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Organic Orchard Floor Management:

An Overview

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Wenatchee, WA

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Center for Sustaining Agriculture & Natural Resources

Outline

- Orchard floor management basics
- Weed control / vegetation management
    - Tillage, mulch, cover crops

Questions

- Soil quality / soil biology
- Water conservation
- Nutrient management

Questions

- Pest reduction
- Conclusions
- Questions and discussion

Mini Tatura Trellis on M.9
Washington

Orchard Floor Management

Functions	Impacted by:
Water intake/storage	Understory species
Physical support	Understory canopy
Gas exchange for roots	Irrigation system
Nutrient cycling/storage	Nutrient inputs
Habitat (micro, macro)	Spray drip
Micro-climate	Organic inputs

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)

Research Knowledge and Needs for Orchard Floor Management in Organic Tree Fruit Systems. Granatstein & Sánchez, 2009. Intl. J. Fruit Science 9:257-281.

Weed Control

Why control weeds ?

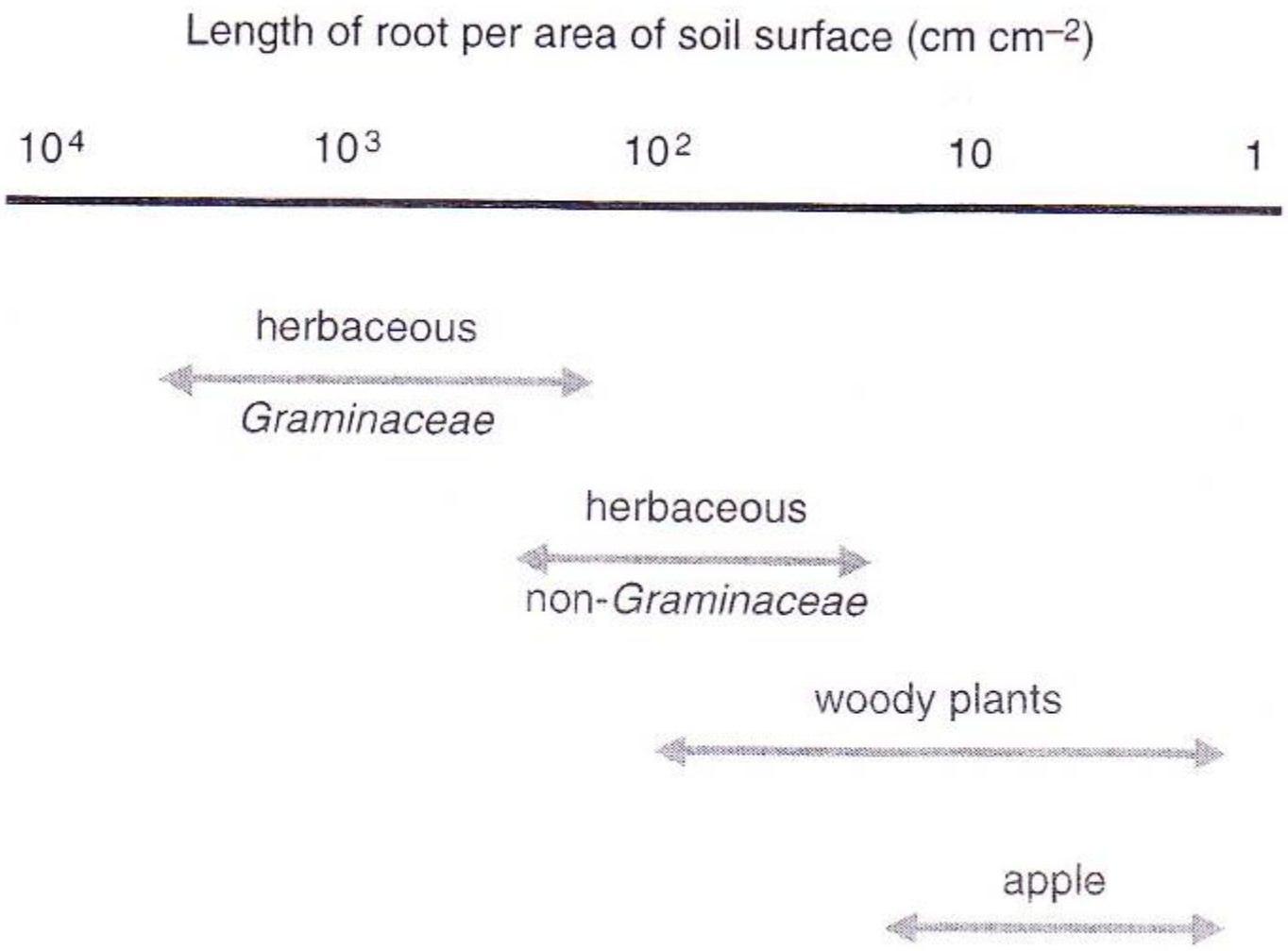
- Limit competition with young trees – nutrients, water
- Minimize rodent habitat
- Weeds as hosts for pests, disease inoculum

Why not?

Benefits to soil organisms

Enhance beneficial insects

Apple Root Density



(Neilsen and Neilsen, 2003)

Area and Timing of Weed Control

New York, 'Imperial Gala/M.26

Weed-free area (ft^2)	Cum. Yield (kg/tree)	Cum. Growth TCSA (cm^2)
0	14.9	20.0
22 (4.7' x 4.7')	41.0	25.5
43	38.2	25.6
65	41.1	24.7
LSD(.05)	11.0	5.1

- Planted in 1991; cumulative data for 1991-1995
- Highest early yield with weed control May, June, July
- After 18 yr, no yield trends for Herb., Mulch, Sod
- Tree growth, soil C > in Mulch
- Optimal=transient weed suppression during growing season, live vegetation other times

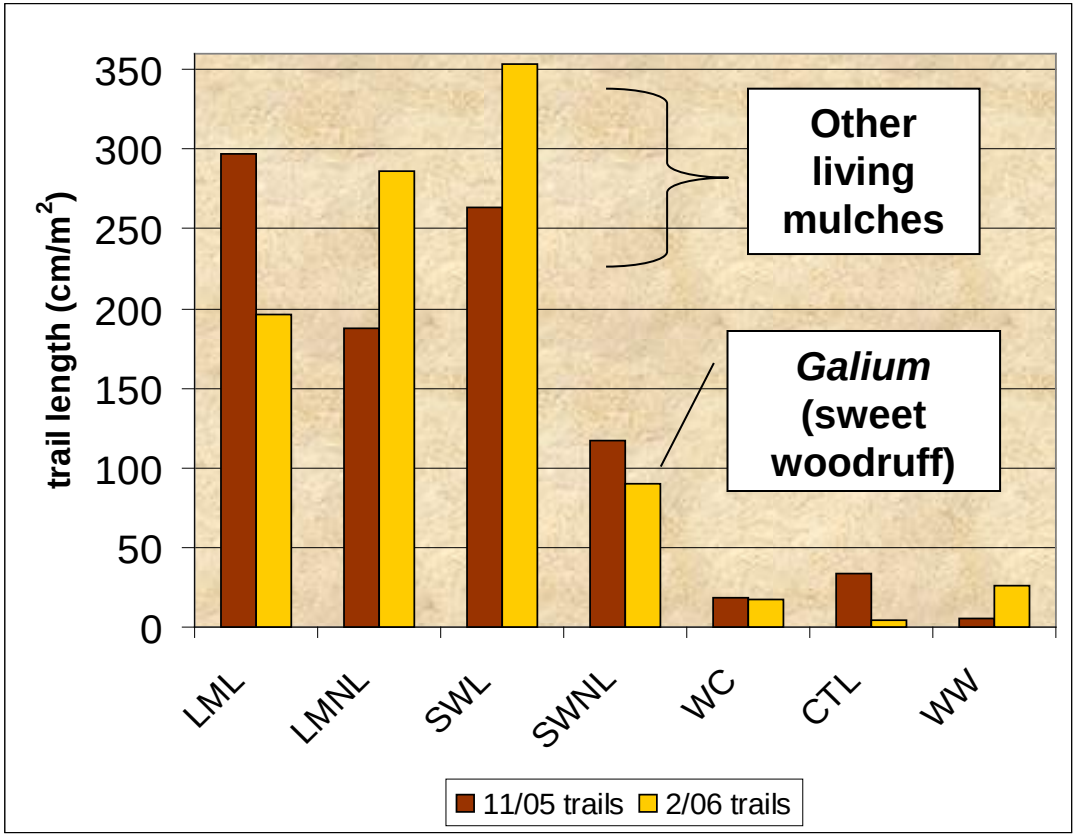
(Merwin & Ray, 1997; Atucha et al., 2011)

Vole Presence

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 fewer voles than other in-row living mulches**



Weed Control Options

Mechanical – tillage, mowing

Thermal – flame, hot water

Mulch, weed fabric

Competition – cover crops

Herbicides

Biocontrol – insects, pathogens

Soil conditions – fertility, structure

Wonder Weeder 440 ft/min

Vertical tine rotary weeder
20 ft/min


Flame Weeding
Brewster orchardist:
• Burn 4-5 ac/hr
• 10 gal propane/hr
• 4x per season
• Cost $70-80/ac
Dovex Orchard, June 2007


Weed Fabric
Swezey,
2005

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**
- **Rodent challenges**

(Tomasini et al., 2007)

Photo: H. Ostenson

Wood Chip Mulch

- weed control 1-3 yr
- increased fruit size & tree growth

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
Tillage (WW)	0.25 hr	4/yr	0	40	40

(adapted from Hogue et al., 2002)

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

(Wooldridge and Harris, 1989)

Reported problems with tillage:

- **Loss of organic matter**
- **Less tree vigor**
- **Lower fruit yield, fruit size**
- **Trees falling over**

Orchard Mulching

Forest litter = mulch

Mulches affect:

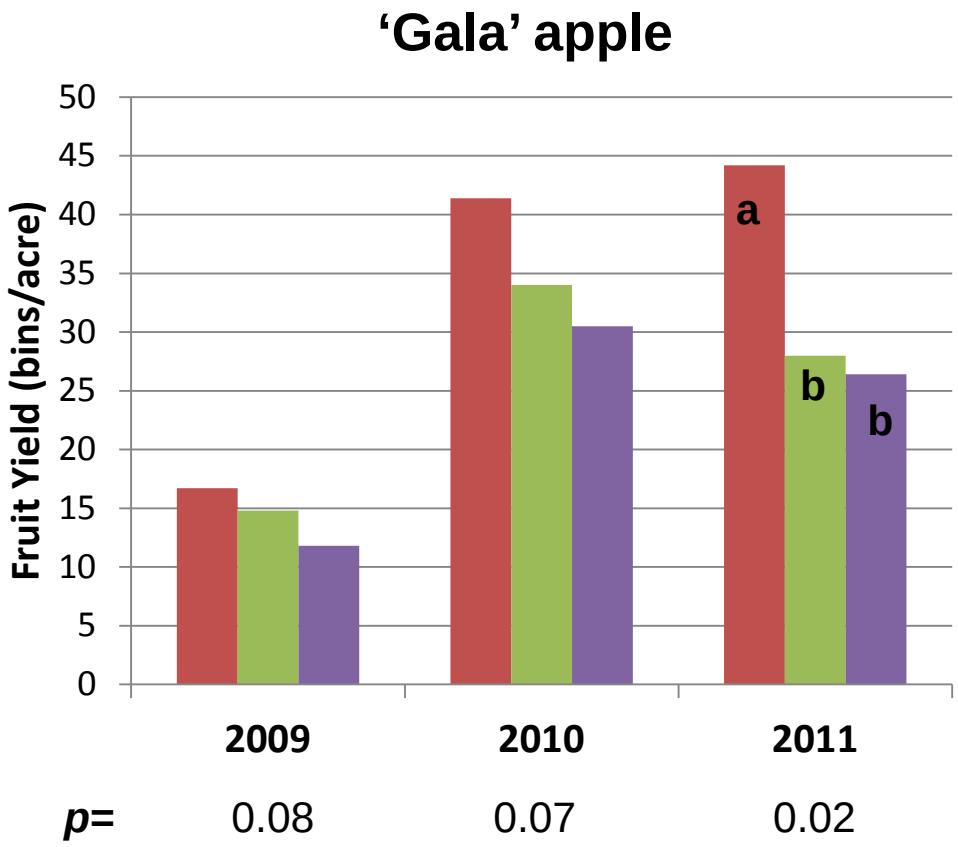
- **Weeds**
- **Soil and orchard temperature**
- **Soil moisture, physical properties**
- **Soil C, N, other nutrients**
- **Soil biology, food web**
- **Tree performance**
- **Pests (rodents)**

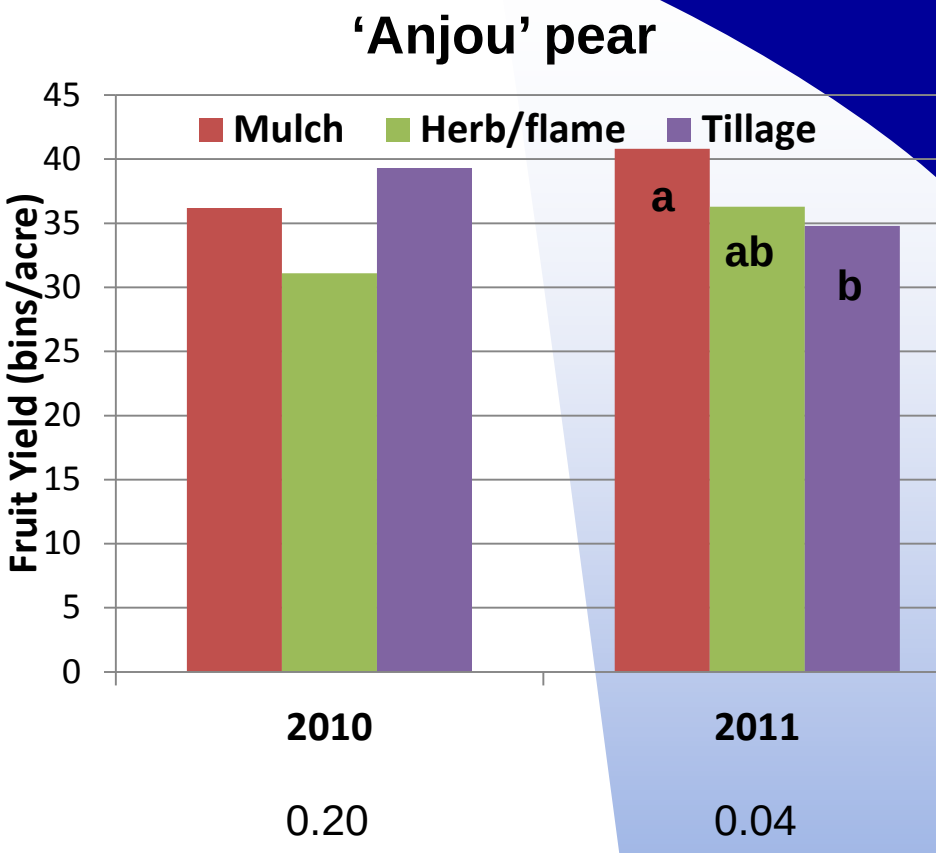
Mulch Trial results

8-yr 'Gala'/M.26 – Wenatchee, WA

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

Yield Effects





Commercial organic orchards, large-scale field plots

Apple 3-yr Mulch cost $1,429/acre
3-yr Mulch net present value +2,984/acre

Orchard Mulching Trials
Summerland, BC

5th 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)

Questions ?

Soil Quality

Soil Organic Matter

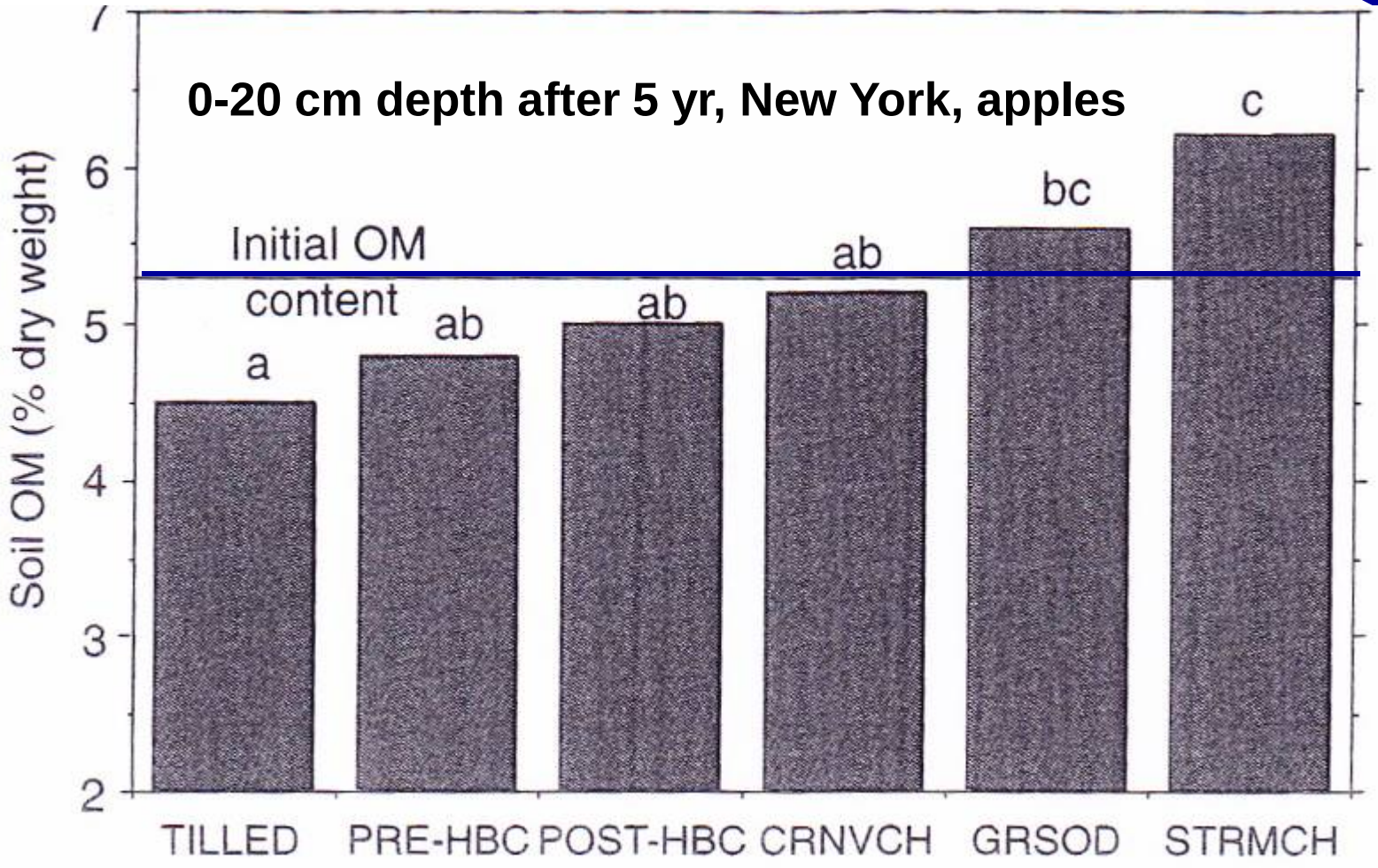
Soil Biology

Microbe - Microbe

Microbe - Macrofauna

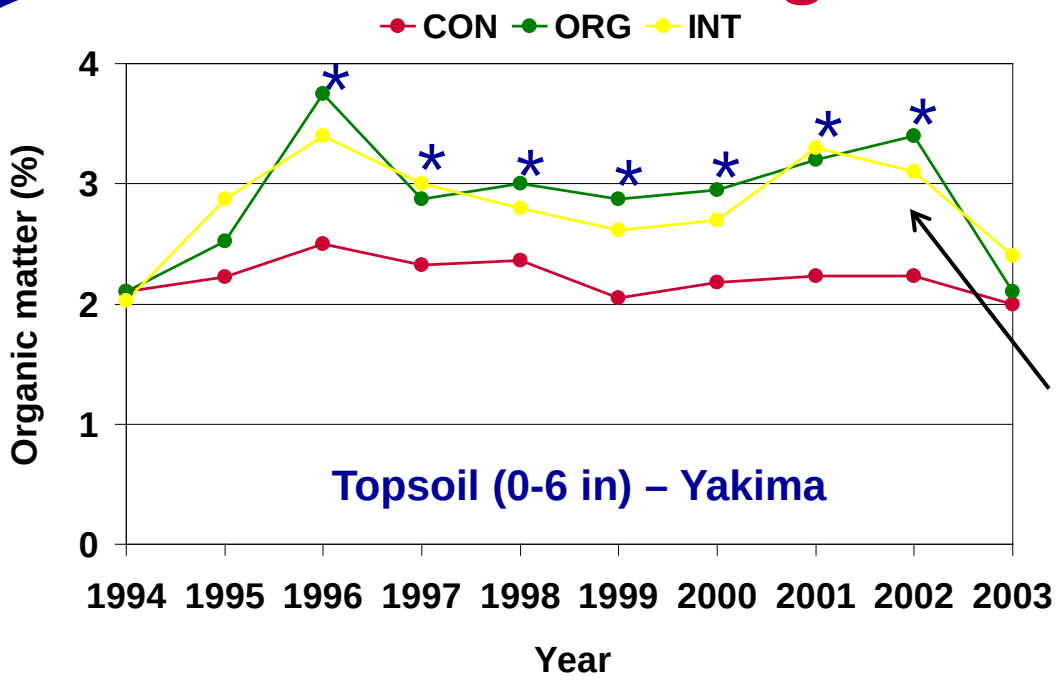
Microbe - Plant

Soil Organic Matter Change



(Merwin, 2003)

Soil Organic Matter



Compost 0.4 t/ac

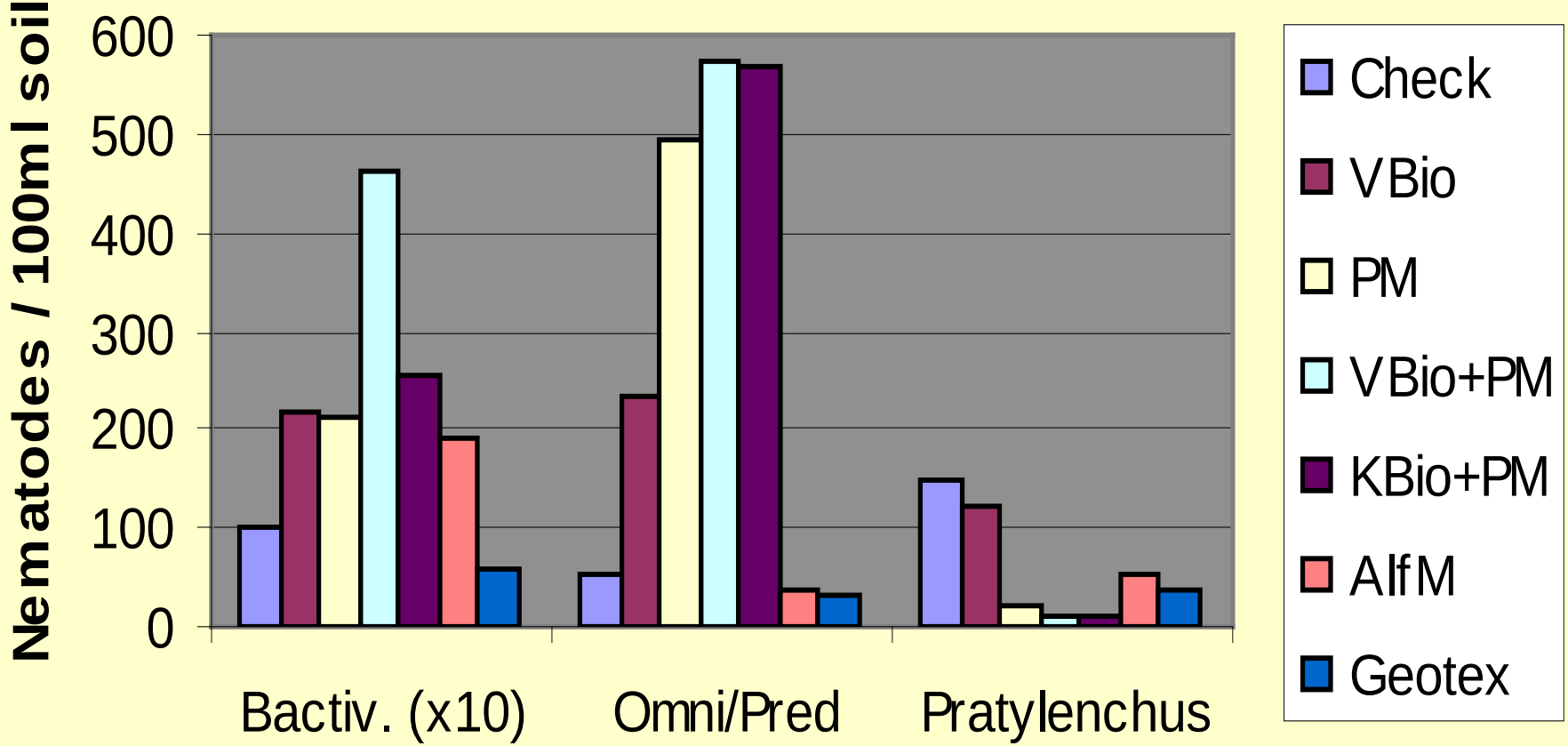
Tillage for weed control

CA strawberries – paired fields		
Soil property (0-10 cm)	**Con**	**Org**
Total C (g C/kg soil)	8.25	10.04 *
Total N (g N/kg soil)	0.666	0.867 **
Organic matter (mg/kg soil)	1.46	1.84 *
Microbial biomass (μg CO_2-C/g soil)	96	249 ***

Compost (t/ac)
CON 5-6
ORG 9-11

Courtesy: P. Andrews

Effect of Mulches on Nematodes in Orchard Soil - Summerland, BC



(T. Forge)

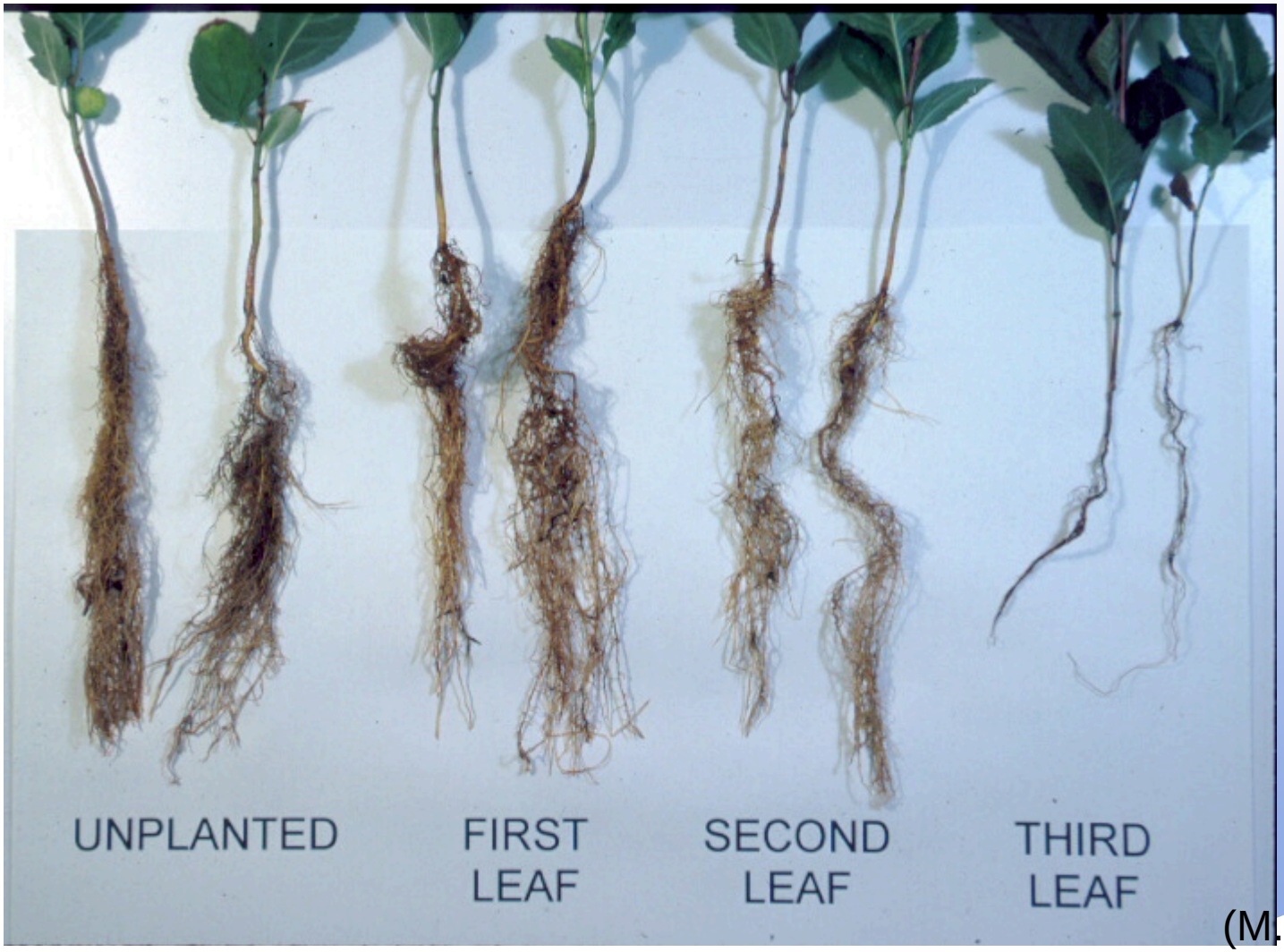
Effect of Apple Replant Disease
Gala/M26, Moxee, WA

Replant soil

‘Virgin’ soil

(M. Mazzola)

Growth of ‘Gala’ Apple Seedlings in Soil from Orchard Blocks of Varying Age



(M. Mazzola)

Growth of 'Gala' Apple Seedlings in CV Orchard Replant Soil Following Planting with Different Wheat Cultivars

(M. Mazzola)

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)

White clover living mulch

Rodents – the weak link for clover.

Growing N in the Orchard

Side Discharge/Mulching Mower

- Reduced passes with mower
- Reduced weed control
- Reduced irrigation

(H. Huntley)

Orchard Alley Legumes

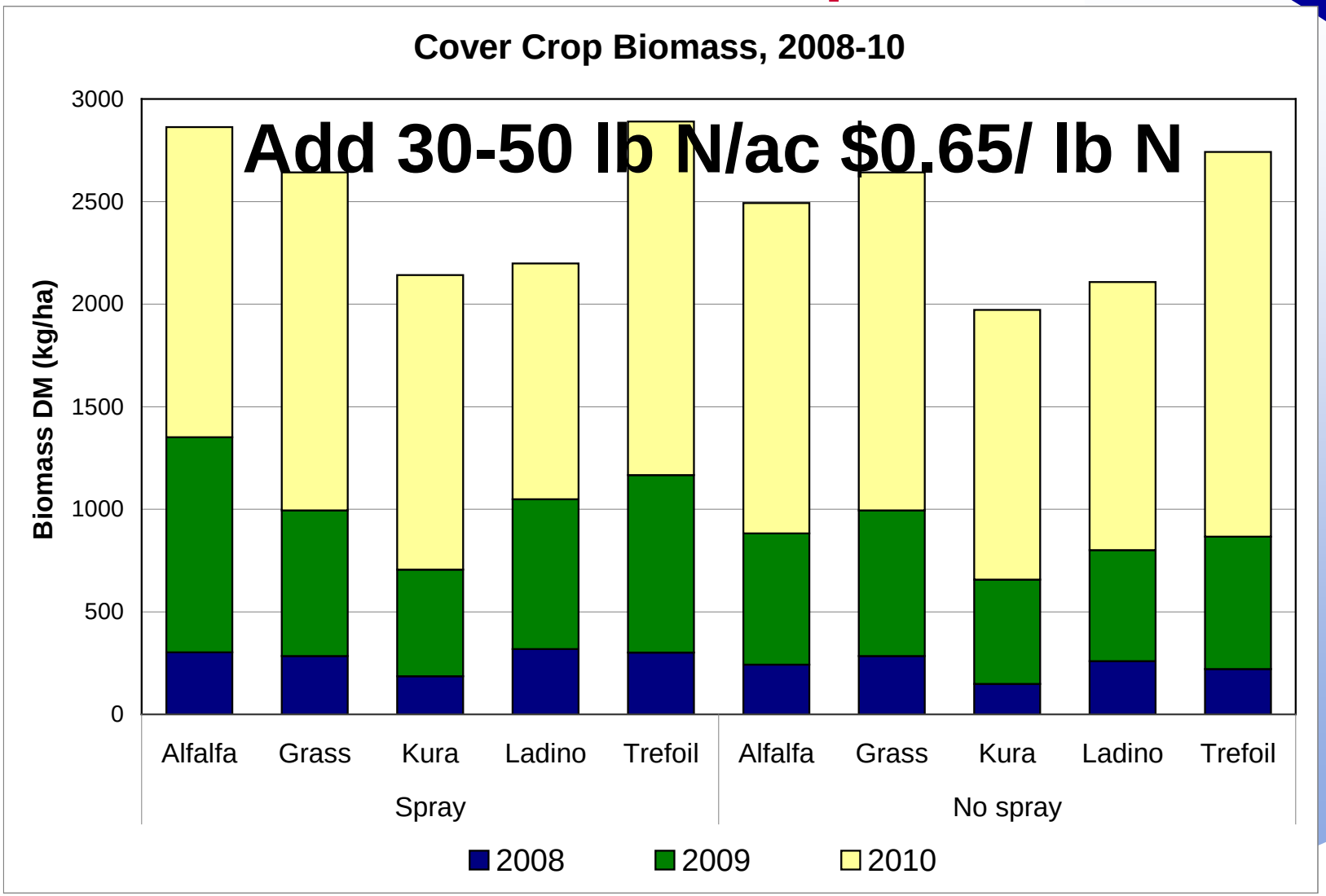
Direct seeded, May 2008

Year 3, 39 days after mowing


Legume Cover Crops for N
5th year
Mulch build-up
Kura clover

Morgan Orchard

Cumulative Cover Crop Biomass



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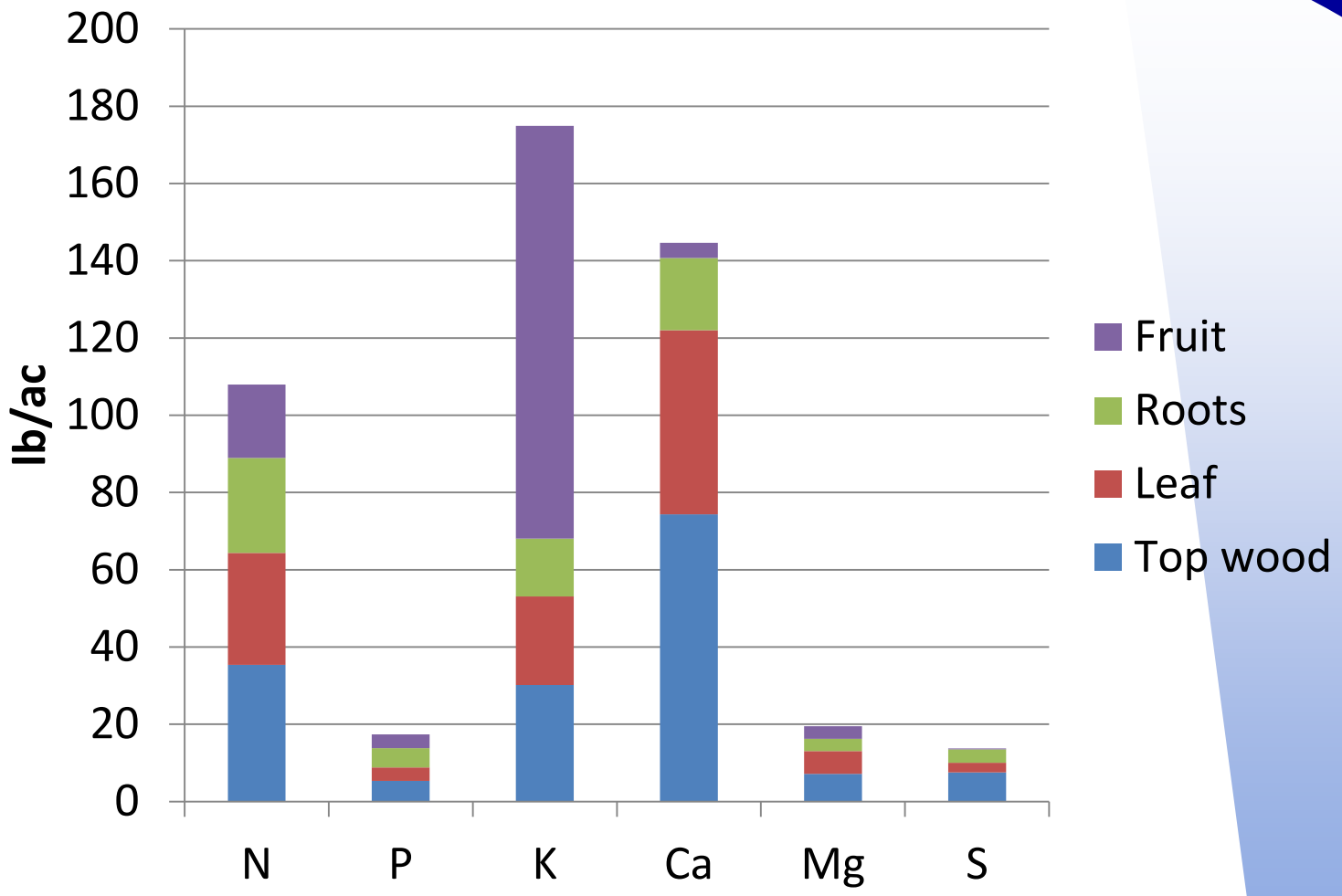
Nutrient Management

Nutrient Content and Distribution in Apple



14 yr old 'Golden Delicious', 200 trees/acre

(Neilsen and Neilsen, 2003)

Nutrient Export by Tree Fruits

	Yield	lb/acre			
		N	P	K	Ca
Apple	50 bin	26	2	56	2
Pear	30 ton	36	7	77	8
Peach	12.5 ton	30	3	73	3

N (lb/ac)	Leaf N %	Yield (bin/ac)	Crop Removal (lb/ac)	Excess N (lb/ac)
45	1.9-2.4	46	21	23
134	2.4-3.2	52	24	109
223	2.5-3.1	43	20	202

(Neilsen & Neilsen, 2003)

Need careful irrigation management to avoid N leaching

Nutrient Additions

Chicken manure compost
For 50 lb avail N, need 3.8 ton/ac

	Avail./ton	For 50 lb N	Crop Removal
	(lb/ton)	(lb/ac)	(lb/ac)
N	**13.1**	**50**	**26**
P	**3.7**	**14**	**2**
K	**29.2**	**111**	**56**

But compost contains 160 lb total N

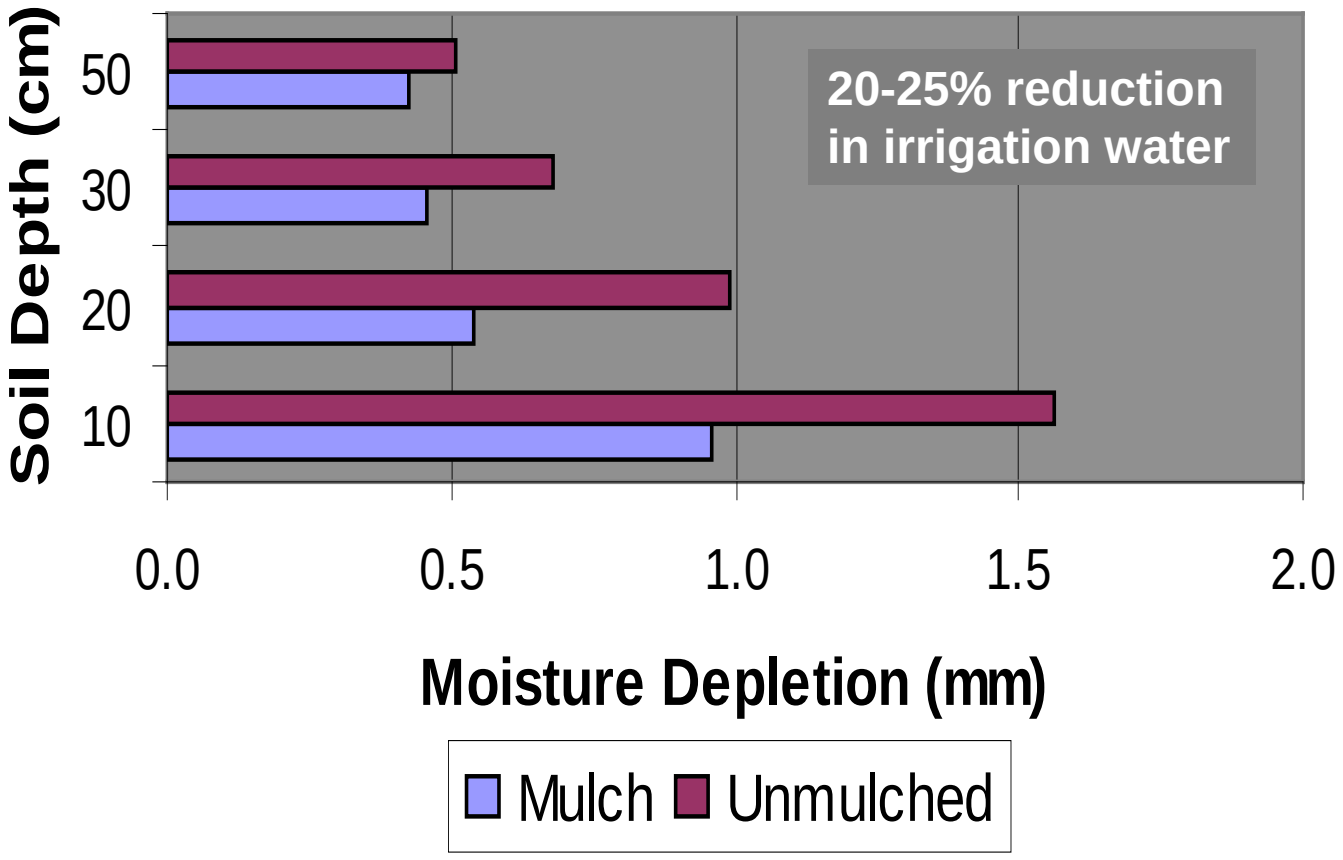
Feather meal **12% N**
Soybean meal **6% N**

Questions ?

Spreading compost in an organic orchard

Water Conservation

Effect of Orchard Mulching on Soil Moisture Depletion



Pest Reduction

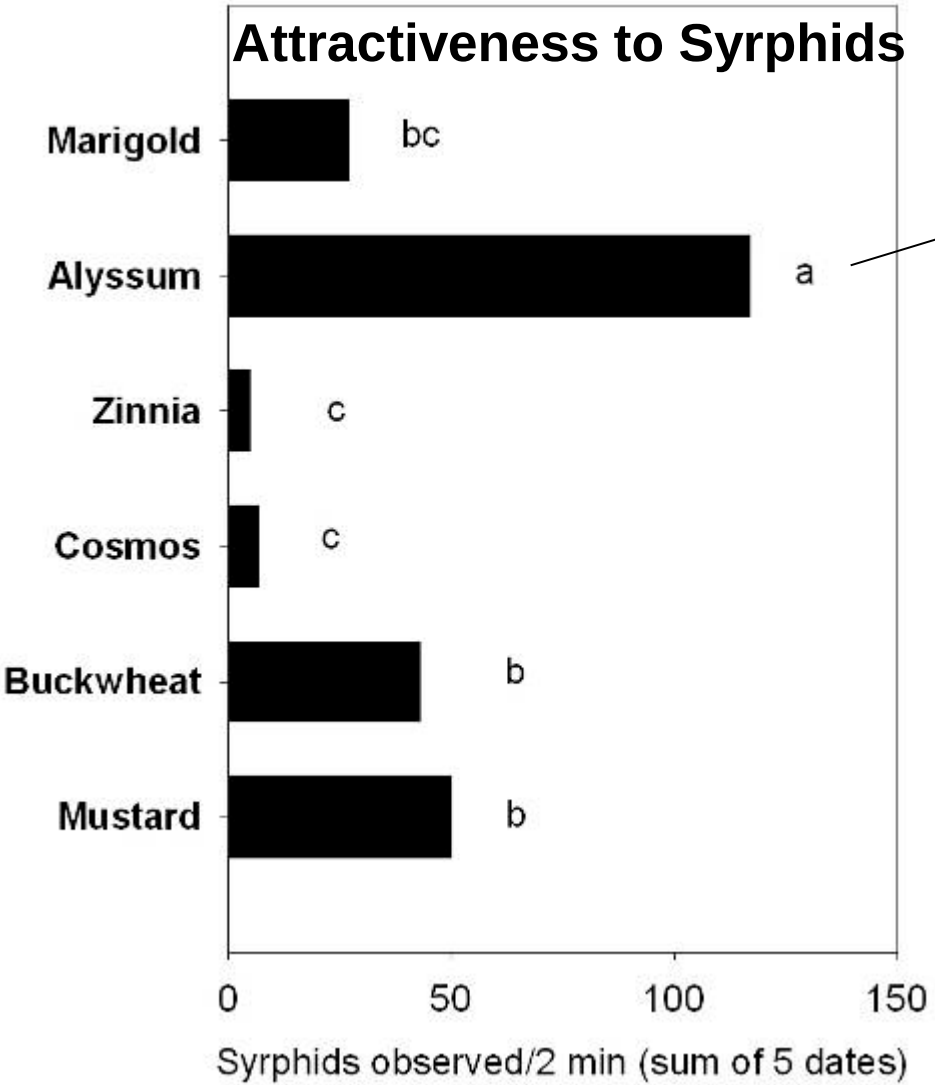
Cover crops can control tree vigor through regulation of N and water, thus reducing some pests.

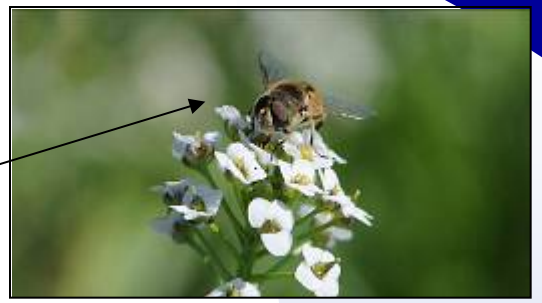
Apple (WV) – lower aphid populations in trees with cover crop than with herbicide strip; also 50% less powdery mildew, slightly less scab, and no fire blight with lower vigor. ***(Brown & Schmitt, 1996)***

Successful biocontrol examples usually involve a specific pest-predator relation.

Citrus (China) – control of citrus red mite by natural enemies (*Amblyseius* spp.) encouraged on the weed *Ageratum conyzoides;* cover is planted or conserved; used on over 135,000 ha of citrus. ***(Liang & Huang, 1994)***

Syrphids to Control Wooly Apple Aphid (WAA)





(E. Beers)

Insectary Plantings - Alyssum

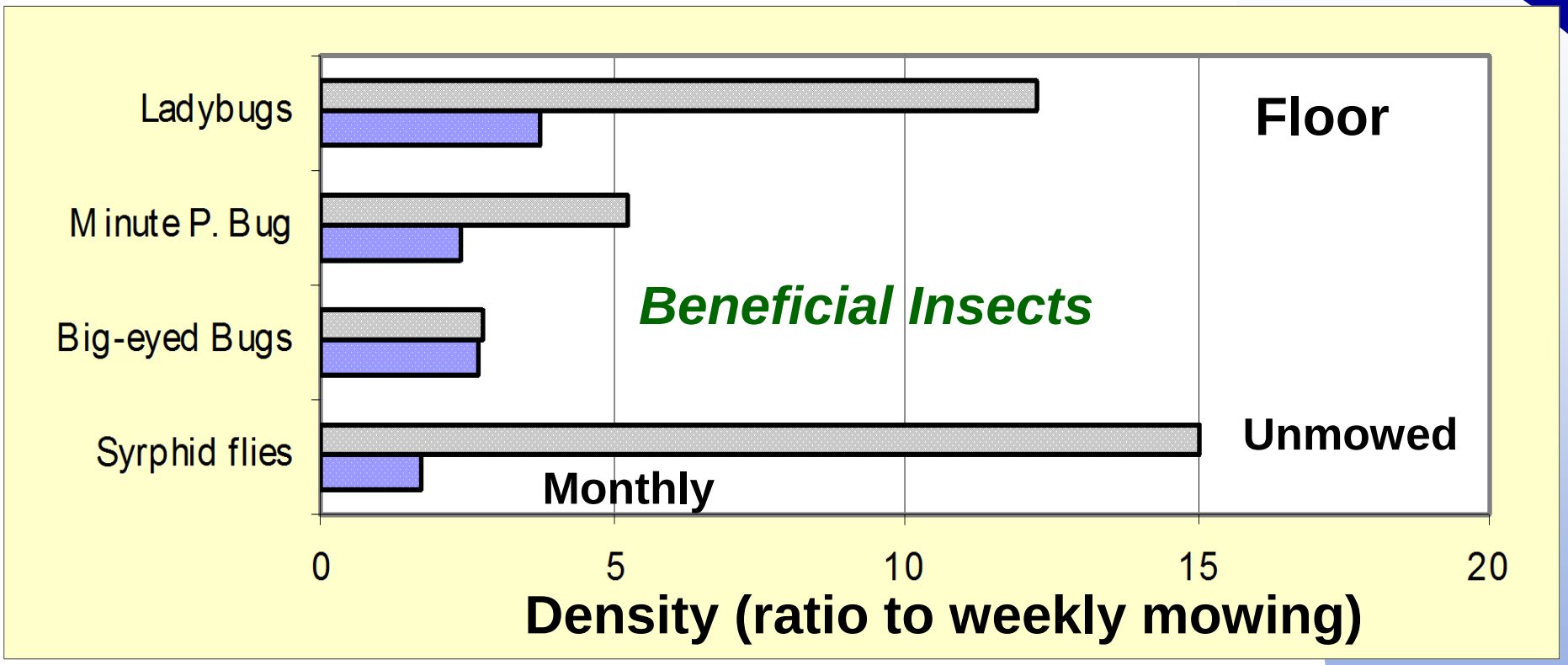
20-acre orchard planted with an alyssum cover crop, July 2009, Wapato, WA

Blooming Alyssum

(E. Beers)

Effect of mowing on insect fauna in pears

Hood River, OR



(Horton, 1998)

Effect of mowing on insect fauna in pears
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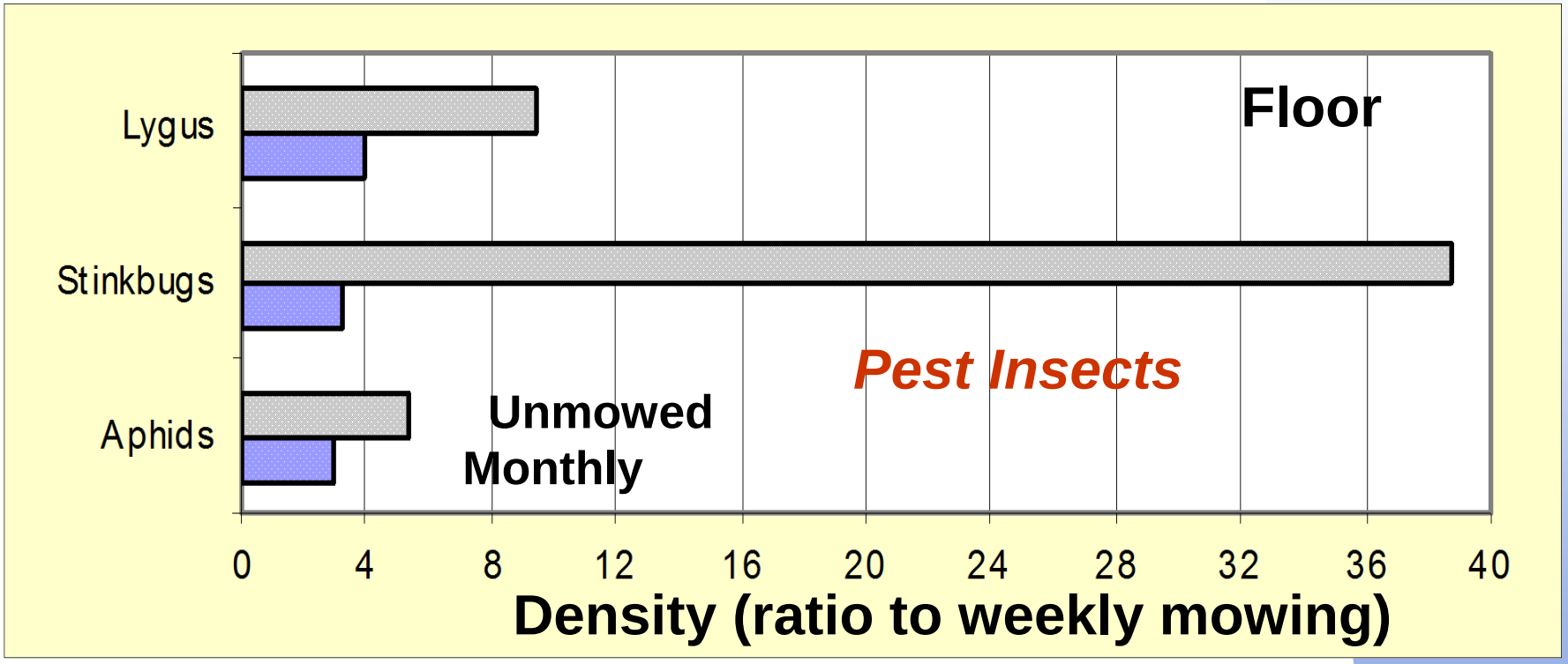


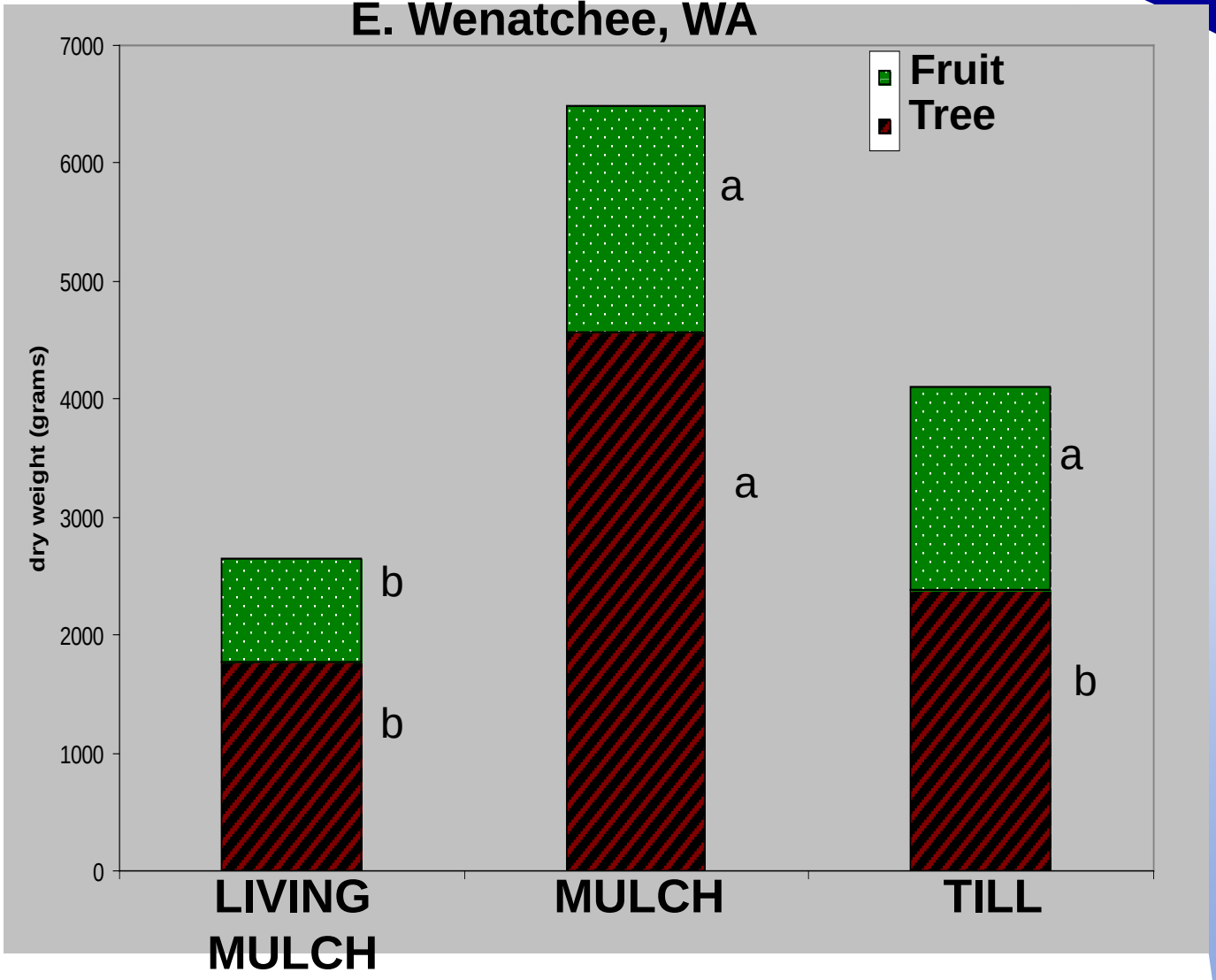
(Horton, 1998)

Goal: “Happy Trees”

Total Biomass

3-yr Pinova/EMLA.7

E. Wenatchee, WA



(D. TerAvest)

‘Mow & Blow’ Mulch Trial

Quincy, WA

- **‘Fuji/M.9’ 2nd leaf**
- **Tall fescue forage grass mix**
- **Mowed multiple times**
- **Oct. 10 – about 10 MT/ha of mulch on tree row (1x)**

TRT	% Increase TCSA
Bare	94 a
1x	96 a
2x	109 b

Prunings for Mulch

2/18/10

Prunings for Mulch

Prunings for Mulch

Prunings for Mulch

Knowledge Gaps

- **Is there an ideal soil quality for orchards?**
- **Manipulation of rhizosphere vs. bulk soil for specific results**
- **Suitable cover crops; species, varieties, mixes**
- **Pest / nutrition interactions**
- **Better weed control options**

What we learned so far …

- No perfect system for weed control
- Ideal: avoid tillage; cover soil
- Need to try more combinations of tactics
- Can generate mulch internal to orchard, but will not provide sufficient weed control
- Can generate a large share of tree N need internally
- Rodents a major barrier
- Potential multiple benefits e.g. insect biocontrol, water savings, better trees

http://www.tfrec.wsu.edu/OrganicIFP

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Questions ?


Living mulches in October

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2nd International Organic Fruit Symposium
http://www.extension.org/pages/64359/2nd-international-organic-fruit-research-symposium