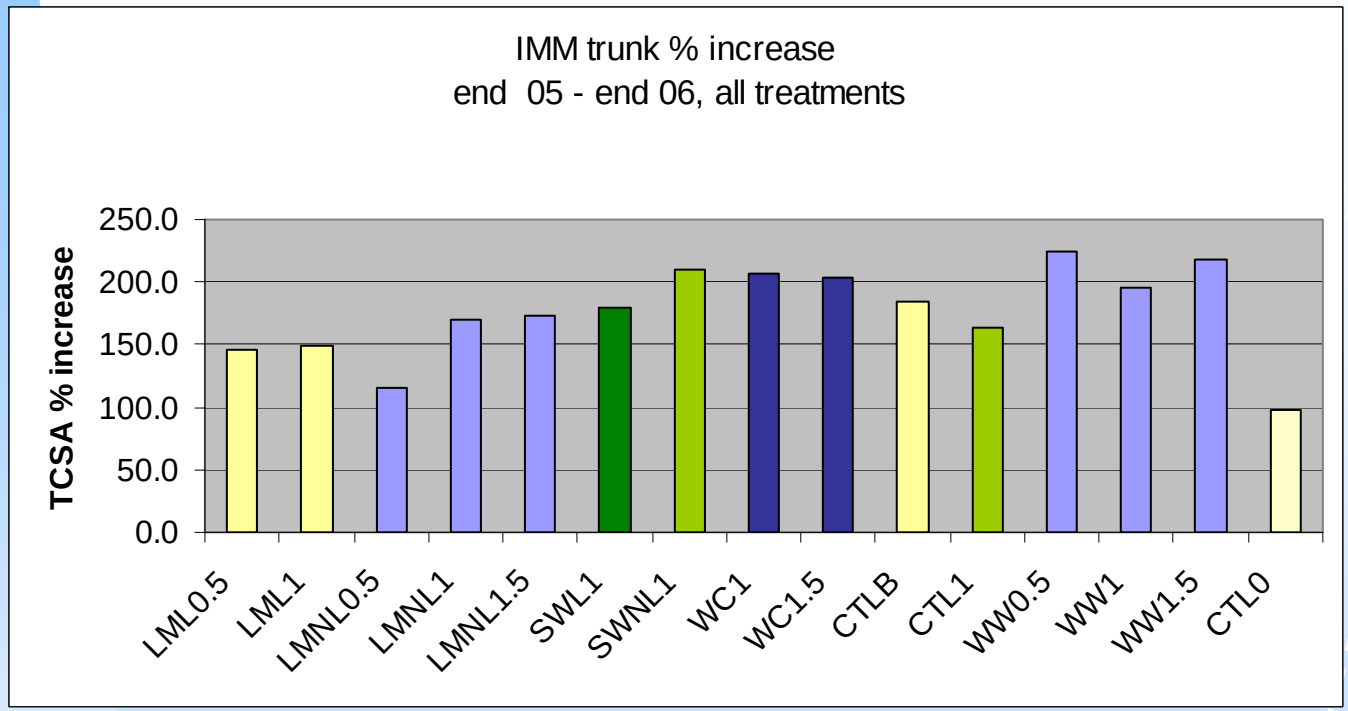
Case Study:
Mint Compost for Mulch

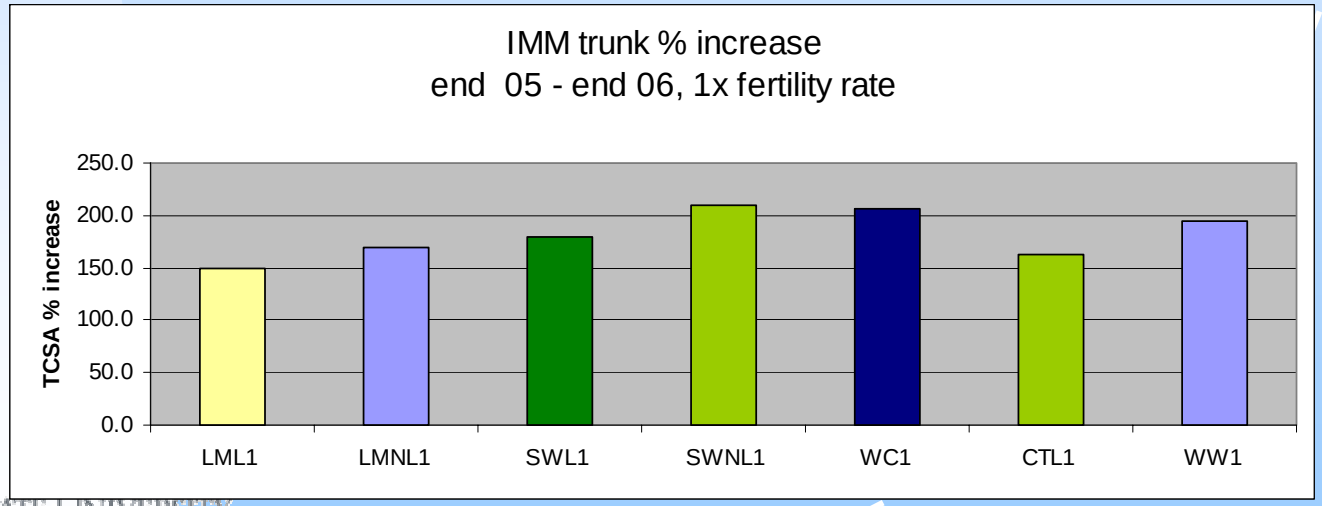
Step 5. Other considerations.

- Any contaminants ? (e.g. arsenic in chicken compost)
- Weed seeds, pathogens, odors, vector attraction
- Other soil factors – mint compost pH 8.7; EC 3.8
- Hauling costs, spreading costs

Availability of Mulch Materials for Orchards in Central WA - 2002

http://organic.tfrec.wsu.edu/OrganicIFP/OrchardFloorManagement/Index.html





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Sandwich system with *Galium odoratum*

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Legume Cover Crops - Wenatchee

	Leaf N (%)	TCSA (%increase)
Control 0	2.08de	97
Bare ground	2.35abc	163
Tilled	2.45ab	195
Wood chip mulch	2.05e	207
Brassica meal	2.25cde	185
Living mulch legume	2.55a	150
Living mulch non-legume	2.50ab	170
Sandwich legume	2.33abc	179
Sandwich non-legume	2.29bcd	210

Going Forward

Conserve N – irrigation mgt., cover crop

Shop around - % N, % moisture, trucking

Legumes have a role, still need work

www.tfrec.wsu.edu/OrganicIFP

www.soils1.org

organicfarming.wsu.edu

Naturalized trefoil

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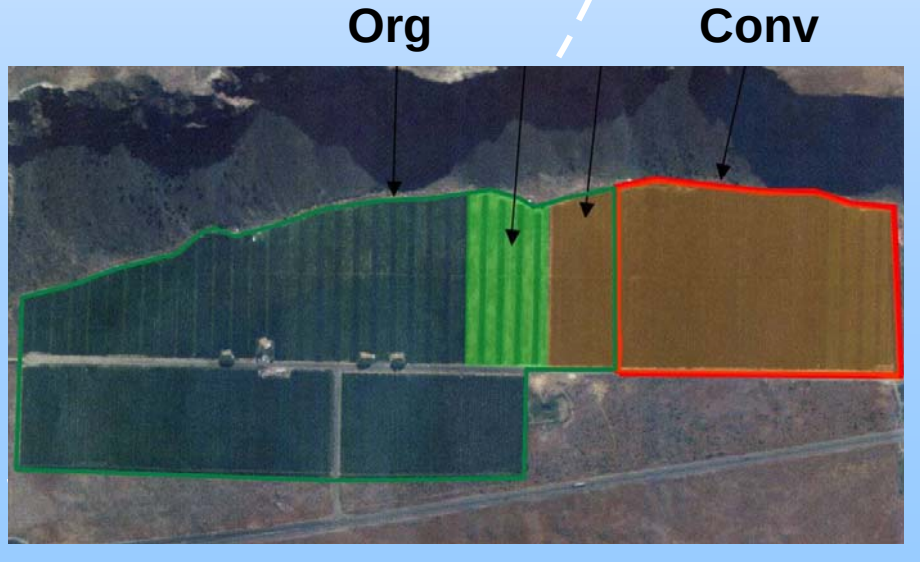
New WSU Research Orchard

- Near Rock Island dam
- 185 acres orchard, 100 certified organic (~10 yr)
- 80 acres of organic Red, Golden, Granny; free standing, semi-dwarf trees
- Planning new plantings, experiments
- TFRC encouraging a ‘systems project’
- Have organic research priorities list from 2002
- Input welcome !



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