

Cover Crops for Orchards

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Apple Root Density

Length of root per area of soil surface (cm cm^{-2})

10^4

10^3

10^2

10

1

herbaceous
Graminaceae

herbaceous
non-*Graminaceae*

woody plants

apple

Mini Tatura Trellis on M.9 Washington



Standard System

Herbicide strip, grass alley

Orchard Cover Crops

Cover crops affect:

- Weeds
- Soil and orchard temperature
- Soil moisture, physical properties
- Soil C, N, other nutrients (root exudates)
- Soil biology, food web
- Tree performance
- Pests (insect, disease, rodents)
- N fixation (legumes)



Cover Crop Choices

Age of orchard, rootstock

Fruit harvest date

Irrigation system, water

Alley, tree row, 'Sandwich'

Legume, grass, broadleaf

Species, cultivar

Annual or perennial

Nematode host?

Insect pest host?

Mulch?



Orchard Floor Management Review

Microclimate:

- soil temperature inverse to the amount of herbage or mulch
- plant mulch dampens extremes of daily soil temperature
- plant cover reduces minimum air temperature by 0.5-1.0°C
- bare, compacted wet soil raised minimum air temperature by as much as 2°C
- effects on humidity and disease? Russet?

(Skroch & Shribbs, 1986)

Orchard Floor Management Review

Soil quality:

- avoid cultivation
- favorable soil effects: legumes > grass > mulch > bare ground > cultivation

Water:

- soil moisture availability: mulch > bare soil > minimal cultivation > grass > legumes > continuous cultivation
- mowing decreases water use

(Skroch & Shribbs, 1986)

WA Peach

5 yr old trees

- Orchard grass – mowed late May
- Alfalfa – mowed late May, mid-summer
- Rye (winter cc) – disked late May, summer cult
- Vetch (winter cc) - disked late May, summer cult
- Mulch under tree
- Herbicide

- Alfalfa **delayed maturity**
- Highest yield with mulch
- N, water effects

(Proebsting, 1958)

MI Tart Cherry

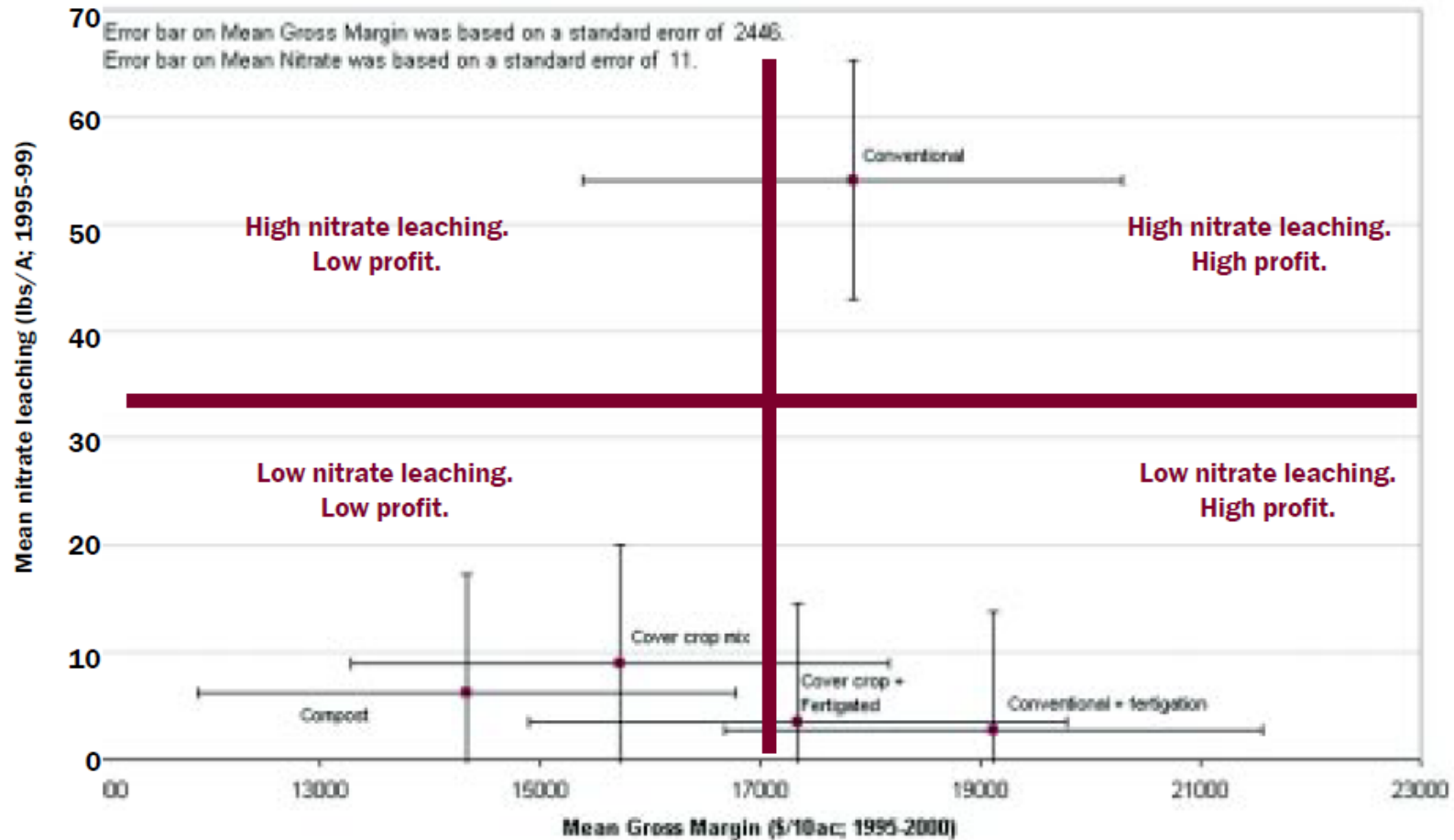
Cover crop mix – crimson cl, annual ryegrass/hard fescue, berseem clover; no herbicides, mowed, irrigated

- Highest yields – mulch
- Cover crops, compost **improved soil quality**
- **Fewest pest mites** in cover crop; beneficial mites all year in red clover
- Cover crop + fertigation was **among most profitable**
- Nitrate leaching – most in season-long herbicide

MI Tart Cherry

Figure 3. Nitrate leaching / profitability trade-off:

Although Conventional was as profitable as the other two top profit treatments, it caused far more nitrate leaching.



NZ Apple

- 8 yr old apple trees
- Several species mixes
- Fixed N can replace harvest and leaching removal (^{15}N method)

Annual N fixed by understory

	<u>kg N/ha</u>
Red clover	33-84
Herb ley	12-105

NZ Apple

- Legumes – increased fruit N, delayed maturity; lower Brix and firmness than grass
- Mow and blow provided large inputs of nutrients; increased tree growth and fruit yield; did not increase fruit disorders

	<u>Mow</u>	<u>Mow & blow</u>
pH	6.1	6.8
N (%)	0.24	0.33
P (ppm)	28	37
K (ppm)	6	30
Ca (ppm)	12	15
Mg (ppm)	18	35

Legume Cover Crops Rio Negro, Argentina

5 yr old apple; 3.2 m drive alleys, mowed twice a year

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

2 tons/ha 5-5-5 fertilizer

(Sanchez et al., 2007)

WA - White clover living mulch

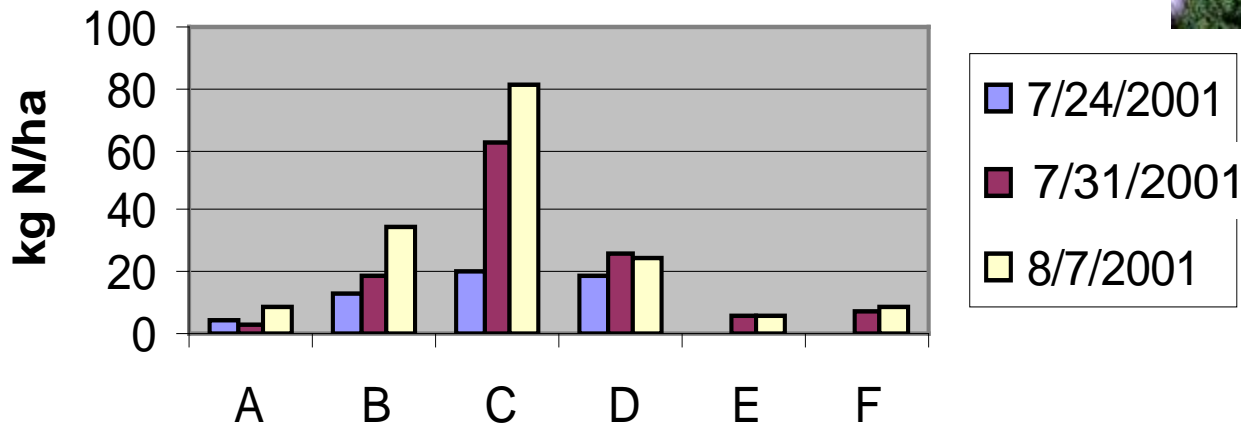
- **In-row**
- **Recycles P, K**
- **Root N contributions,
but N fix suppressed**
- **Suppresses weeds**
- **Saves water**

Grow Your Own N

Nitrogen release over 3 weeks from ambient soil with and without clover, root exclusion tubes, and tube covers.



Soil Nitrate



46% of clover N mineralized

Tree growth, fruit yield enhanced

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



Late summer 2000



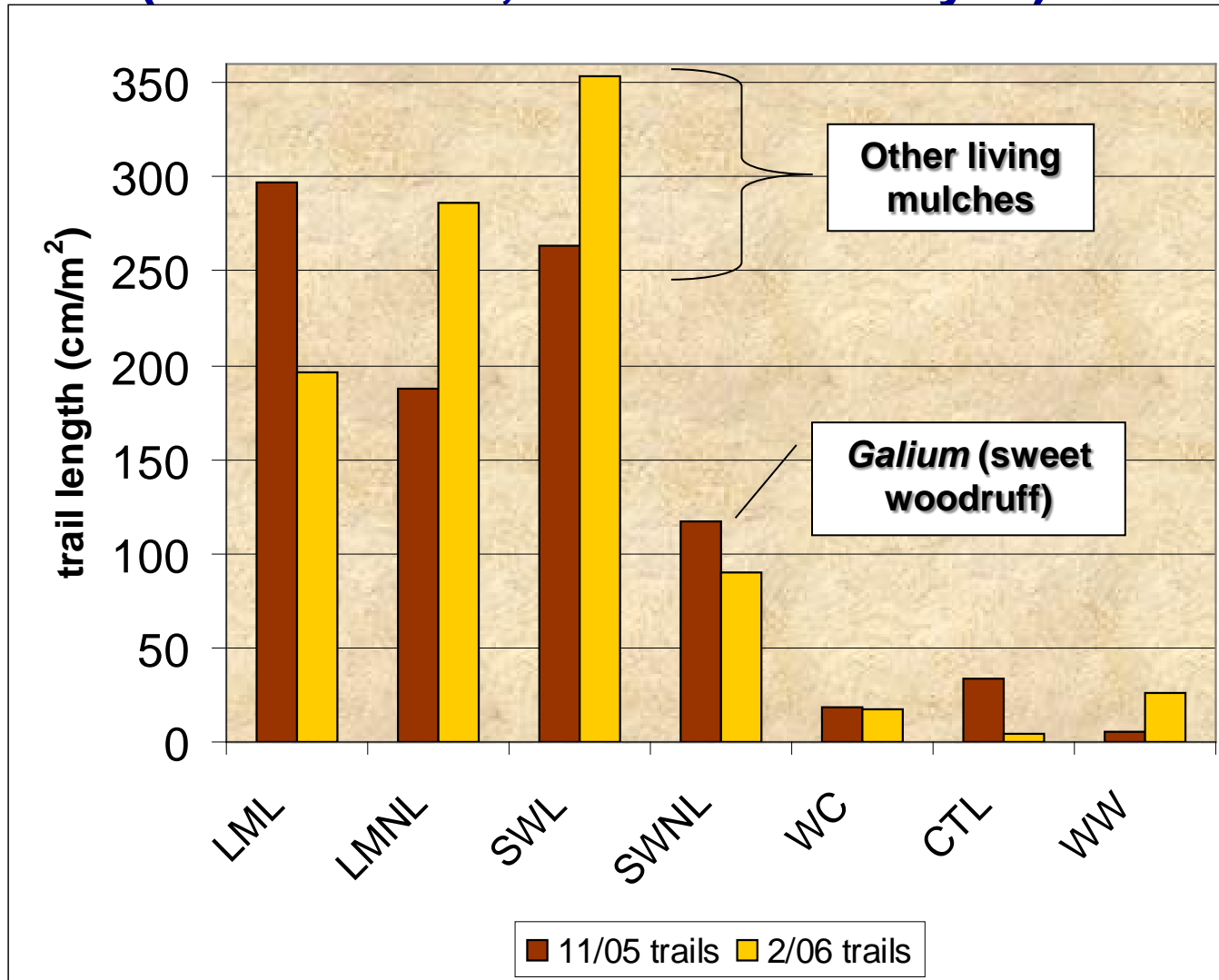
Early spring 2002

Rodents – the weak link for clover.

Vole Trail Length

WA IMM Trial, Winter 05/06

(Winter 06/07, too few to analyze)





Sweet Woodruff
(*Galium odoratum*)

Wenatchee area



Thyme

Mow and Blow Alley Cover Crop



2008 Trial – Qunicy, WA

- Legumes direct seeded in drive alley (4' swath) – May 19
 - Alfalfa cv. *Radiant*
 - Jumbo Ladino white clover
 - Kura clover
 - Birdsfoot trefoil cv. *Norcen*
- **SPRAY or NO SPRAY** prior to seeding
- **Mow and blow** before apple harvest



No-till drill



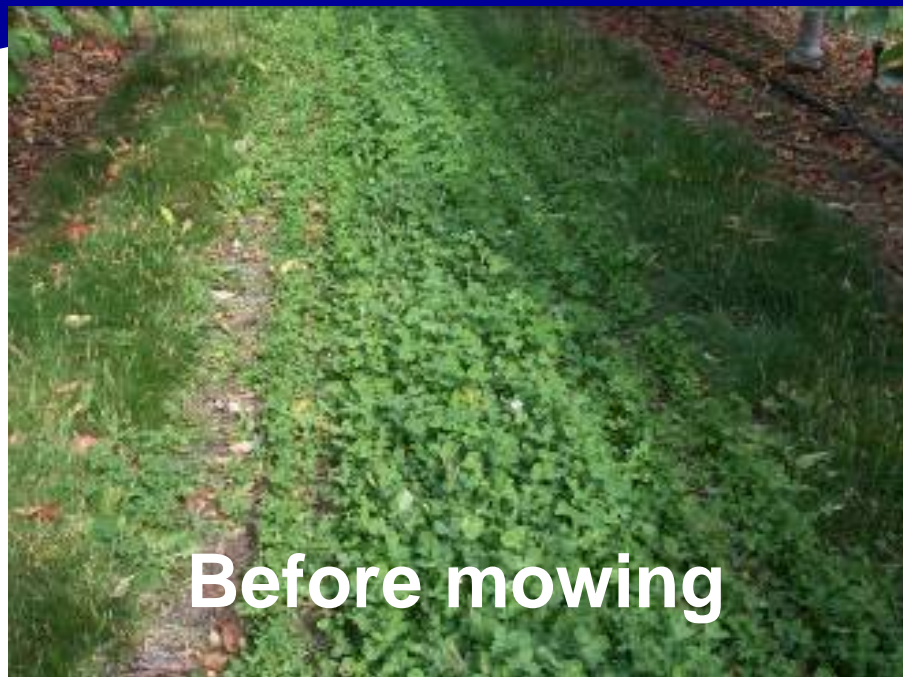
Alfalfa after seeding





**Drill - 8" spacing;
narrower would
be better**





Before mowing



Alfalfa tractor



Alfalfa no tractor

Year 1



Spray



No spray

**Ladino
clover**

Ladino Clover – May, Yr 2



Alfalfa – May, Yr 2



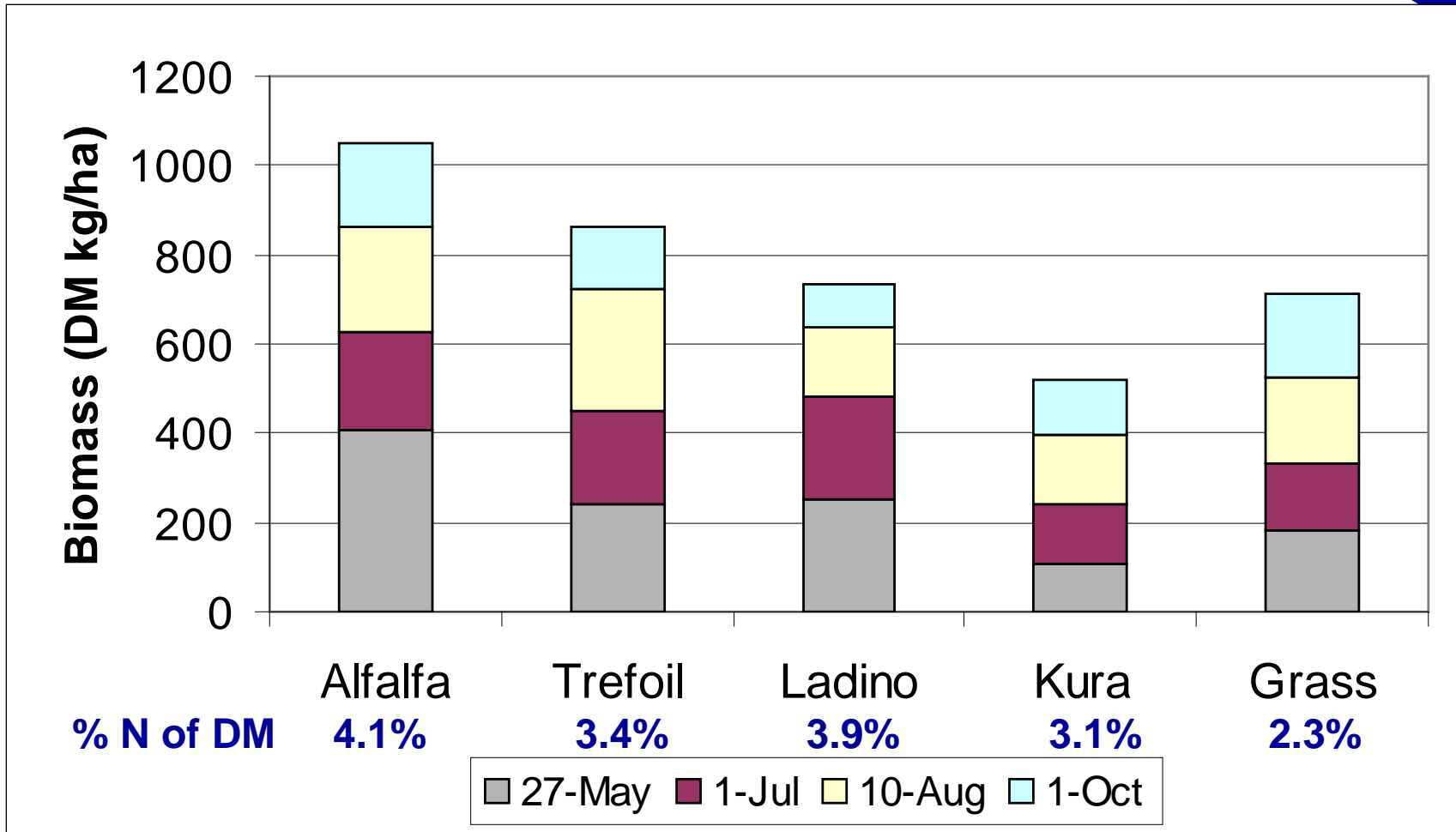
Mow and Blow



Legume residue in tree row after mow and blow

Legume Biomass

(Yr 2, 2009, 4 cuttings)



Effect of Pre-seeding Treatment on Biomass

	Sum of 8/08, 7/09, 8/09 cuttings		Legume only, 7/09	
	<i>Sprayed</i>	<i>Unsprayed</i>	<i>Sprayed</i>	<i>Unsprayed</i>
	----- Dry matter (kg/ha) -----			
Alfalfa	759 a	685 a	157 a	105 b
Ladino	701 a	719 a	191 a	131 b
Trefoil	783 a	716 a	141 a	74 b
Kura	476 a	486 a	56 a	18 a

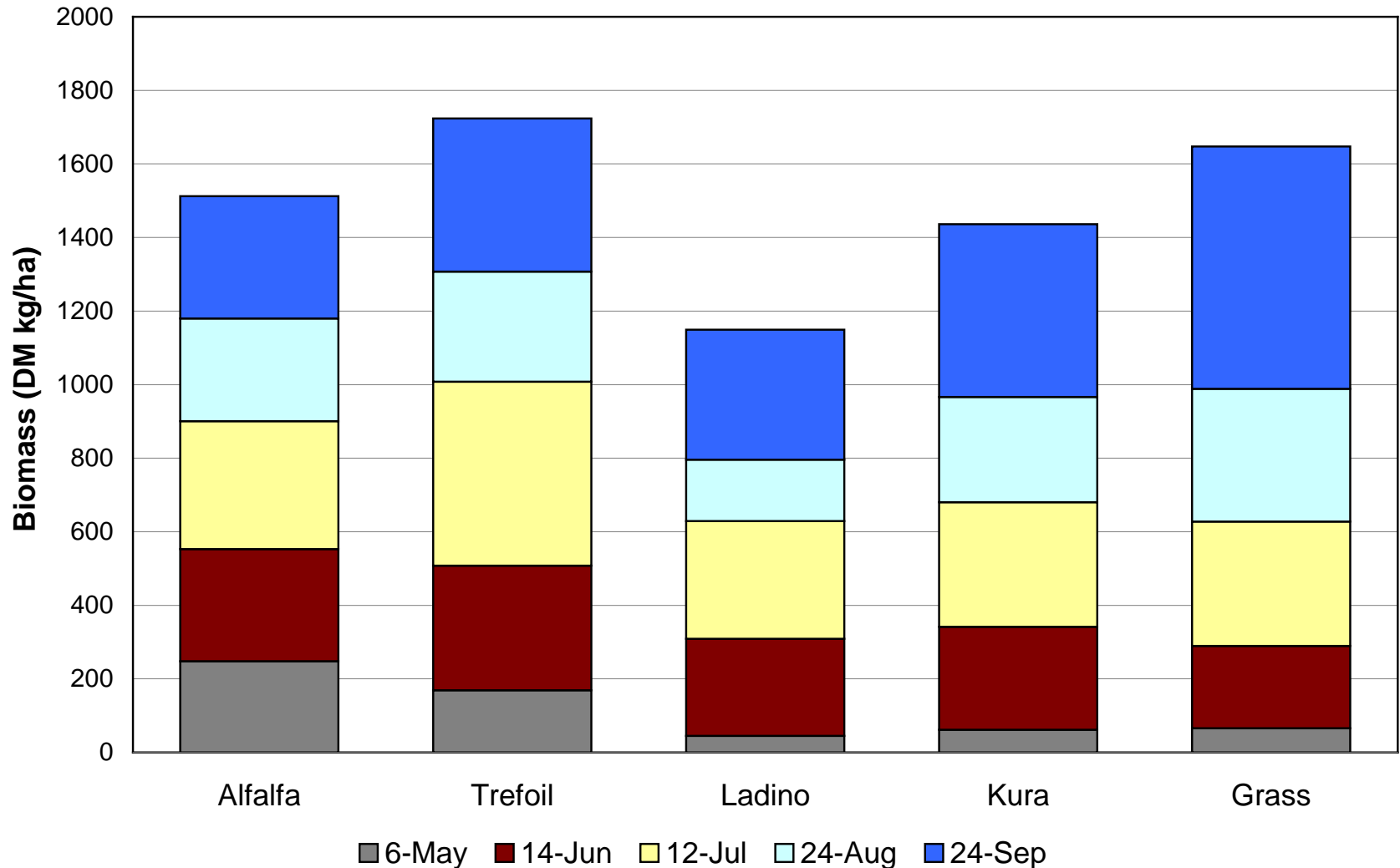
Year 3, 2010



39 days after mowing

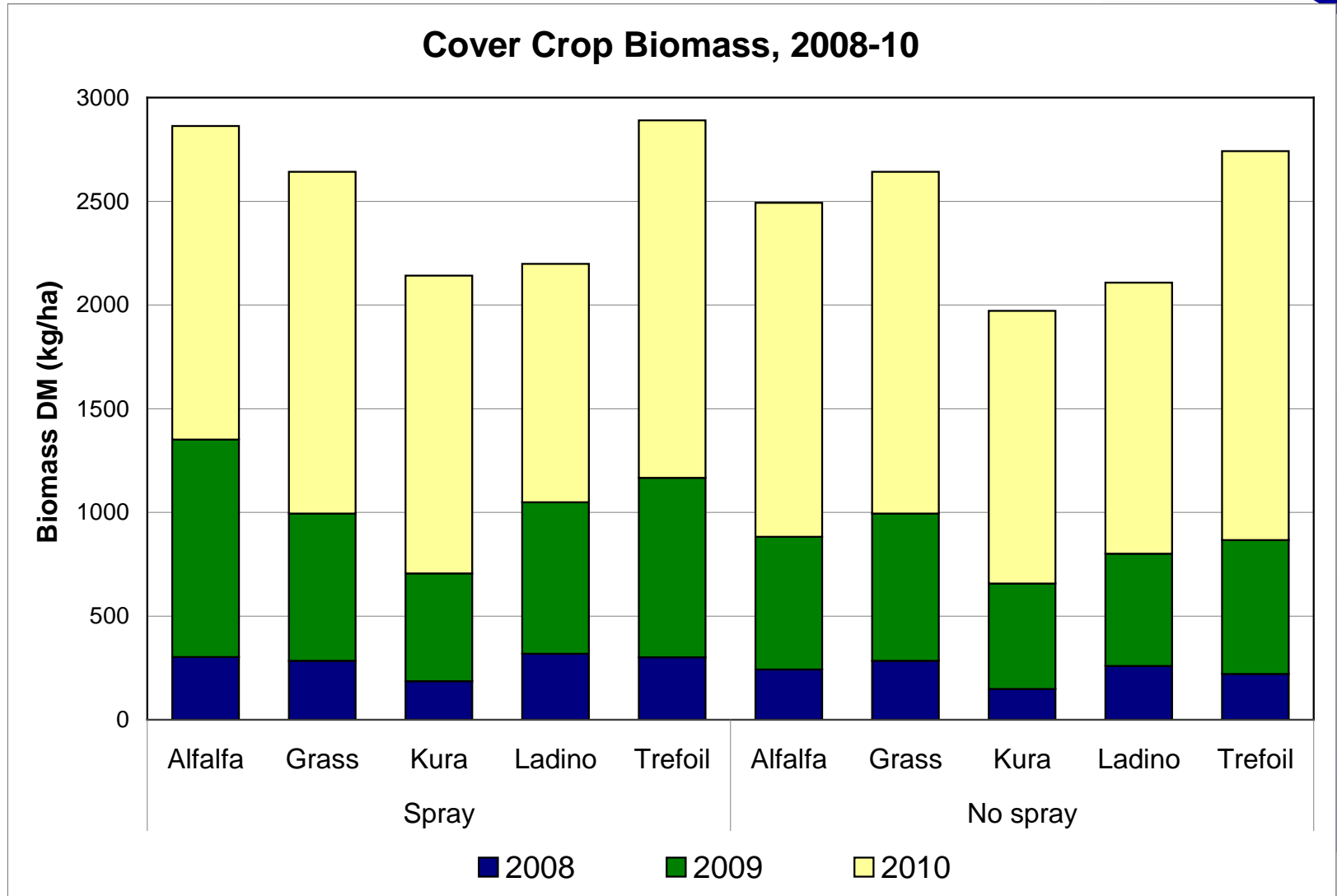
Cover Crop Biomass, Yr 3

Morgan Orchard, Cover Crop Biomass 2010- Spray



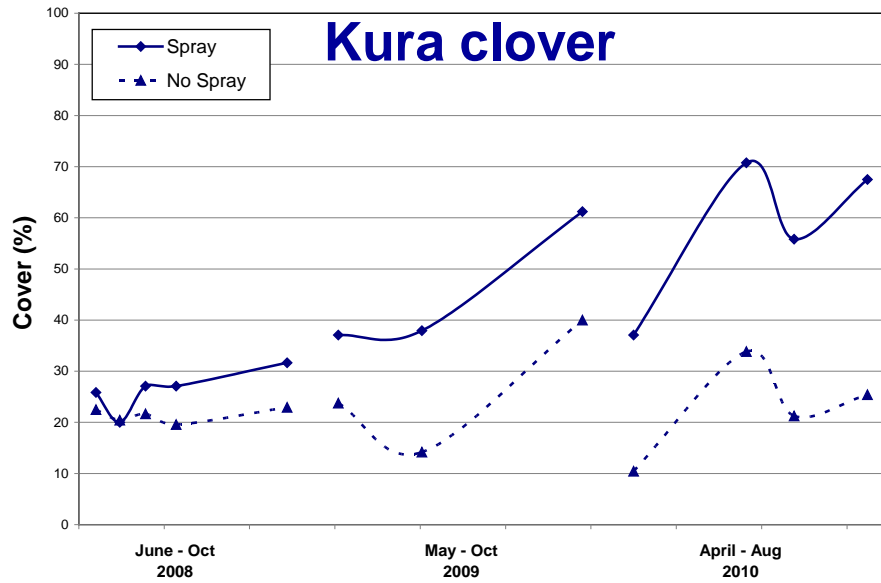
Morgan Orchard

Cumulative Cover Crop Biomass



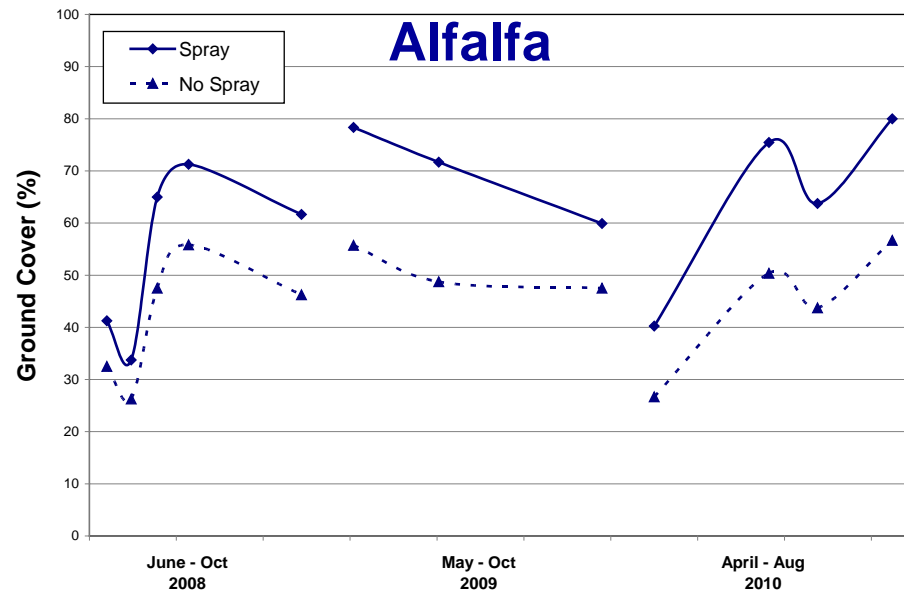
Morgan Orchard 2008-10, Kura clover

Kura clover



Morgan Orchard 2008-10, Alfalfa

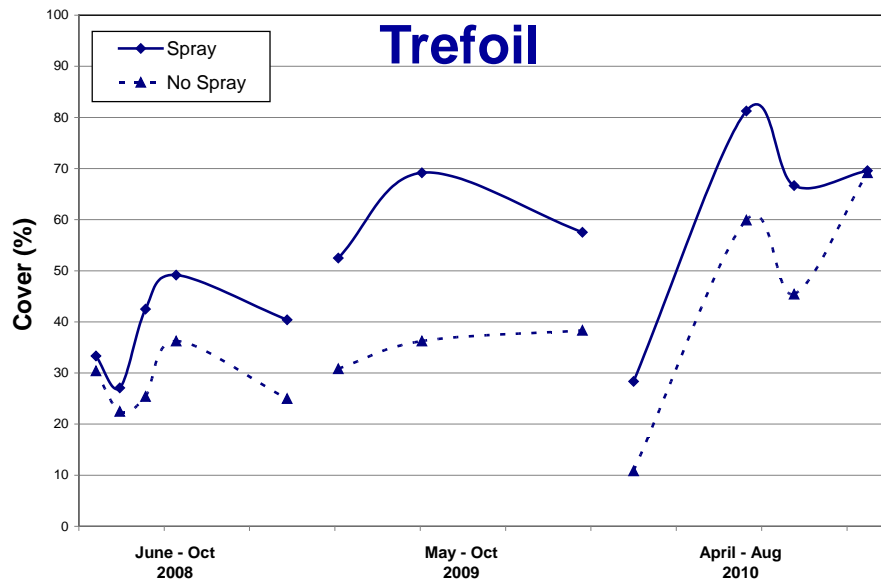
Alfalfa



% Cover of Legumes in Drive Alley

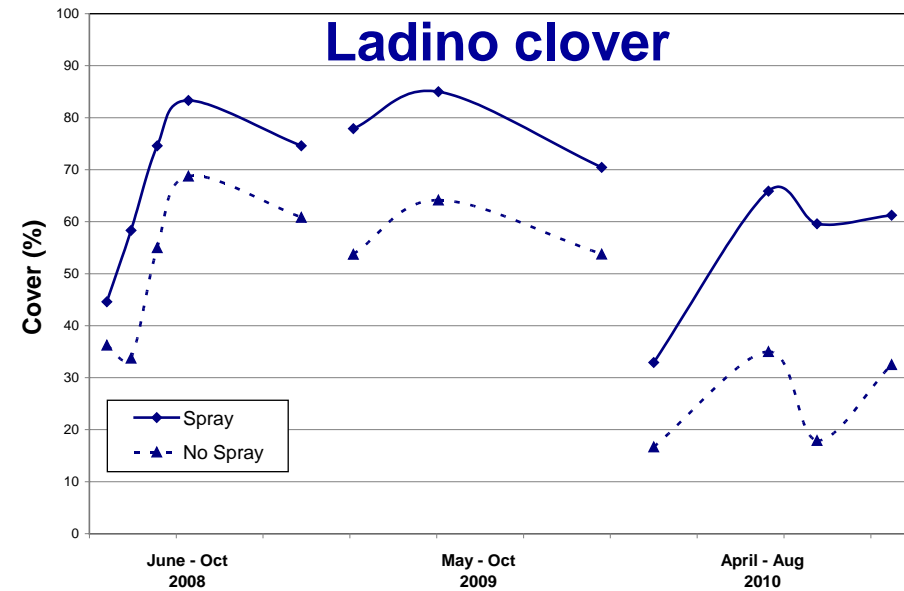
Morgan Orchard 2008-10, Birdsfoot trefoil

Trefoil



Morgan Orchard 2008-10, Ladino clover

Ladino clover



Grower Application

- Grafted 'Fuji' Young apple block
- Seeded mid May of 2010
- Direct seed drill directly into existing vegetation of grasses and weeds (flailed before seeding)
 - double pass, high seeding rate
- Excellent establishment; ~7' swath



Photos June 16, 2010

Direct-seeded Alfalfa



June 23, 2010

Red Clover



Tilled and seeded

June 14, 2010

N Contribution

	Biomass N 2009	Soil PRS 2009	Ave. Dry Matter*	2009 Tissue N	Ave. N Added
	(lb N/ac)	(ppm NO₃- N)	(ton/ac/yr)	(%)	(lb N/ac/yr)
Alfalfa	38	251	3.56	4.11	46.9
Trefoil	26	179	3.60	3.40	39.2
Ladino	25	173	2.62	3.92	32.8
Kura	14	132	2.72	3.07	26.7
Grass	15	103	3.28	2.30	24.2

*Ave. 2009 and 2010. Yield on a full acre basis; actual strips are 0.16 of area (2.2' strip)

Economics

Costs per acre of orchard, 4' swath

Herbicide	7.15
Tractor/sprayer	14.85
Tractor/seeder	29.70
Seed	<u>32.00</u>
Total	83.90

Planting good for at least 5 yr - **\$21/yr cost**

Alfalfa – 3.5 ton/ac/yr @ 4% N = 280 lb N

<u>Width</u>	<u>N content</u>	<u>Fert. Value^a</u>
5'	101	\$71
4'	81	\$57
3'	59	\$41

Over 4 yr, \$84 cost / 130 lb N^b = \$0.65/lb

^aEstimate N fertilizer at \$0.70/lb

^b40% avail., accounting for Nmin (50-70%), losses
[4' swath, 81 lb N/yr x 4 yr x 0.4 avail = 130]

Sampling

Percent cover

Point intersect – stiff wire with 20 pts; place at 45° to seeding rows; at least 3 representative spots per plot

Biomass

Quadrat frame – 3-4 representative samples per plot; cut at mower height; dry, weigh; convert to lb/ac DM; can weigh wet sample first for moisture content estimate and future wet basis sampling

See OSU cover crop sampling instructions



Figure 1a. Placing the sampling frame.



Figure 1b. Working the frame through the canopy.



Figure 1c. Cutting plants rooted within the frame.



Figure 1d. One quadrat after sampling.

Sampling

Nitrogen

Ideal – C,N analyzer, by combustion

Mow and Blow trial, Year 1 Tissue N

	% N	C:N
Alfalfa	4.06	10.6
Ladino	3.77	11.2
Trefoil	3.36	13.0
Kura	2.83	14.9
Grass	2.15	18.8
Non-legume	2.32	17.7

Sampling

Nitrogen

Ideal – C,N analyzer, by combustion

Total N analysis – reported as %N; e.g. alfalfa 4.11%

$N \text{ content} = 0.0411 \times 7120 \text{ lb/ac DM} = 293 \text{ lb N/ac}$

Need to adjust for area – 4' strip, 14' row spacing;

$4/14 = 0.2857 \times 293 = 83.6 \text{ lb N/ac of orchard}$

Need to adjust for N mineralization

Get C:N from tissue test e.g. alfalfa 10.6

$83.6 \text{ lb} \times 0.40 = 33 \text{ lb avail N/ac orchard}$



[Home](#)

OSU Organic Fertilizer & Cover Crop Calculator

This free online tool compares the nutrient value and cost of cover crops, organic and synthetic fertilizers and compost. Use this Excel Calculator to develop well balanced and cost effective nutrient management programs for your farm. Developed by Nick Andrews, Dan Sullivan, Jim Julian and Kristin Pool.

[Quick Guide & Records Sheet](#) The Quick Guide describes the main steps used to sample cover crops in the field, list the laboratory analyses required and describe how to use the Calculator.

[Cover Crop Sampling Instructions](#) These instructions describe the recommended method for sampling and analysing cover crops in more detail than the Quick Guide.

[Organic Fertilizer & Cover Crop Calculator](#) (per acre calculations for cover crops and fertilizers).

[Small Farm/Garden Calculator](#) (square foot calculations for fertilizers only).

[Research Background](#) This page links to research papers and other information that explains how the calculator was developed.

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Organic Fertilizer and
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Oregon Small Farms

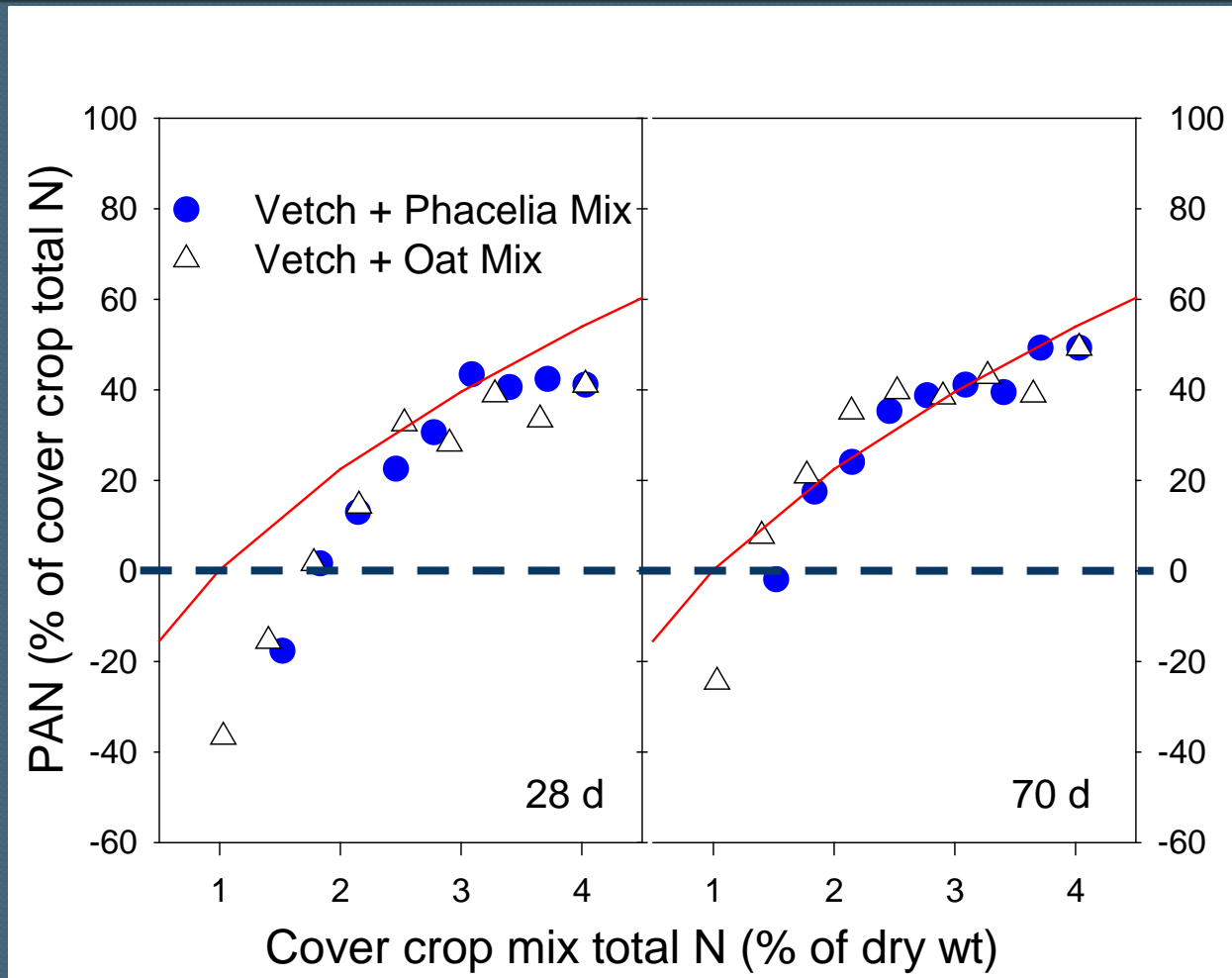
Technical Reports

Small Farms

Conference

<http://smallfarms.oregonstate.edu/calculator>

Cover Crop N Mineralization



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

Courtesy: N. Andrews

Perennial vs. annual?

- Could perennial cover crop roots contribute more available nitrogen?
- Residues on surface, not incorporated.
- After 40 days surface applied legumes provided about 20% of the nitrogen provided by incorporated legumes.
- Orchard floor PAN release is probably lower than calculator estimates.
- Less control over timing of PAN release, e.g. decomposition slower on dry surface.

Do legume roots provide short term PAN?

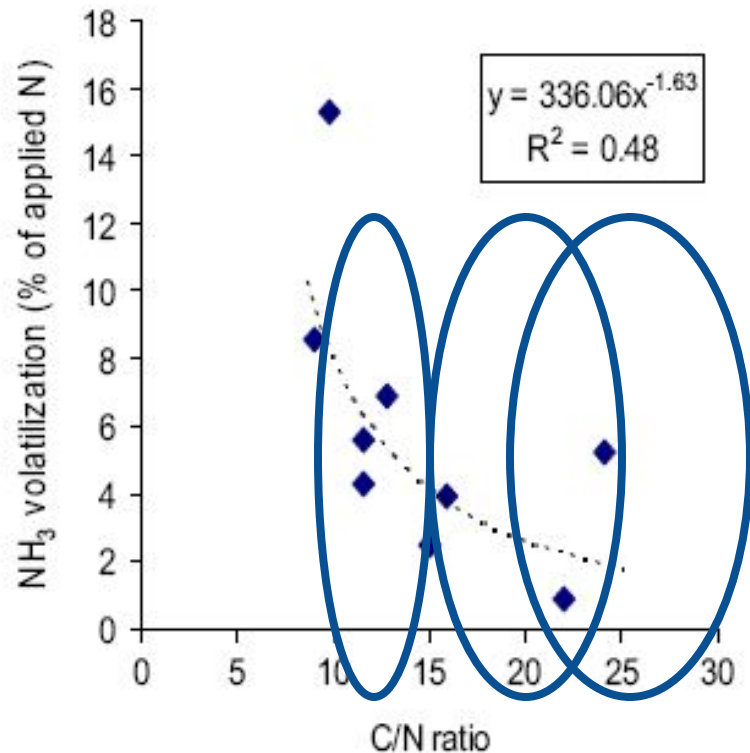
Material	C/N
Hairy vetch tops	10
Hairy vetch roots	25-30
Break even point for short term N-mineralization	~20

Adapted from Kuo et al (1997). Soil Science Society of America Journal, 61: 1392-1399.

Courtesy: N. Andrews

Perennial Cover Crops

– mowed, left on surface



Surface residues

- Legume C/N ~10-15
- Cereal C/N ~ 20-40
- Mixtures ~ 15-25
- Suggests that orchard floor residues may lose 0-5% of the total %N as NH₃

Dutch lab research, 37 day duration.

Ruijter et al (2010). Atmospheric Environment **44**, 3362-3368

Courtesy: N. Andrews

What we learned so far ...

- Need multiple years to assess species; many novel species to test
- Shade, traffic affecting growth
- Spraying out grass helped, but all legumes had reasonable stands; compensate with double pass, higher seed rate
- Need greater growing surface to boost N contribution; net ~3' with tires
- Combinations ? Alfalfa + ladino + kura?

*Thanks to USDA Organic Research
Special Grant for funding.*

Resources

UC Davis SAREP

<http://www.sarep.ucdavis.edu/ccrop/>

- Cover Cropping in Vineyards

Midwest Cover Crops Council

<http://www.mccc.msu.edu/>

USDA SARE Program

<http://www.sare.org/>

- Managing Cover Crops Profitably

WSU

- EB 2010 – Cover Crops for PNW Vineyards
- Orchard floor management

http://www.tfrec.wsu.edu/pages/organic/Orchard_Floor