WASHINGTON STATE UNIVERSITY

World Class. Face to Face.

Weed and Nutrient Management in Organic Orchards

David Granatstein

WSU CSANR

Wenatchee, WA

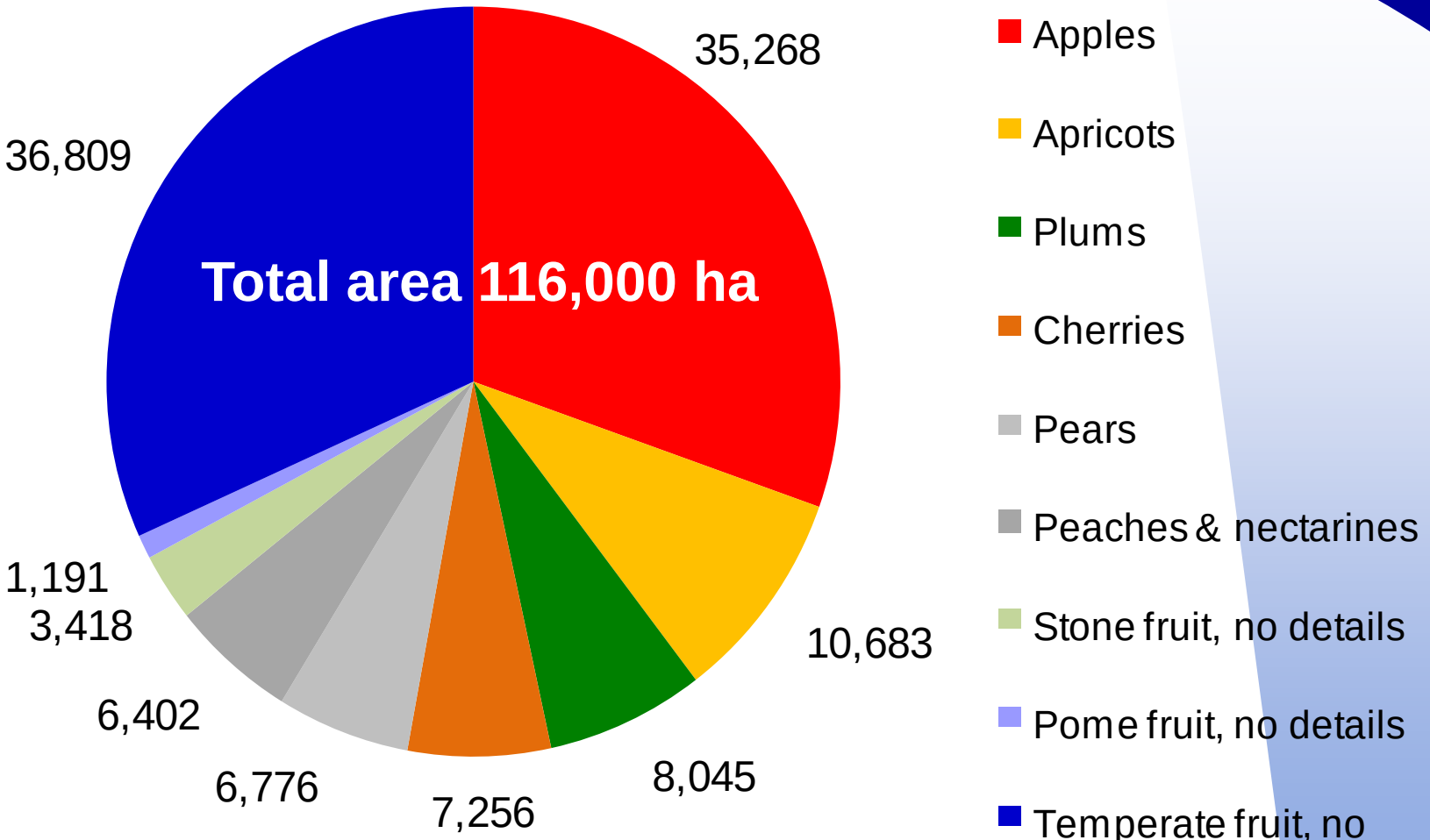
Center for Sustaining Agriculture & Natural Resources

UC Organic Tree Fruit Meeting, Feb. 23, 2011

Outline

- Organic tree fruit trends and economics
- Weed control studies
- Growing N
- Discussion

World organic temperate tree fruit area, 2008



Source: FiBL/IFOAM survey, CDFA 2008; WSDA 2008

http://csanr.wsu.edu/Organic/OrganicStats.html

Economic Estimates

Organic / conventional* apple production

	USA (WA)		Canada (BC)		USA (NY)		Switz.	
	Org. (US$/ac)	*% Diff.*	*Org ($/ac)*	*% Diff.*	*Org ($/ac)*	*% Diff.*	*Org ($/ac)*	*% Diff.*
Fertilizer	71	+58	309	+312	199	+198	287	+66
Weed control	493	+43	129	+115	115	+56	245	+12
Pest mgt.	644	+17	367	+60	851	+51	1,897	+15
Total direct cost	3,685	-4	3,190	+92	2,945[b]	+21	10,949	+10
Gross return	7,209	+40	6,979	+66	6,078	+40	13,920	+14
Net return	183	[a]	3,002	+17	3,132[c]	+63	-2,011	-2
Price (US$/lb)	0.14	+58	0.18	+74	0.59	+62	0.95	+110
Yield (ton/ac)	26.0	n.d.	16.0	-5	23.8	-12	9.1	-44

% Diff. is % difference between conventional and organic. n.d. is no difference. * For NY and Switzerland, 'conventional' system was Integrated Fruit Production

WA: 'Golden Delicious'/M26; Yakima Valley; adapted from Glover et al., 2002. [a] Conv. apple lost US$4587/ha

BC: variety not specified, Okanagan Valley, BC; MAFF, 2002.

NY: IFP vs. organic; 'Liberty'/M9; G. Peck, umpublished; [b] no pruning, training, taxes, interest, etc.; cullage IFP 3-17%, organic 3-75%; [c] gross margin only

Switzerland: IFP 'Golden Delicious' vs. organic scab resistant variety; E. Bravin, ARBOKOST, ACW. No land charge or establishment cost included.

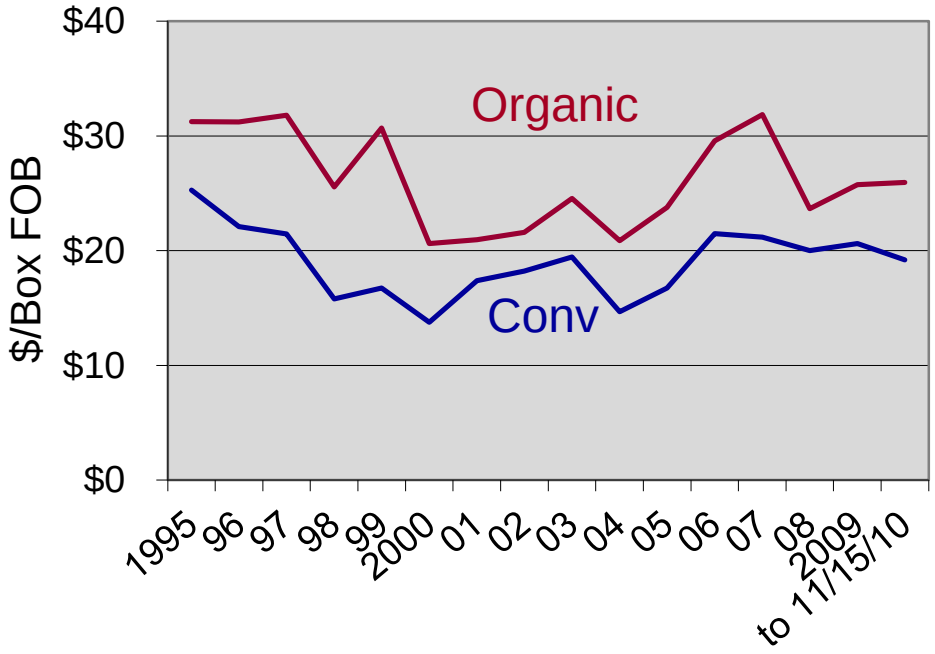
WA Apple Costs at Full Production

	Org (2010)	Conv (2009)	Difference Org vs Conv
Fruit thinning	630	653	
Chemicals, fertilizer	1,518	900	+68%
Total variable costs	6,558	5,651	+16%
Total fixed costs	4,848	5,105	-5%
Total costs	11,407	10,757	+6%
Production bin/ac	50 x $300/bin	50 x $250/bin	
Gross income	15,000	12,500	+20%
Net return	3,593	1,743	+106%

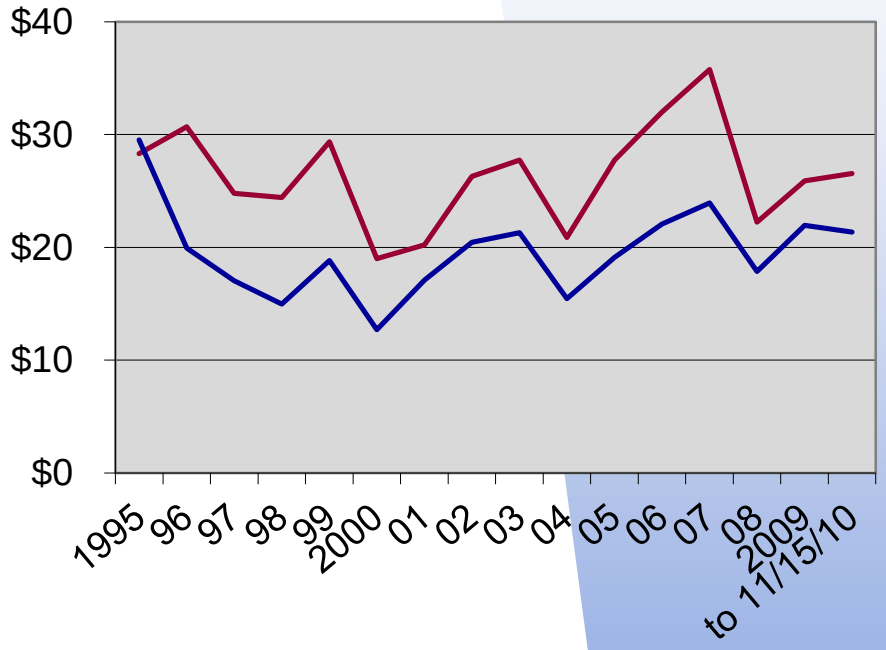
‘Gala’/M.9 4’x10’ trellised

Price Trends
Washington Apples

Gala



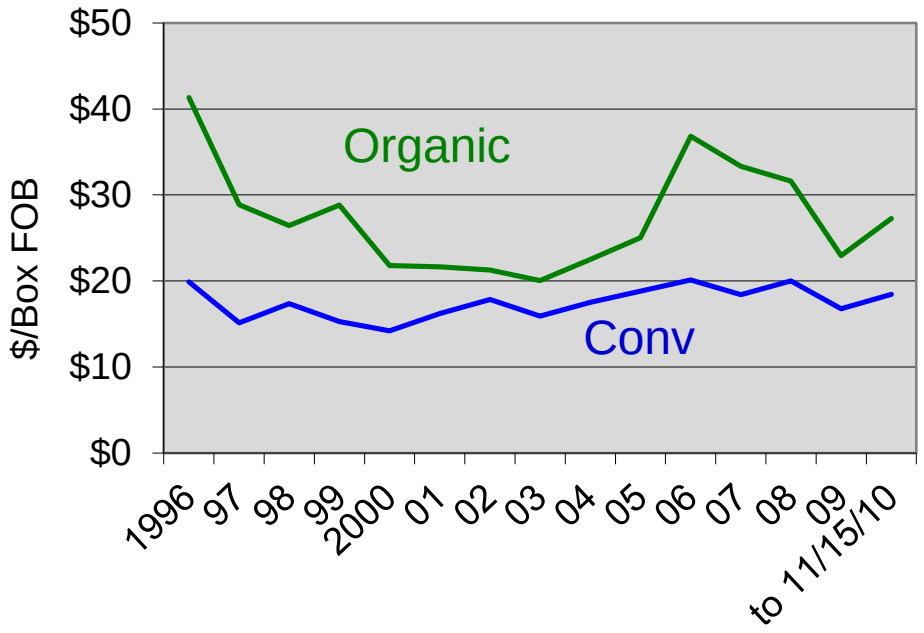
Fuji



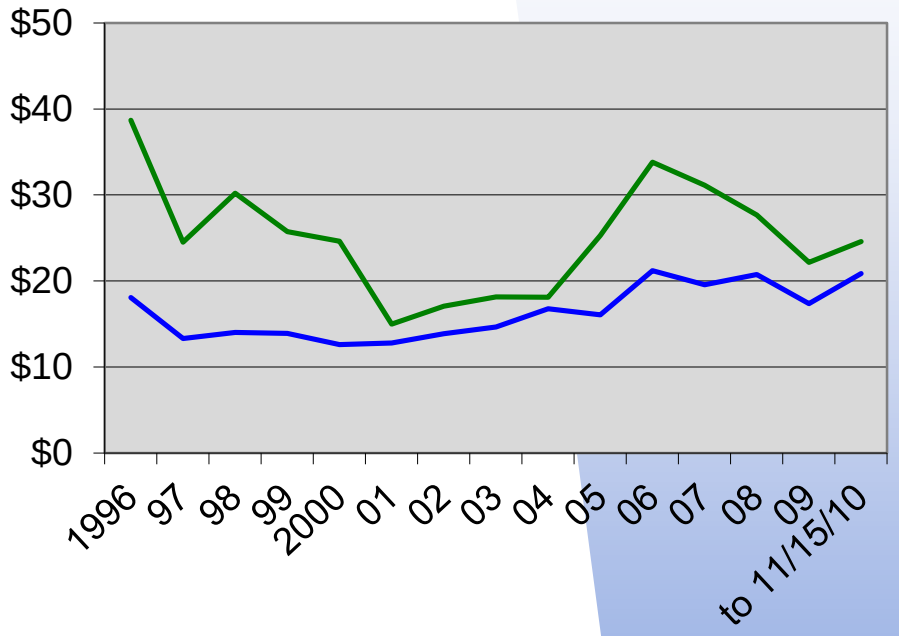
WAGCHA data; FOB average, all storage, grades, sizes

Price Trends
Washington Pears

Bartlett

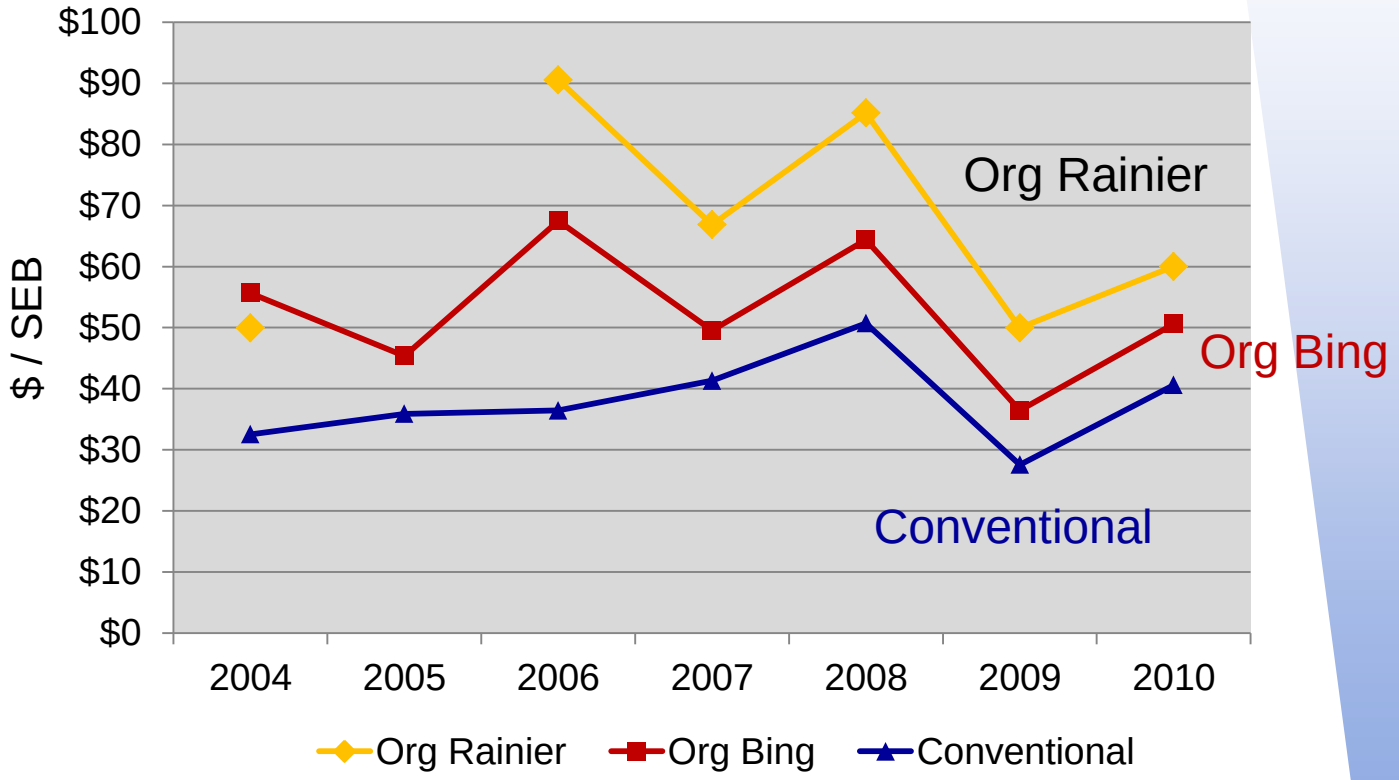


D'Anjou



WAGCHA data; FOB avg, all storage, grades, sizes

Cherry Price Trends
Washington State



WAGCHA data. Conventional prices are from season FOB histories; may include organic 2008-2010. Organic prices are from season FOB histories or from sales data search. All grades and sizes. Photo: ARS Image Gallery

Was organic fruit production profitable?

	Yes	No
2008 crop	43%	57%
2009 crop	65%	35%

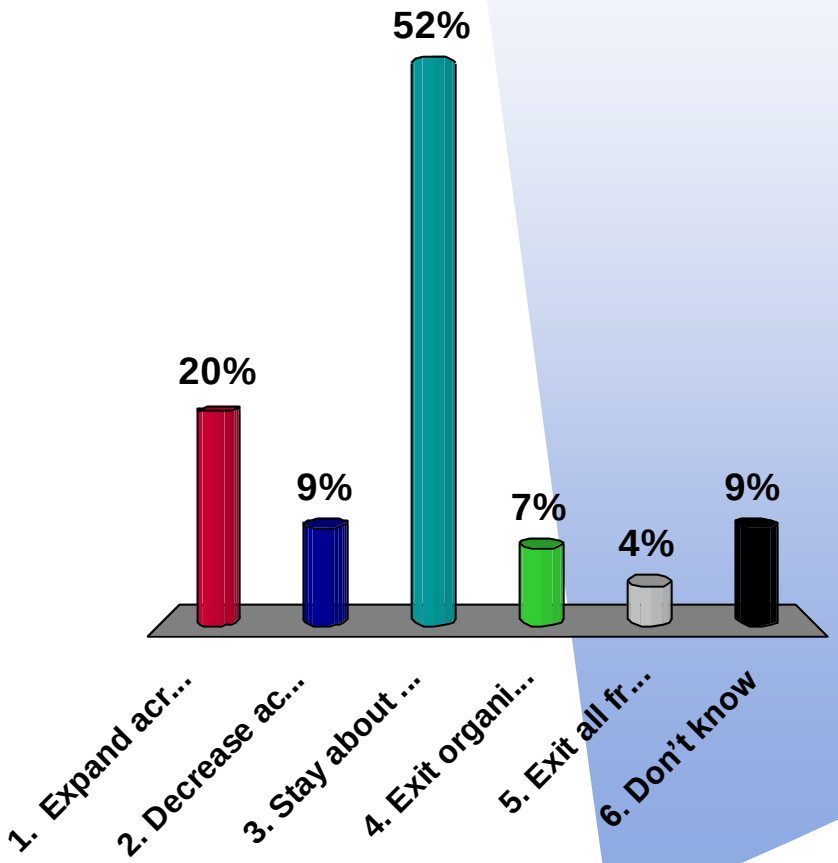
Wash. organic orchardists

Compare cost of organic fruit production to similar conventional. (% of responses)

	2008	2009	2010
20% or more lower	4	5	3
10% lower	8	15	1
Similar	13	7	7
10% higher	34	18	28
20% or more higher	41	55	61

How do you see your organic fruit production changing over the next five years?

1. Expand acres under organic management
2. Decrease acres of organic management
3. Stay about the same
4. Exit organic production
5. Exit all fruit production
6. Don't know



Wash. organic orchardists, Jan. 2011

Weed Control

Why control weeds ?

- Limit competition with young trees – nutrients, water
- Minimize rodent habitat
- Weeds as hosts for pests, disease inoculum
- Maintain good sprinkler pattern

Organic Orchard Weed Control Options

	Pro	Con
Tillage	**Effective; rodents; low cost**	**Reduced tree growth, fruit size; soil quality; damage trees**
Flaming	**Control weeds around trunk; rodents; low cost**	**Tree injury, perennial weeds, fossil fuel**
Inert mulches	**Effective; soil quality; moisture**	**Costly; N tie up; soil quality**
Living mulches	**Add biodiversity; soil quality; fix N**	**Competition; rodents; persistence**
Organic herbicides	**Control weeds around trunk; rodents; no tree, root damage**	**Effectiveness; high cost; multiple applications**

(Granatstein & Mullinix, 2008)

Alternative Weed Control Costs

Method	Rate	Freq.	Cost/ac/yr ($)		
	(ac)		Material	Appl.	Total
Glyphos.	0.5 l	4/yr	24	80	104
Weed fabric	5’ x 3750’	1/6 yr	286	51	337
Alfalfa hay	8.5 ton	1/2 yr	319	90	409
Wood chip	100 yd^3	1/3 yr	200	150	350
Spray on	3.4 ton	1/1.5 yr	234	211	445
Flaming	48 lb	3/yr	36	90	120

(Hogue et al., 2002)

Flame Weeding

Brewster orchardist:

- **Burn 4-5 ac/hr**
- **10 gal propane/hr**
- **4x per season**
- **Cost $70-80/ac**

Dovex Orchard, June 2007


Wenatchee orchard:
Fabric $330-800/acre; lasts ~ 10 yr
Labor to apply $100-200/acre
Labor to open and close each year $200/acre
Weed fabric
Courtesty: S. Swezey

Weed Fabric in Sweet Cherry

OSU, Hood River, OR – 2001-2007

- **Fabric groundcover vs. bare ground in tree row**
- **2001-2004 – fabric $2125/acre increased costs**
- **2004 – fabric trt gross returns $3240/ac more than bare ground (1st yr of production)**
- **2005 - $1633/ac more with fabric**
- **Fabric – trees produced more fruit at an earlier age, maintained higher yields**

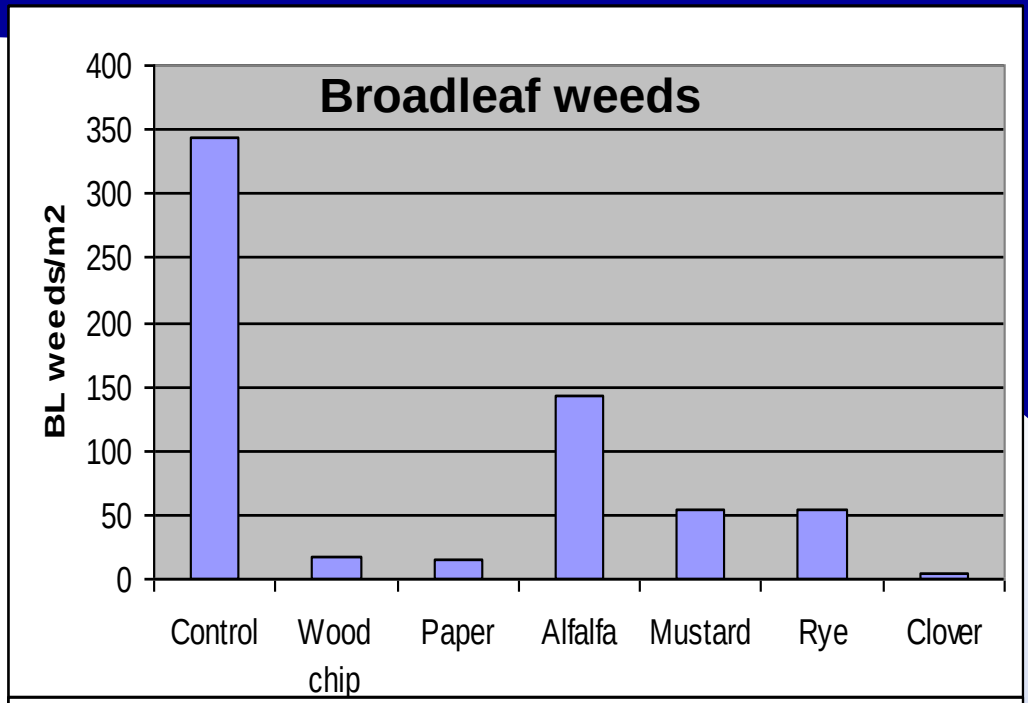
(Tomasini et al., 2007)

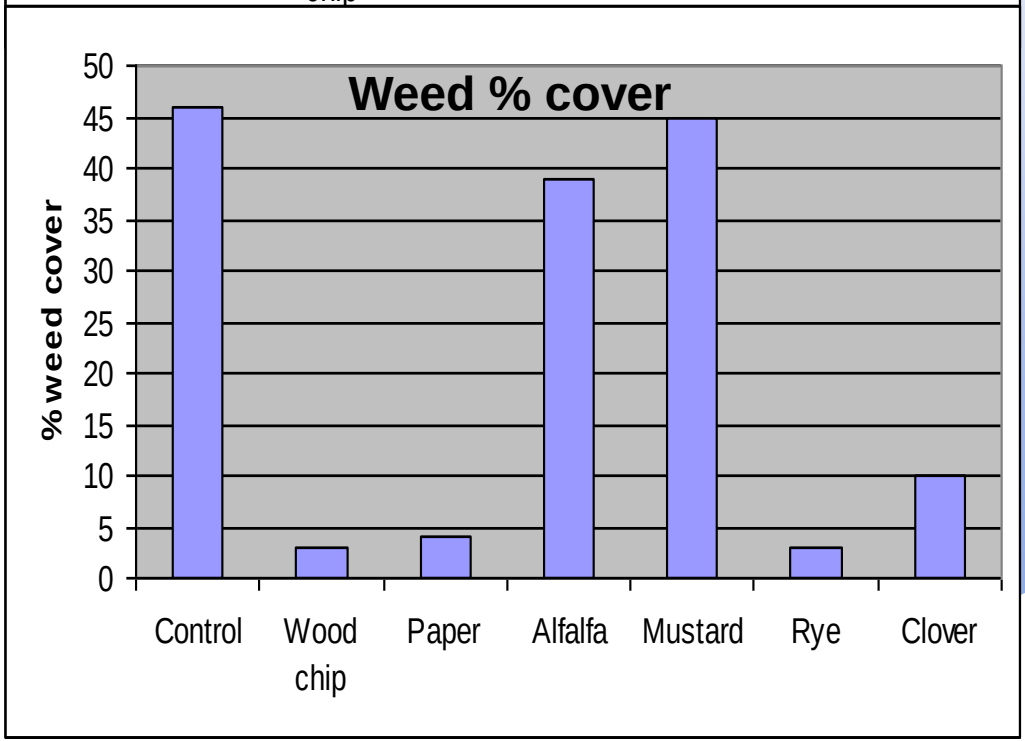
Photo: H. Ostenson

WVC Mulch Trial

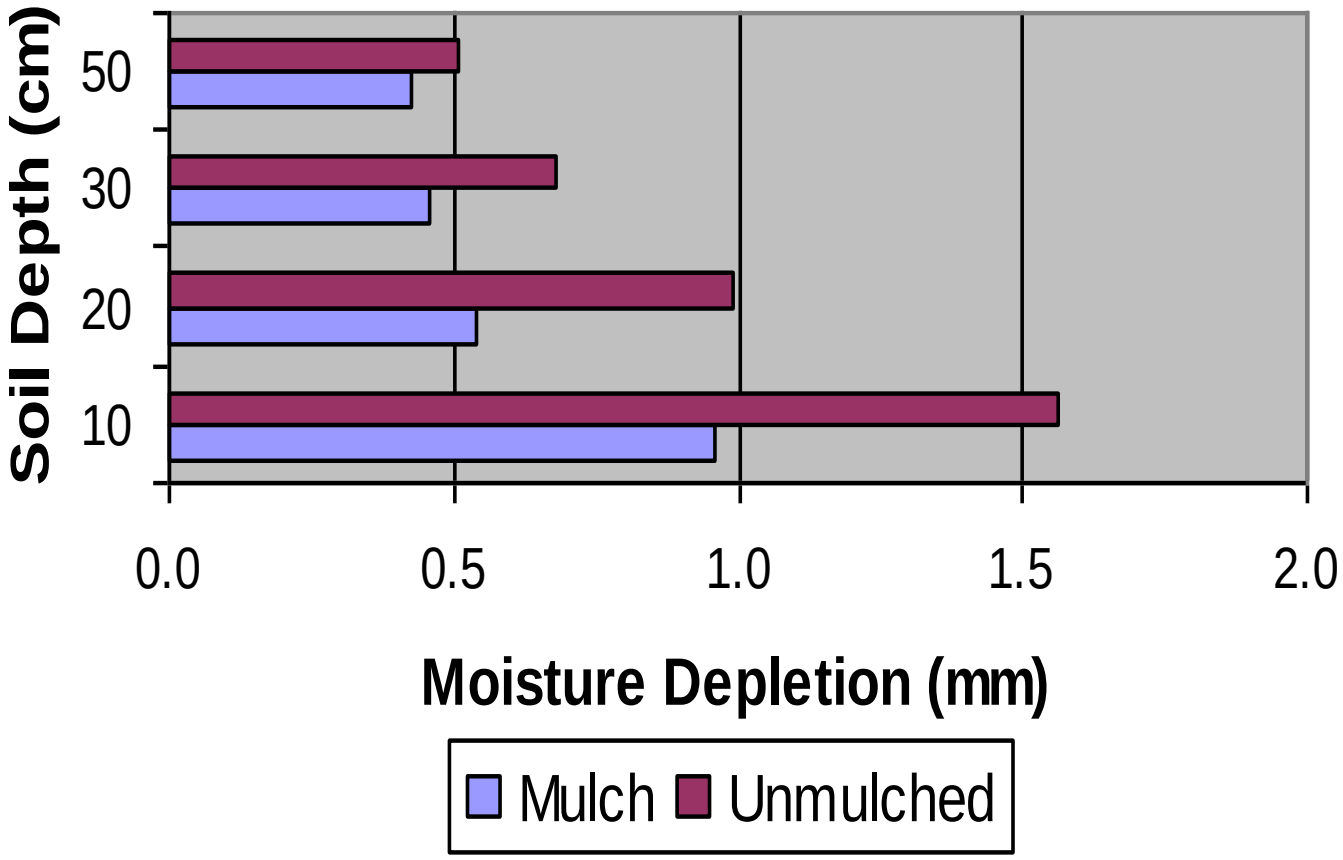
Weed Control by Mulches – 6/1/00

8-yr ‘Red Delicious’/M.26
Wenatchee, WA





Effect of Orchard Mulching on Soil Moisture Depletion



Spray-on Paper Mulch

Cost and longevity are key issues.


Winter rye

Tillage Effects

Treatment	Stem Circ. (mm)	Pruning Mass (g/2 trees)
Herb. Strip	100.3 a	604 a
Mech. Cult.	85.2 b	234 b

3-yr old high density apple

Significant growth reduction with tillage

(Wooldridge and Harris, 1989)

Tillage Effects

	Depth (in)	Length (in)	Root Conc. (in/in)	Weight (g)
Tilled (3” depth, 4x)	0-3	0	0	0
	3-7	666	222	19.6
	7-12	240	40	60.9
	12-18	213	36	131.3
Herb. Strip	0-3	838	279	29.9
	3-7	712	237	43.5
	7-12	330	55	57.1
	12-18	234	39	103.2

19-yr old pear

Trees did not compensate deeper in soil for surface roots lost from tillage

(Cockroft & Wallbrink, 1966)

Weed Control

Tillage Comparison Trial, 2004-2006

- Control (mow), wood chip mulch, Weed Badger, Wonder Weeder at tillage frequencies (2x, 3x, 4x)
- Control = mowed weeds
- Wood chip layer 6” thick

Tree row after tillage with Wonder Weeder

Wonder Weeder
465 ft/min

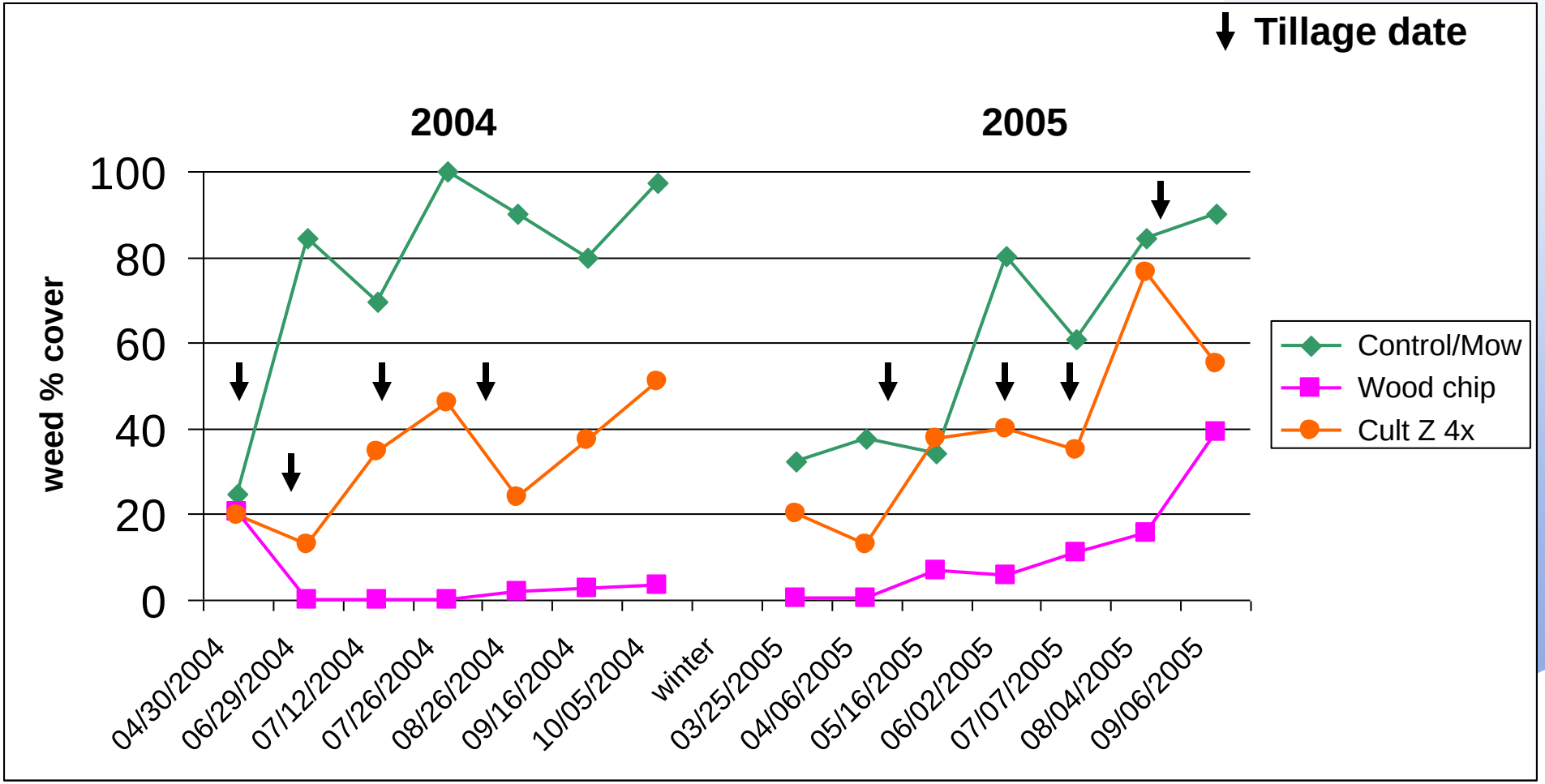
WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Weed Badger
21.2 ft/min

Wood chip mulch

Tillage Comparison Trial

'Gala'/M.26, E. Wenatchee, WA



Tillage Trial results

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	%	$/ha	kg/tree	%	$/ha	cm^2	m^3 /5 trees
Wood chip	22.4	15.5 a	35,454	14.7	39.0	27,249	3.7 a	56.7 a
Control mow	20.4	6.6 b	29,647	14.3	33.5	24,077	3.0 b	47.6 ab
Cultivator Z 3x	17.6	7.0 b	23,603	13.3	22.0	25,100	2.3 c	39.2 b
p=	0.150	0.014		0.805	0.076		0.001	0.008

Orchard Floor Management in a New Planting

Sweet Woodruff ‘Sandwich’ system

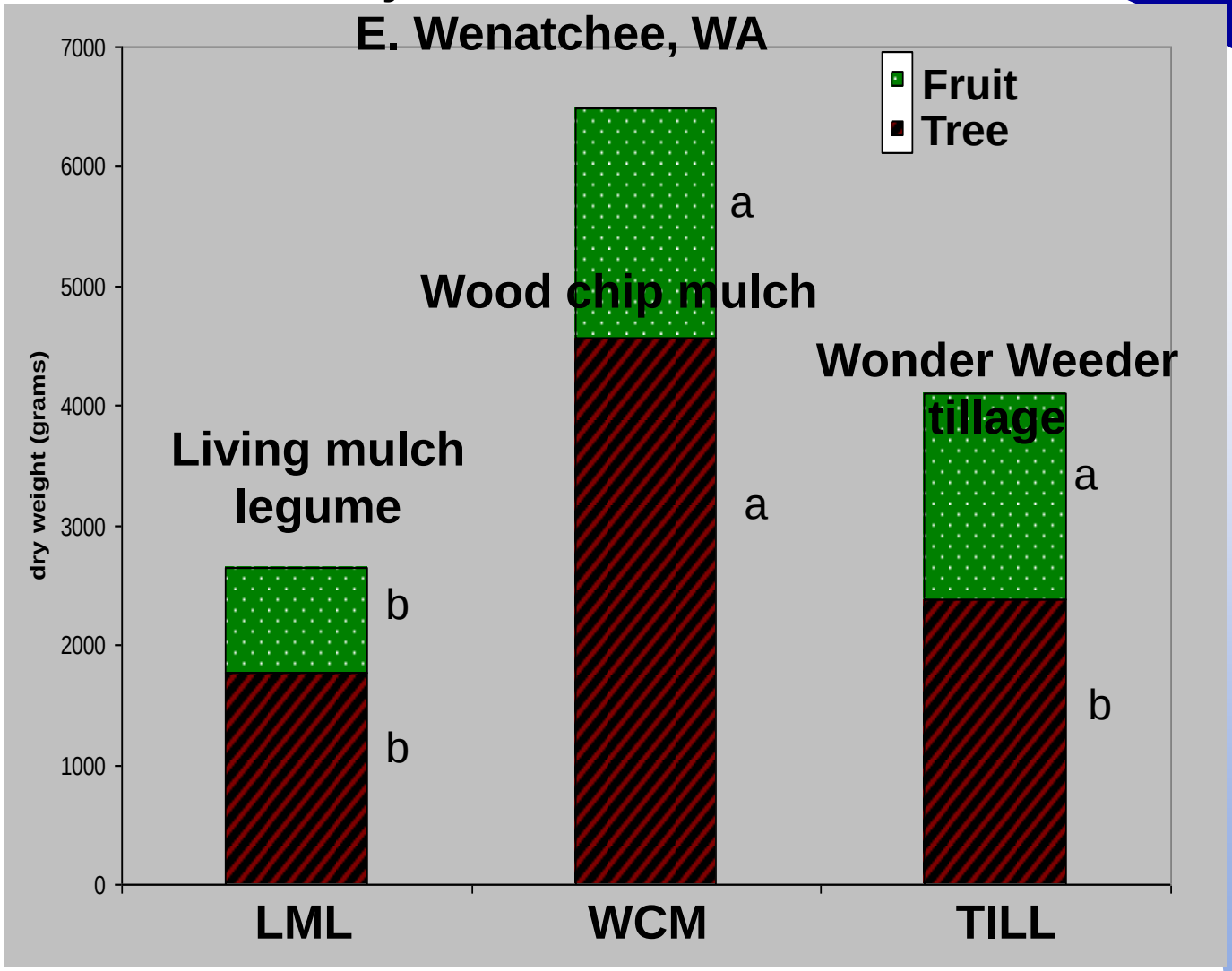
Living mulch non-legume

‘Pinova’/EMLA.7

‘Green islands’ from fertilizer injection

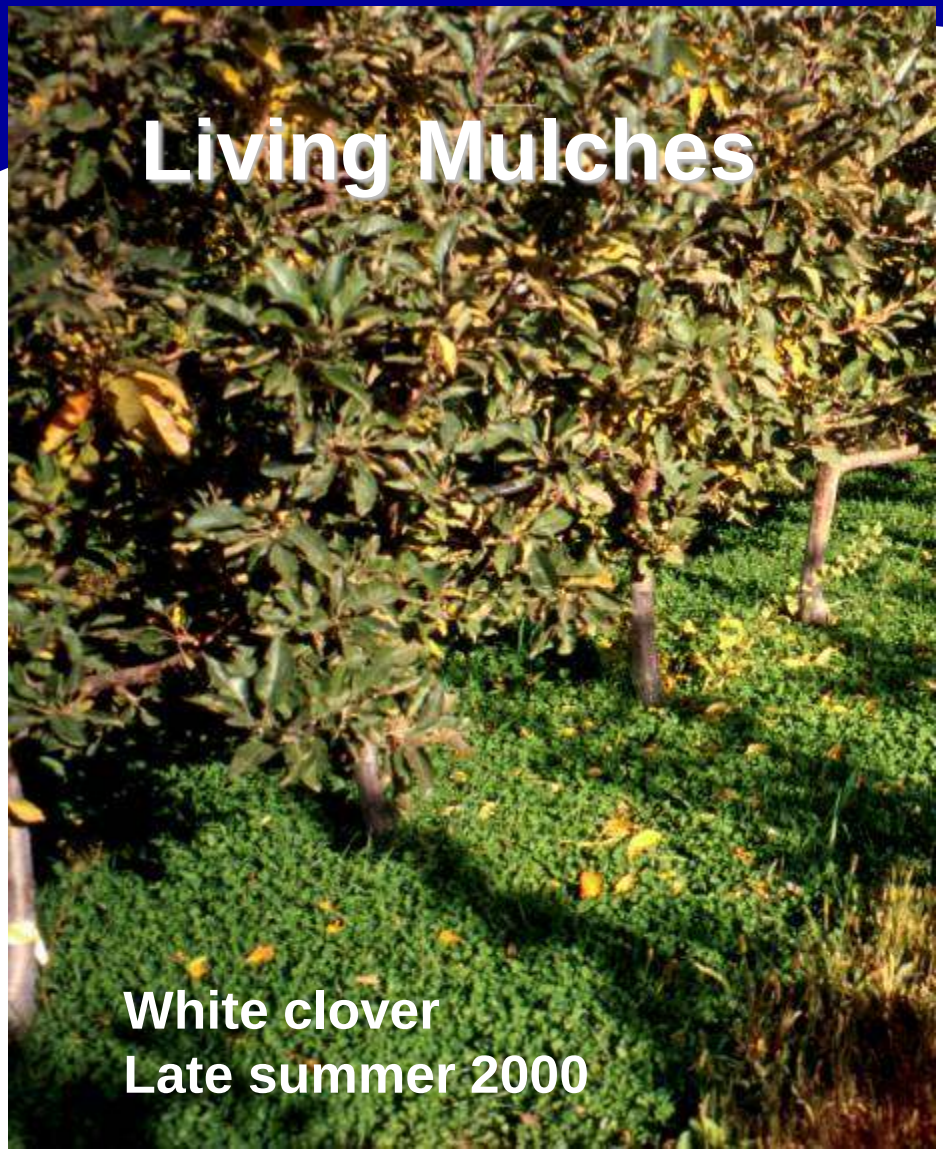
Total Biomass

3-yr Pinova/EMLA.7



Yield Efficiency (g fruit/g tree DM)	**0.78**	**0.41**	**0.50**

Living Mulches



Rodents – the weak link.

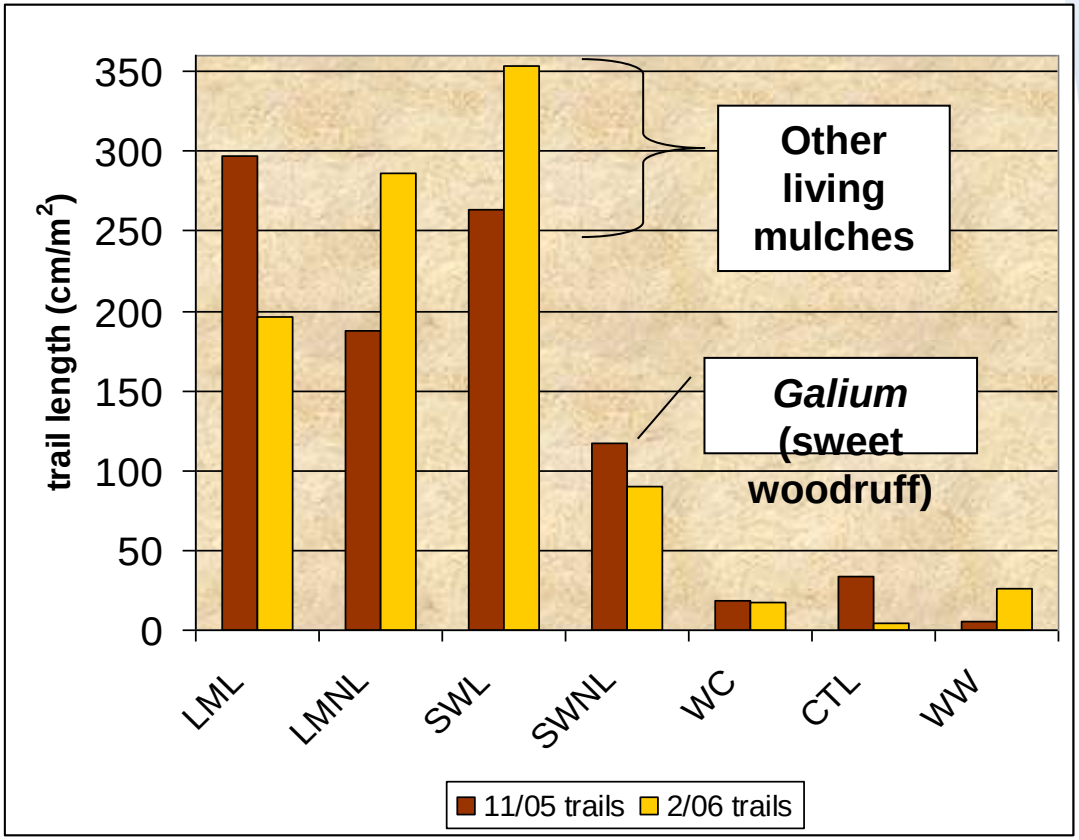
Vole Trail Length

IMM Trial, Winter 05/06

(Winter 06/07, too few to analyze)

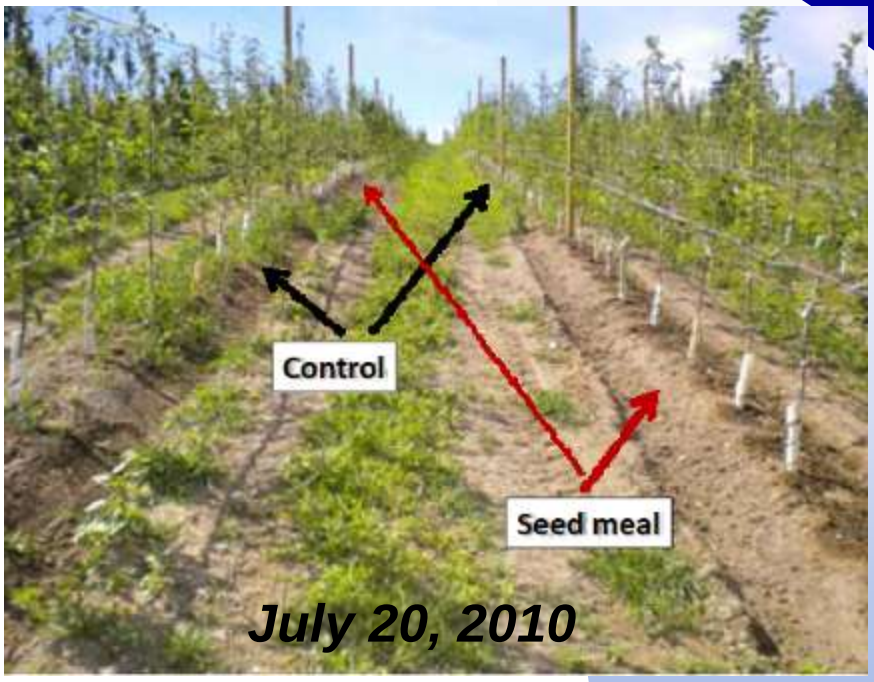
Wood chip (WC) = bare ground (CTL) = tilled (WW)

***Galium* in Sandwich system (SWNL) significantly lower voles than other in-row living mulches**



Brassica Seed Meal

- BSM to control apple replant disease
- Assess weed suppression, N effect (6% N); 'weed and feed'?



- 85% reduction of weeds with BSM; adequate for first season
- Results varied with soil type

Courtesy: L. Hoagland, M. Mazzola

FLF Co. Trials

3 sites

- **‘Gala’/M.26 – 8 yr old, sandy soil, quackgrass**
- **‘Honeycrisp’/M.26 – 4 yr old, loam soil, quackgrass**
- **‘Anjou’ pear – 15 yr old, loam soil, quackgrass**

Comparing mulch, tillage, herbicide/burn

Shade in pears reduced weed pressure

Herbicide not effective for long, mulch helped

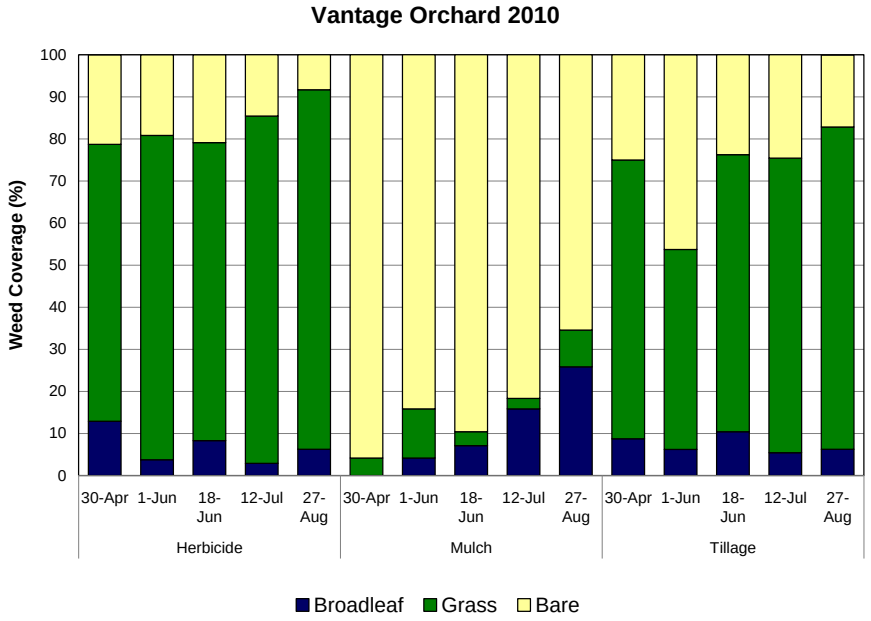
$230/ac for dedicated tractor and driver for cult., burn, or herb – 3-4 trips per month

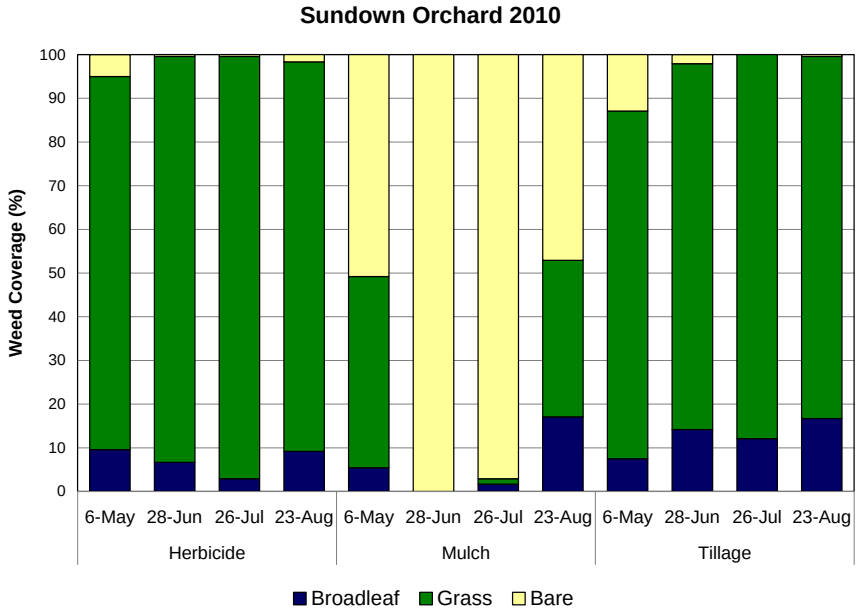
‘Gala’ fruit yield: Mulch>Till>Herb, fruit size same

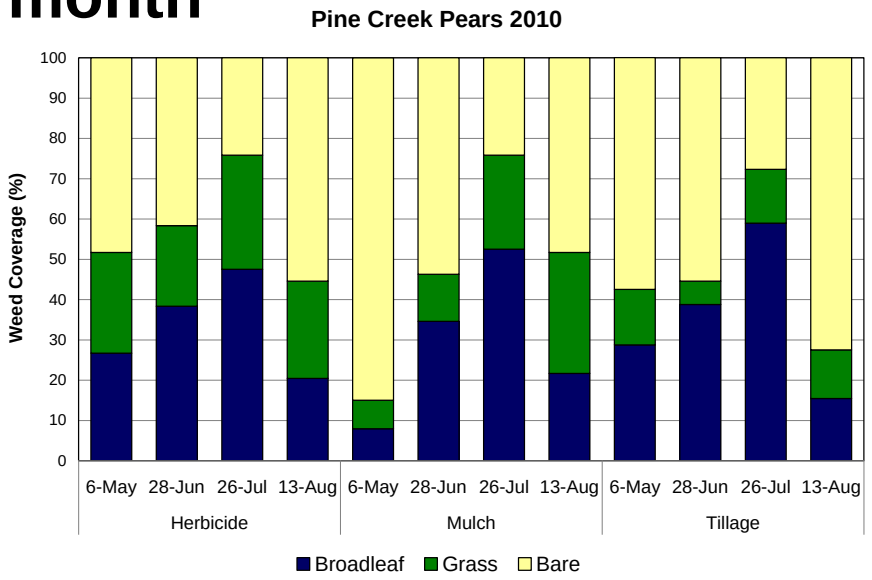
WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Effect of Weed Management on In-row Vegetation

$230/ac for dedicated tractor and driver for cult., burn, or herb – 3-4 trips per month





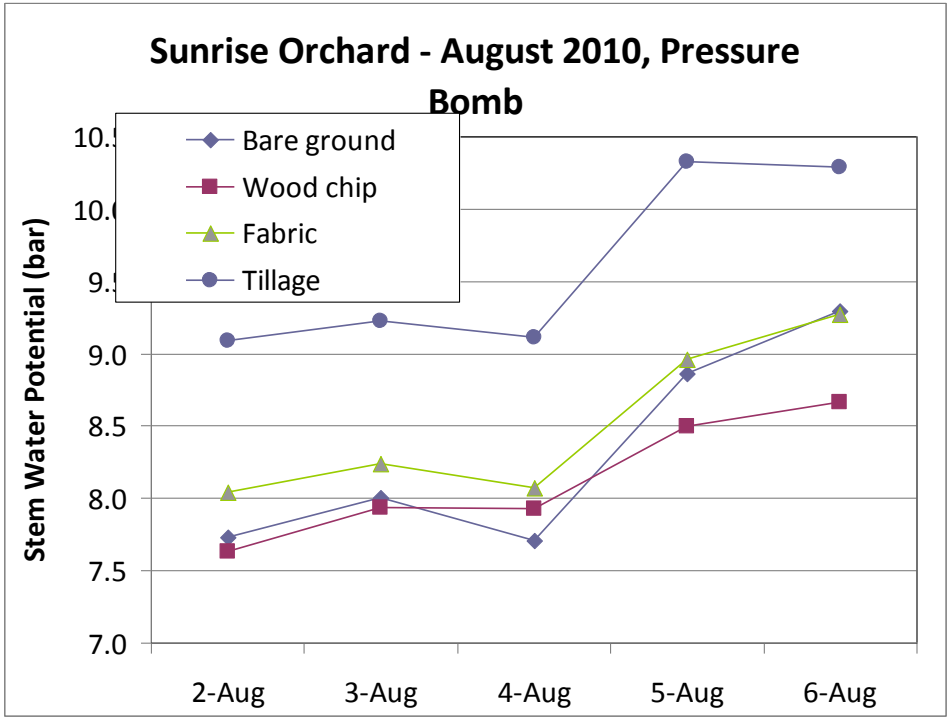


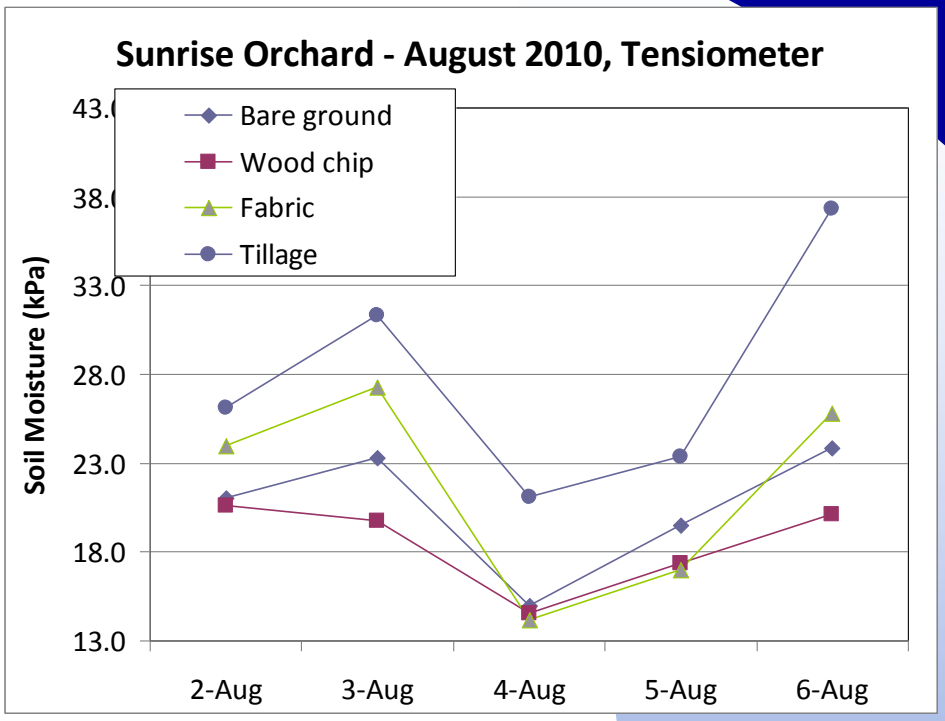
Tree leaf total N, 2010

	Vantage	Pine Creek	Sundown	Sunrise
Treatment	- - - - - - - - - - - - - Total N (%) - - - - - - - - - - - - -			
Herbicide	2.32 b	1.99	2.66	2.40 a
Tillage	2.34 b	2.08	2.71	2.43 a
Wood chip	2.39 a	2.00	2.51	2.27 b
Weed fabric	--	--	--	2.37 a
p	0.012	0.281	0.562	0.017

Foreman Land and Fruit Co.

Tree and Soil Water





Soil temperature (5 cm) Aug. 3

Till	**31.3º C**
Mulch	**19.7º C**

Optimum for dwarfing rootstock 14º C
(Skroch and Schribbs, 1986)

GreenMatch® herbicide, mid-summer

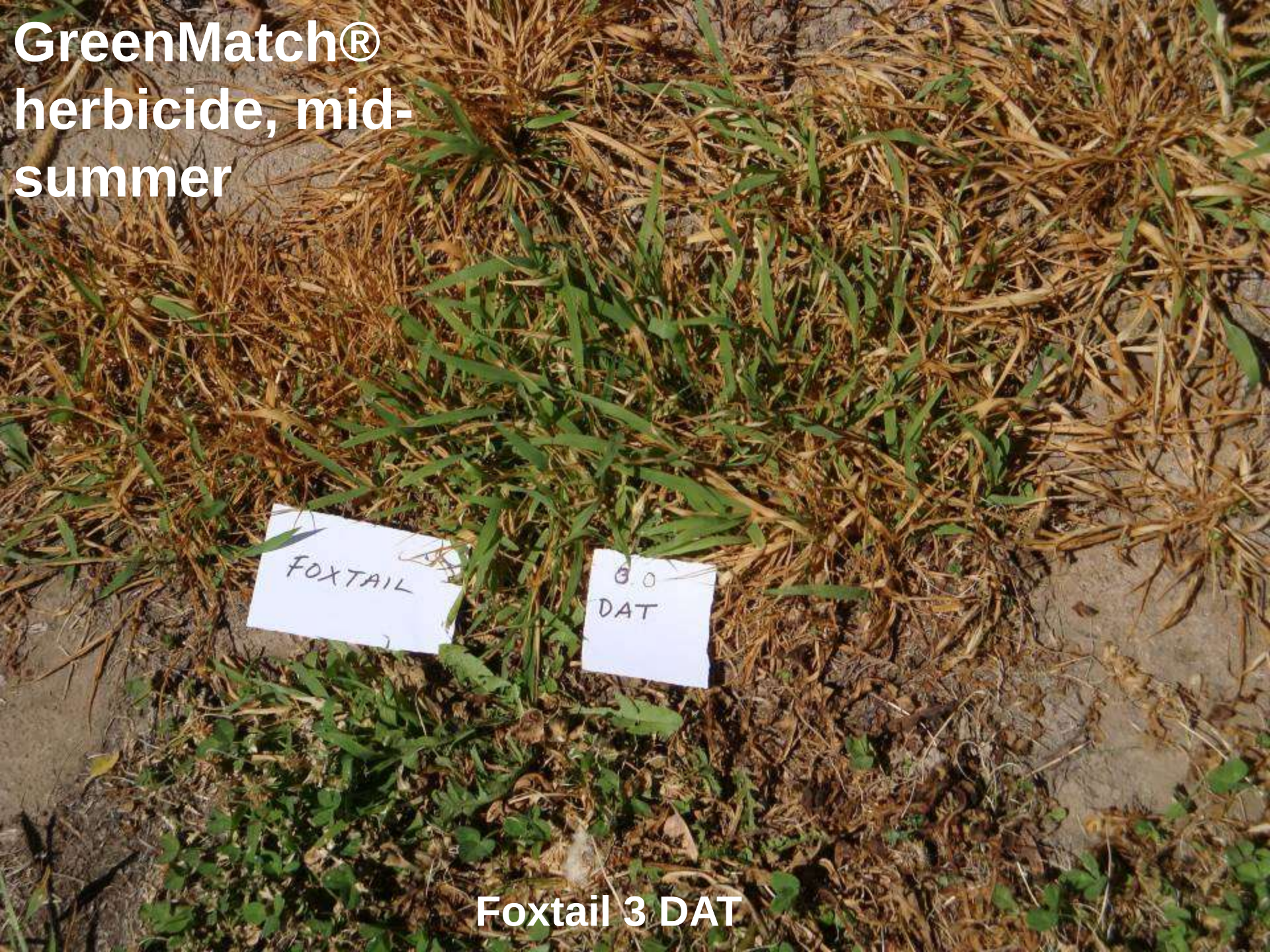
Lambsquarters 3 DAT

Nightshade
3 DAT

Dandelion 3 DAT

Dandelion 7 DAT

GreenMatch® herbicide, mid-summer

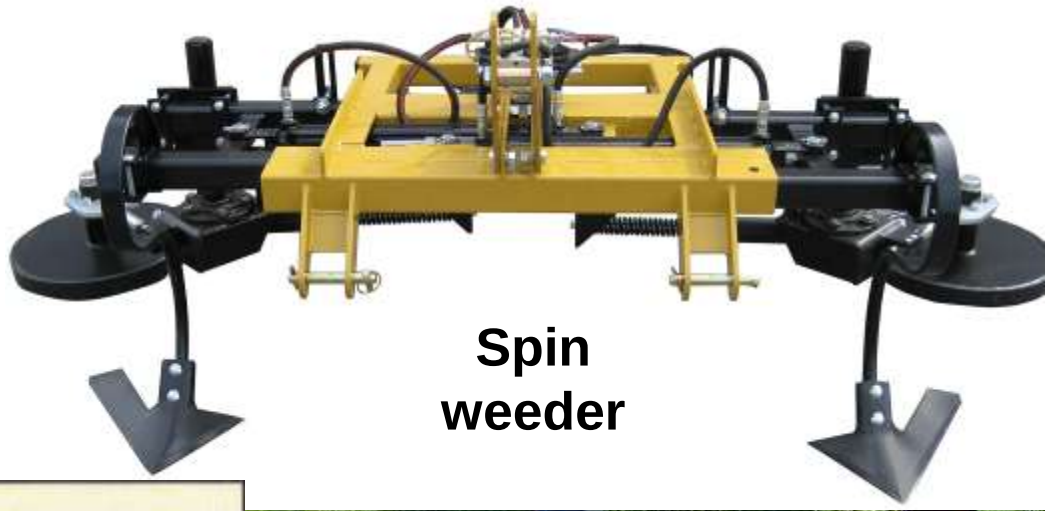


Foxtail 3 DAT

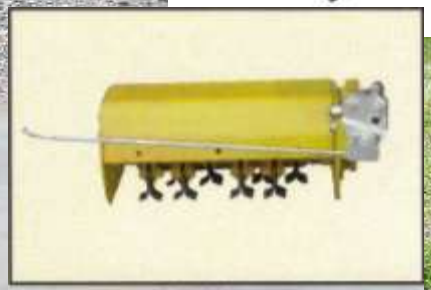
Going Forward

New Equipment

Weed brushes, Italy



Spin weeder



Flail Mower

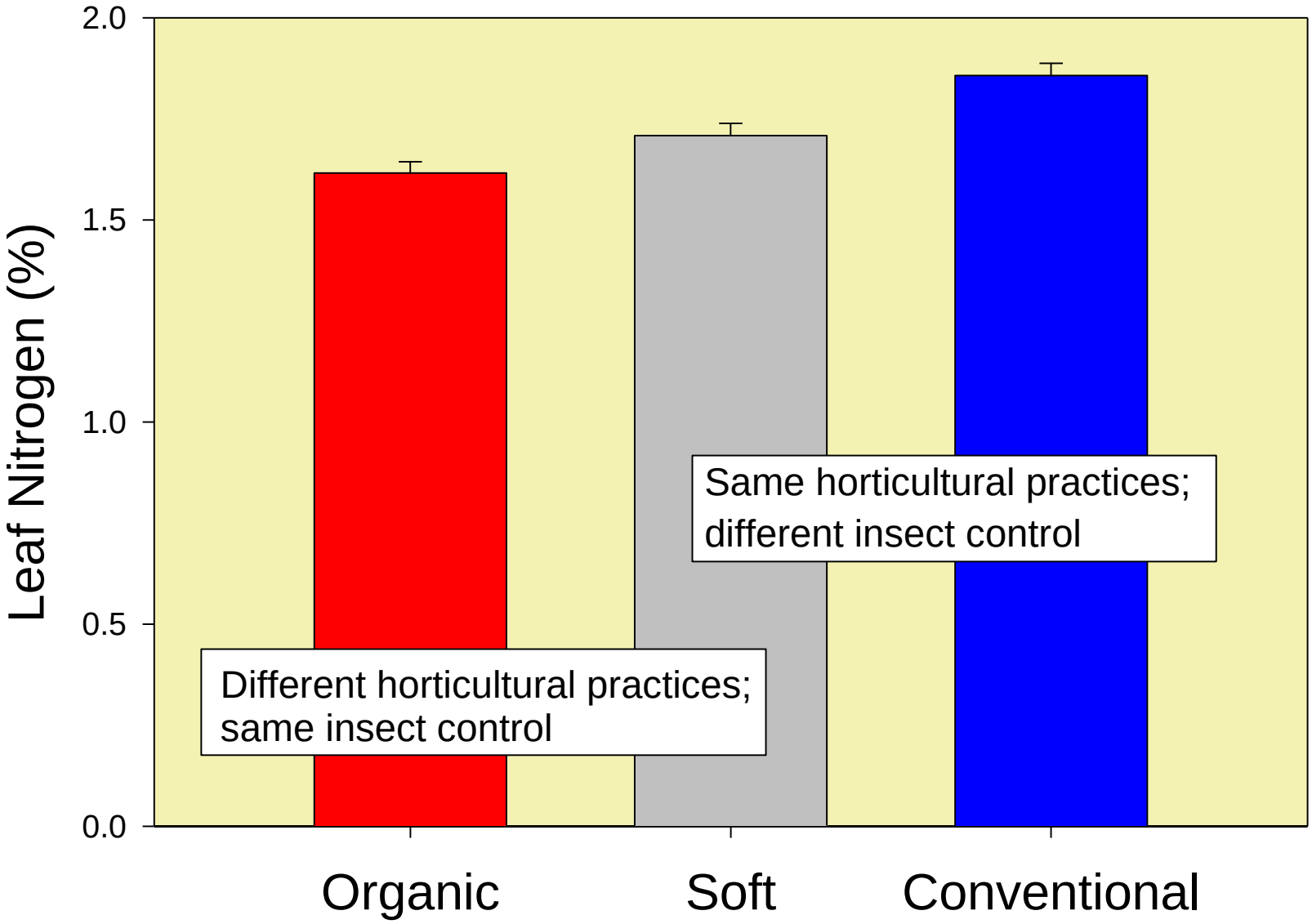
Spedovator

Microwave weeder

Nutrient Management

- Nitrogen – always needed
- Organic sources – nutrient release rate (manure vs compost), nutrient composition, origin (e.g. chicken and arsenic)
- Organic sources – higher transport cost, application cost; pre-harvest interval
- Need good water management
- Need weed control to minimize competition with trees

Peshastin Creek Growers Association
D'Anjou Pear Leaf Nitrogen, 2004



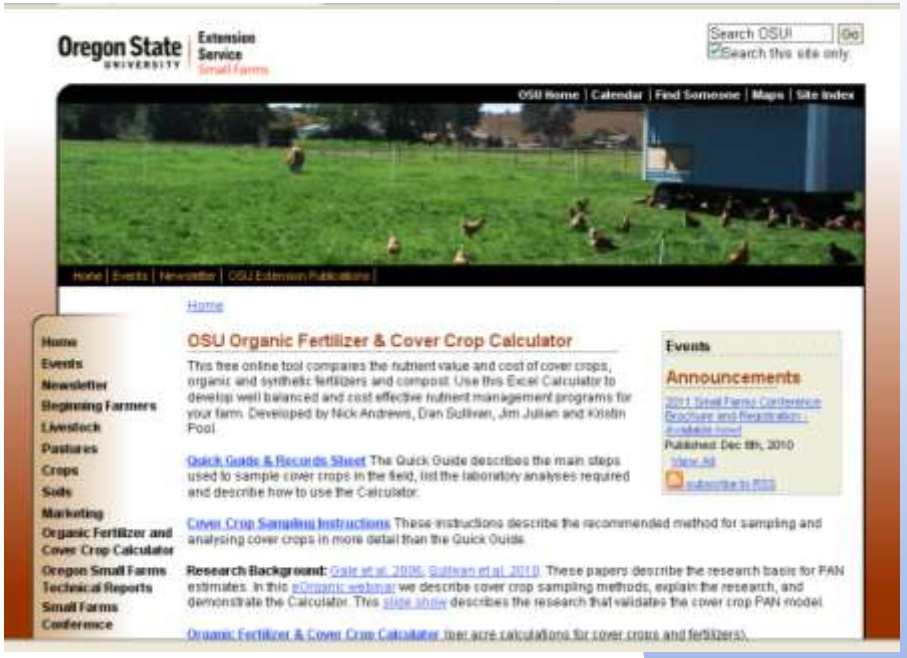
F. Peryea

Organic Nutrient Content, Release and Cost

Extensive lab and field research done on many amendments

Release rate correlated to total N

Organic fertilizer calculator developed based on this research



http://smallfarms.oregonstate.edu/calculator

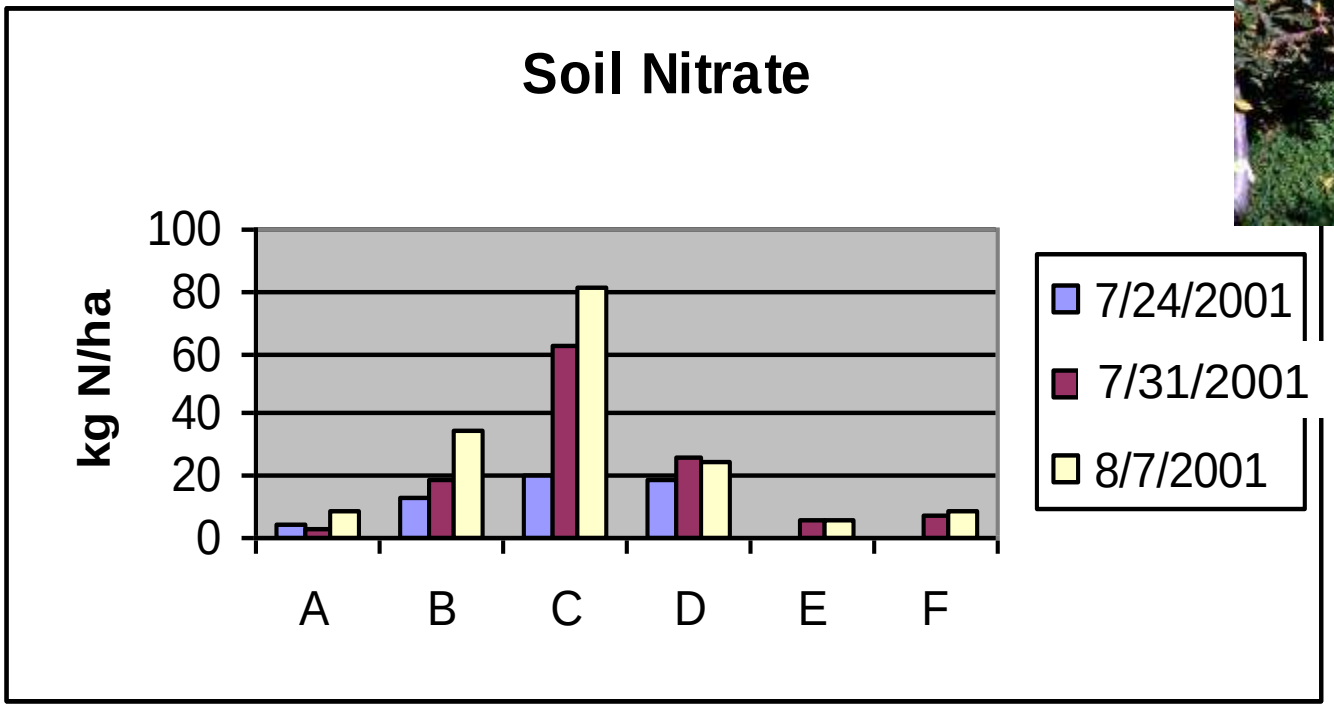
White clover living mulch

- In-row
- Recycles P, K
- Root N contributions, but N fix suppressed
- Suppresses weeds
- Rodent risk

- 46% of clover N mineralized over 3 weeks
- Tree growth, fruit yield enhanced

Grow Your Own N

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



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

Grow N Trial

- **Legumes direct seeded in drive alley (4’ swath) – May 19, 2008**
  - **Alfalfa cv. *Radiant***
  - **Jumbo Ladino white clover**
  - **Kura clover**
  - **Birdsfoot trefoil cv. *Norcen***
- **SPRAY or NO SPRAY prior to seeding**
- **Mow and blow on to tree row**

No-till drill

Alfalfa after seeding

Year 1

Ladino clover

Effect of Pre-seeding Treatment on Biomass

	Sum of 8/08, 7/09, 8/09 cuttings		Legume only, 7/09	
	Sprayed	*Unsprayed*	*Sprayed*	*Unsprayed*
	- - - - - - - - - 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**

Ladino Clover – May, Yr 2

Alfalfa – May, Yr 2

Mow and Blow

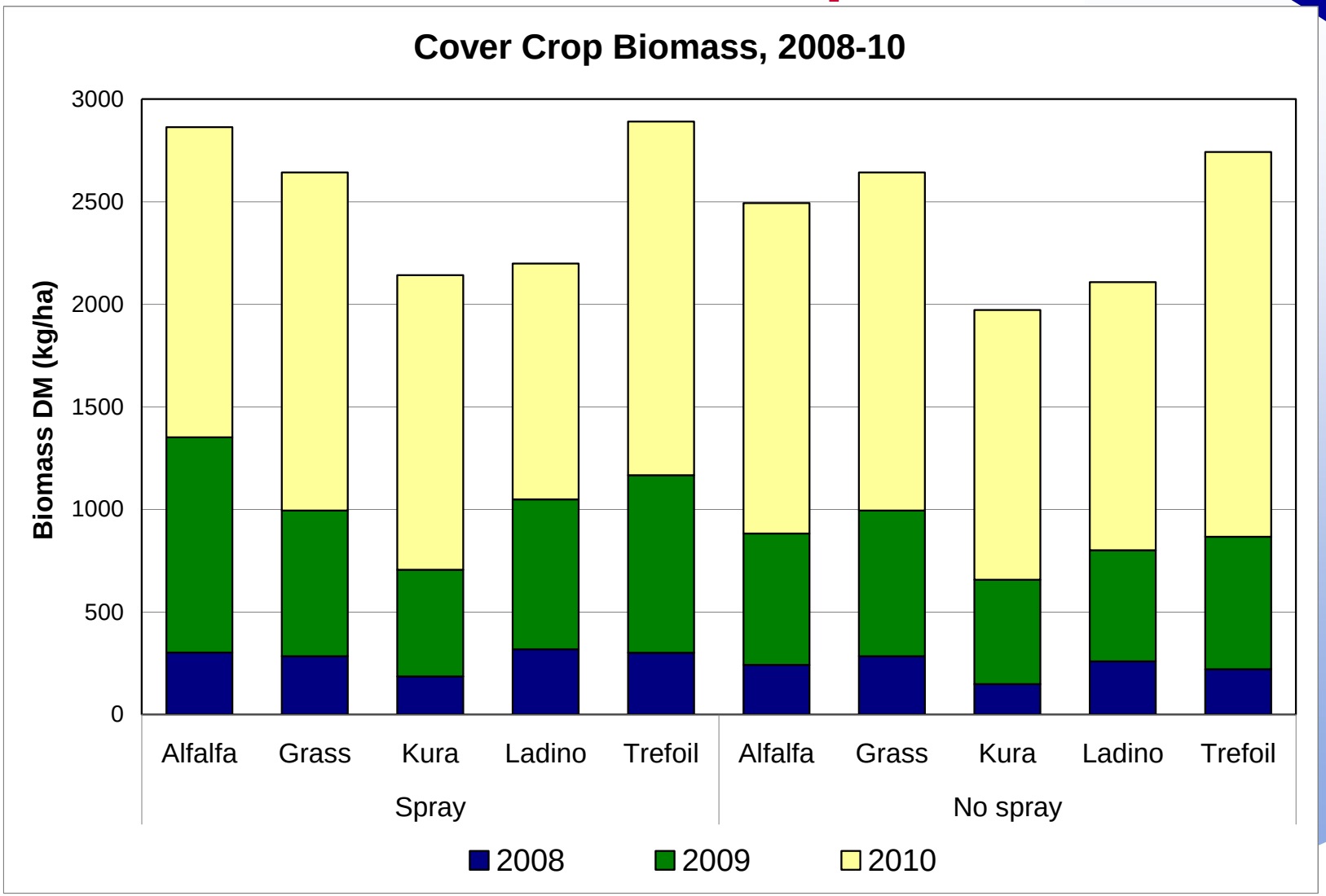
Legume residue in tree row after mow and blow

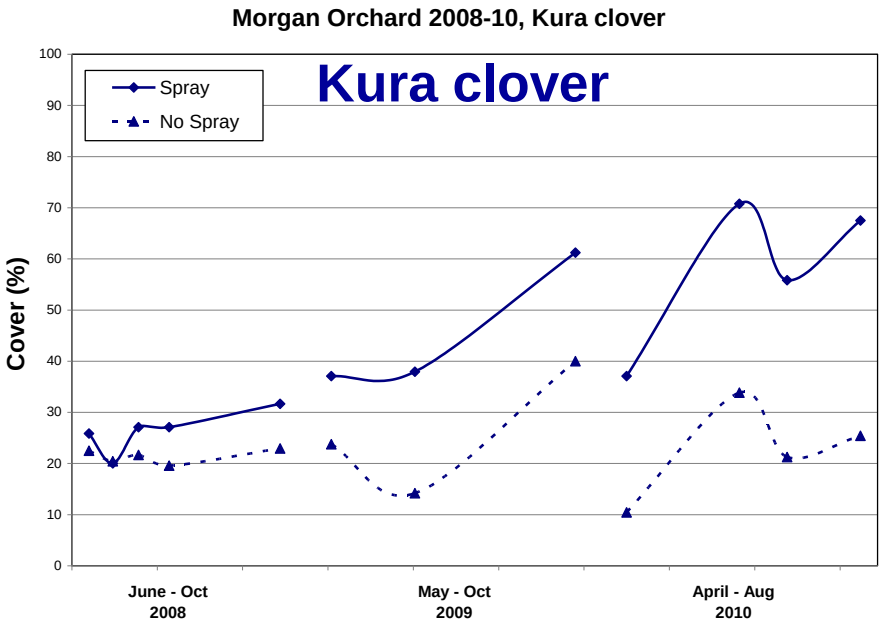
Year 3, 2010

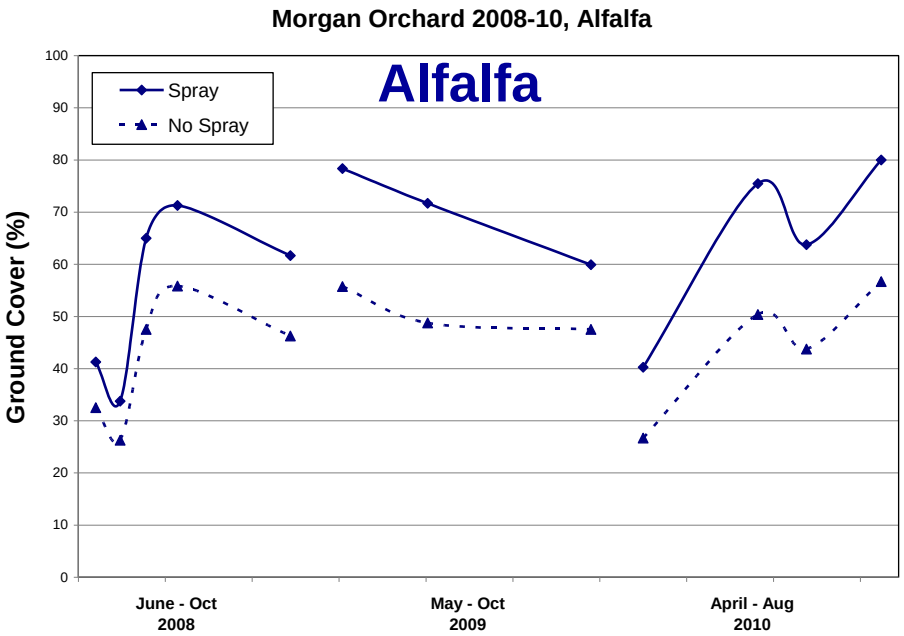
39 days after mowing

Morgan Orchard

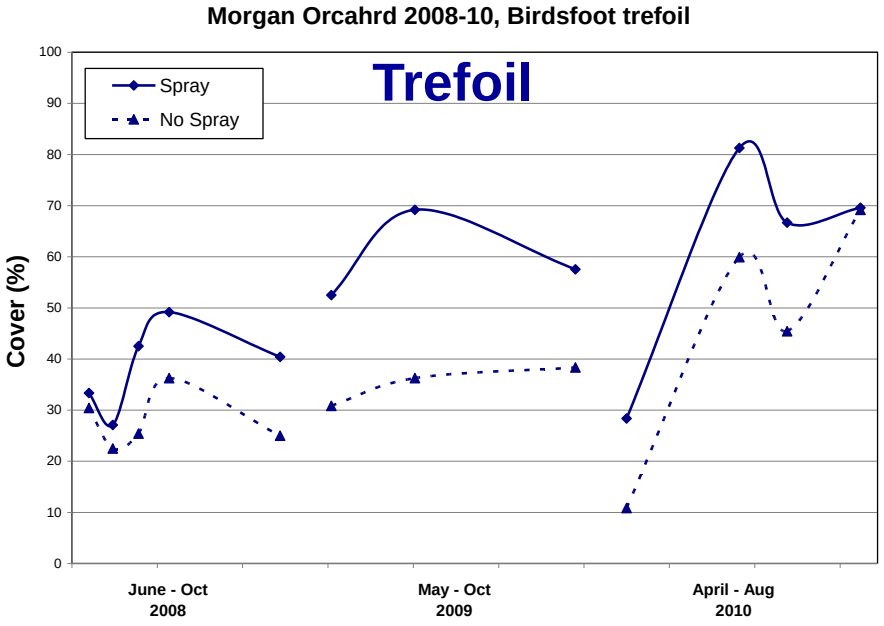
Cumulative Cover Crop Biomass

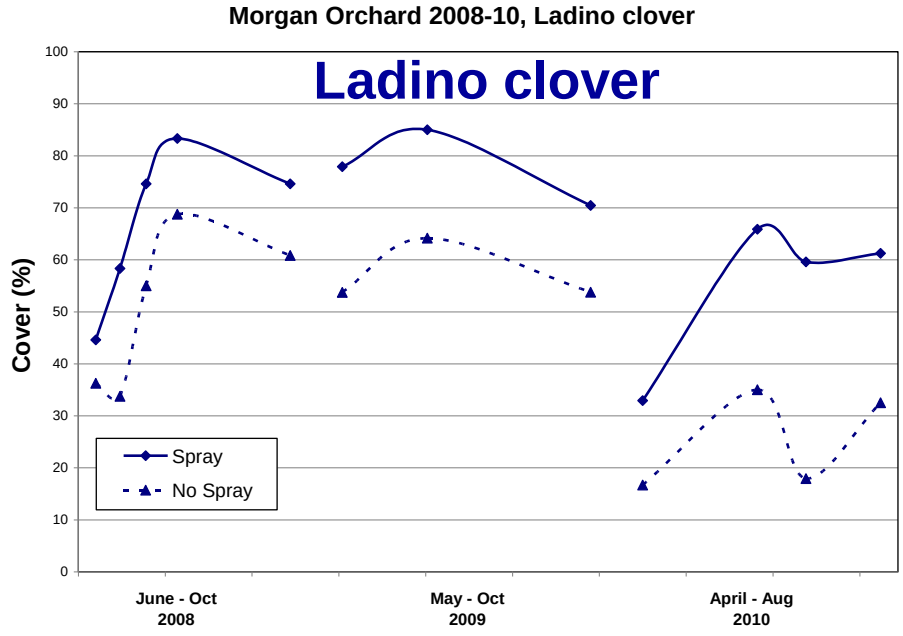






% Cover of Legumes in Drive Alley





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

Red Clover

N Contribution

	Biomass N 2009	Soil PRS 2009	Ave. Dry Matter*	2009 Tissue N	Ave. N Added
	(lb N/ac)	(ppm NO_3-N)	(ton/ac)	(%)	(lb N/ac)
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	32.00
Total	83.90

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

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

Width	N content	Fert. Value[a]
5'	101	$71
4'	81	$57
3'	59	$41

$84 cost / 130 lb N[b] (4 yr) = $0.65/lb

[a]Estimate N fertilizer at $0.70/lb

[b]40% avail., accounting for Nmin (50-70%), losses

What we learned so far …

- Need multiple years to assess species
- 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?
- Effects on soil P, K levels over time?

Thanks to USDA Organic Research Special Grant for funding.


Questions ?