

Orchard Floor Management

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Outline

- Orchard floor management basics
- Weed control
- Soil quality and soil biology
- Mulching and cover crops
- Management effects on pests, water
- Conclusions
- Questions and discussion



Spray-on paper mulch

Mini Tatura Trellis on M.9 *Washington*



Standard System

Herbicide strip, grass alley

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



(Neilsen and Neilsen, 2003)

Orchard Floor Management

Functions

Water intake/storage
Physical support
Gas exchange for roots
Nutrient cycling/storage
Habitat (micro, macro)
Micro-climate

Impacted by:

Understory species
Understory canopy
Irrigation system
Nutrient inputs
Spray drip
Organic inputs

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
- dwarf rootstocks grow best at 14°C vs. up to 27°C for seedling rootstocks

(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)

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

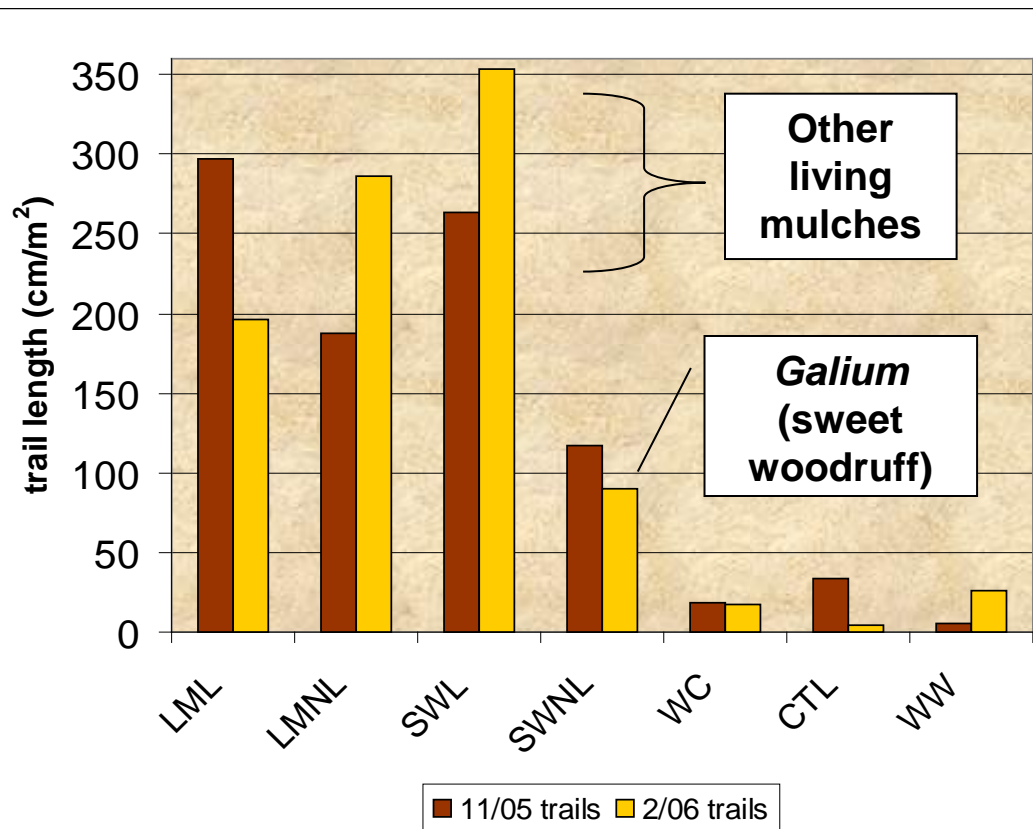


Vole Presence

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



Weeds don't kill trees; rodents do

Area and Timing of Weed Control

New York, 'Imperial Gala/M.26

<u>Weed-free area (ft²)</u>	<u>Cum. Yield (kg/tree)</u>	<u>Cum. Growth TCSA (cm²)</u>
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
- After 18 yr, no consistent yield trends
- Tree growth, soil C > in Mulch
- Optimal=transient weed suppression during growing season, live vegetation other times

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

Area and Timing of Weed Control

New York, 'Imperial Gala/M.26'

Weed Control Time		Cumulative Yield
<u>(days)</u>	<u>(month)</u>	<u>(kg/tree)</u>
0	check	15.0
30	May	34.4
30	June	34.5
30	July	30.7
30	August	36.6
60	May, June	46.3
60	June, July	42.7
60	July, Aug	40.5
90	May, June, July	51.9
90	June, July, Aug	46.0

(Merwin & Ray, 1997)

Alternative Weed Control Costs

Method	Rate (ac)	Freq.	Cost/ac/yr (\$)		
			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)

Flame Weeding

Brewster orchardist:

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



Dovex Orchard, June 2007



Wonder Weeder 440 ft/min

Can be cheaper
than glyphosate

Weed Badger 20 ft/min





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

(Tomasini et al., 2007)



Photo: H. Ostenson

Wood Chip Mulch



- weed control
- increased fruit size & tree growth

**All these
practices can
impact the soil**

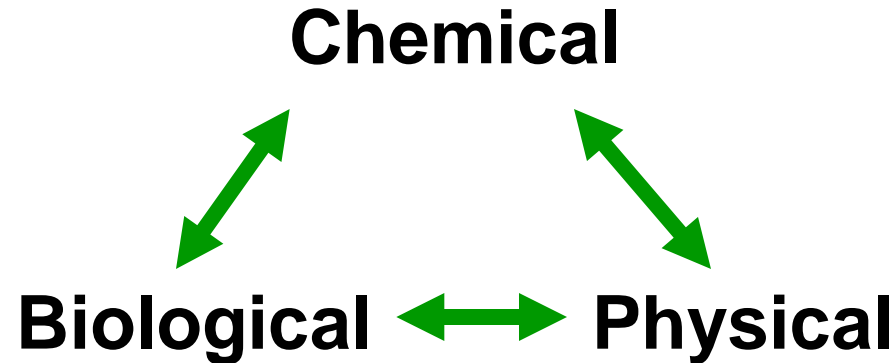
Spreading wood chip mulch



Wonder Weeder results



Soil Quality



- **Dynamic interplay of 3 aspects**
- **Short-term and long-term changes**
- **Influenced by environment (climate, geology, plants)**
- **Influenced by human activity (erosion, fertilization, irrigation, plants)**

Carbon – the key ingredient

Carbon (C), the basis of Soil Organic Matter, which affects:

Physical – bulk density, aggregate stability, water-holding capacity

Chemical – cation exchange capacity, nutrient release

Biological – energy source for microbes, base of the soil food web, nutrient turnover, soil-borne diseases

Soil Organic Matter

Friends:

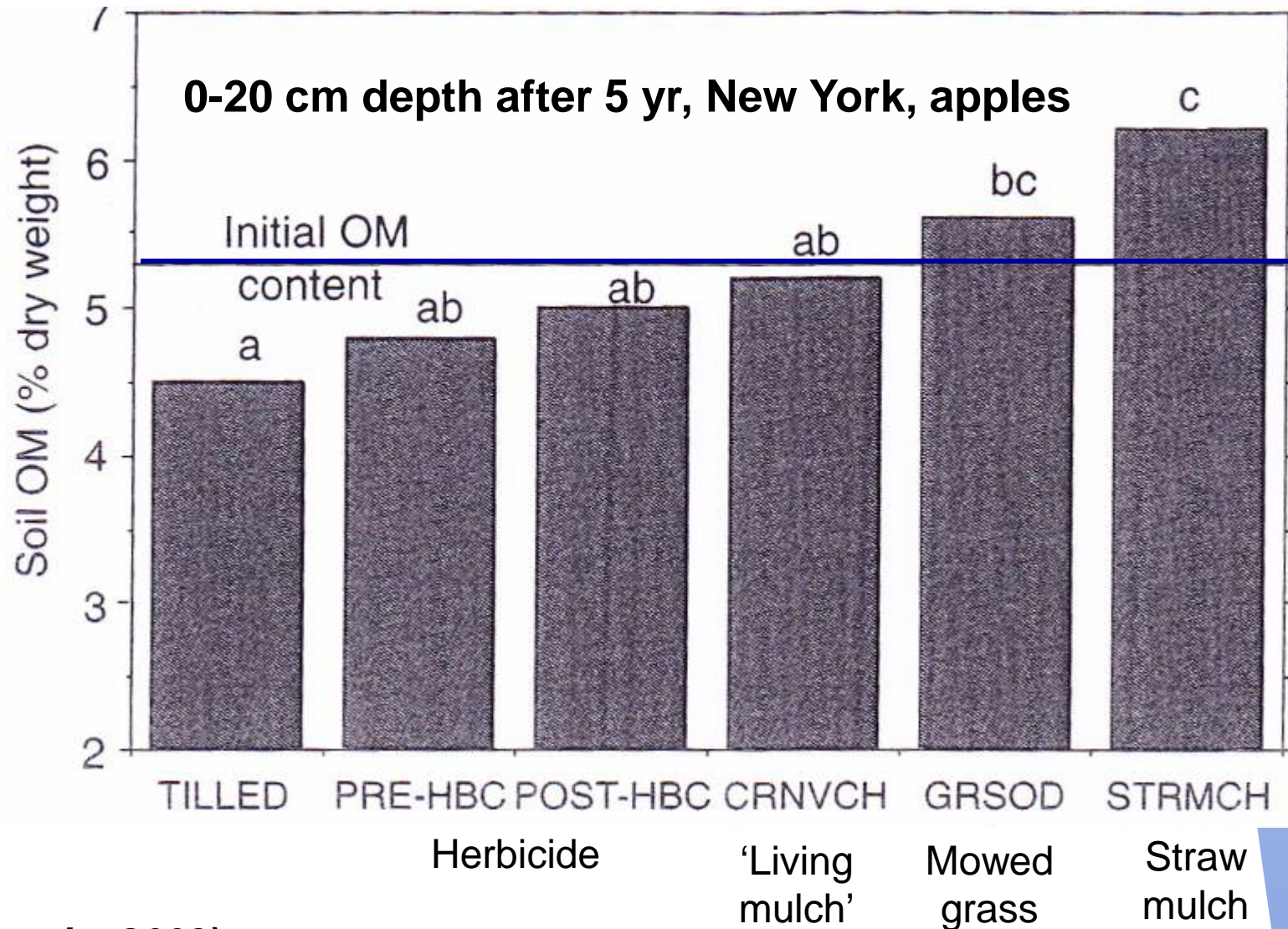
No-till
Mulching
Organic amendments
Cool temperatures
Nutrient balance

Enemies:

Tillage
Erosion
Fumigation
Herbicides, bare ground
Leaching, nutrient export

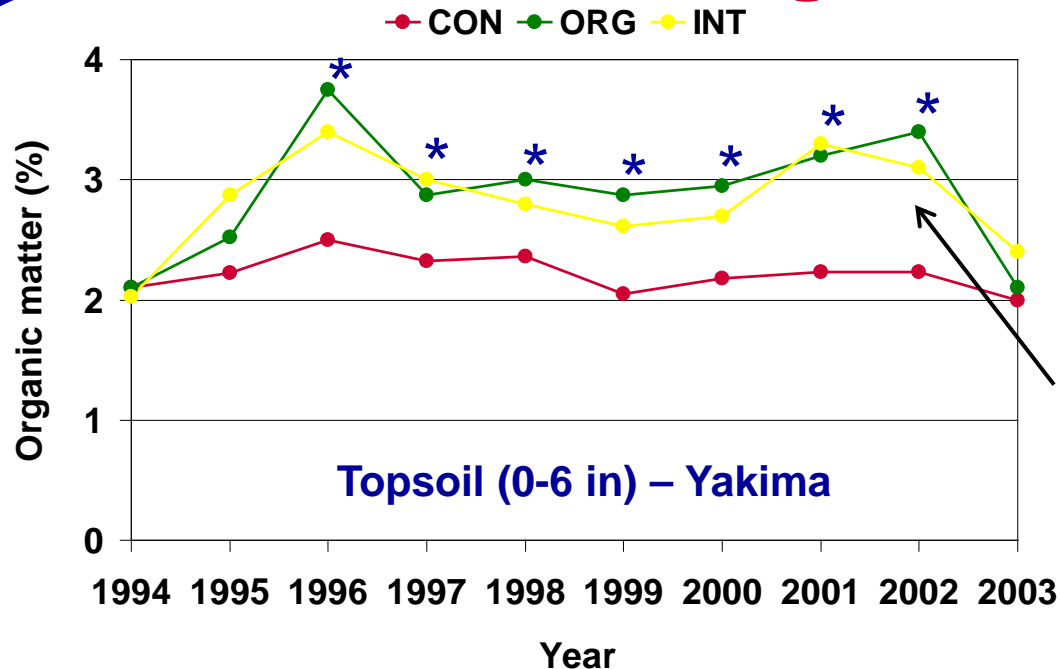
Goal: inputs > losses

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 ($\mu\text{g CO}_2\text{-C/g soil}$)	96	249 ***

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

Courtesy: P. Andrews

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

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

(Cockroft & Wallbrink, 1966)

Soil Biology

The last frontier ?

The ultimate black
box ?

Microbe - Microbe

Microbe - Macrofauna

Microbe - Plant

Effect of Apple Replant Disease

Gala/M.26, Moxee, WA



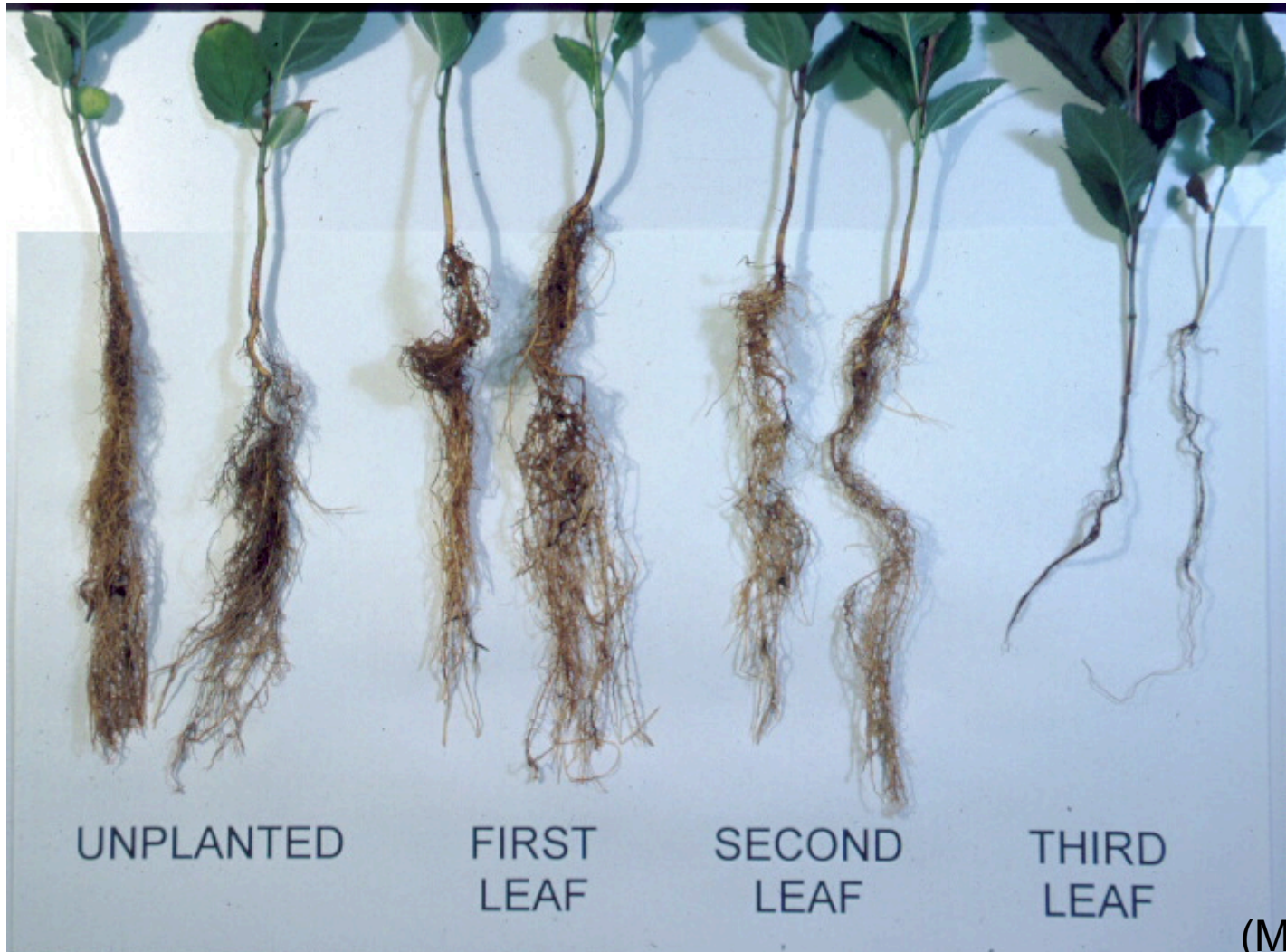
Replant soil



'Virgin' soil

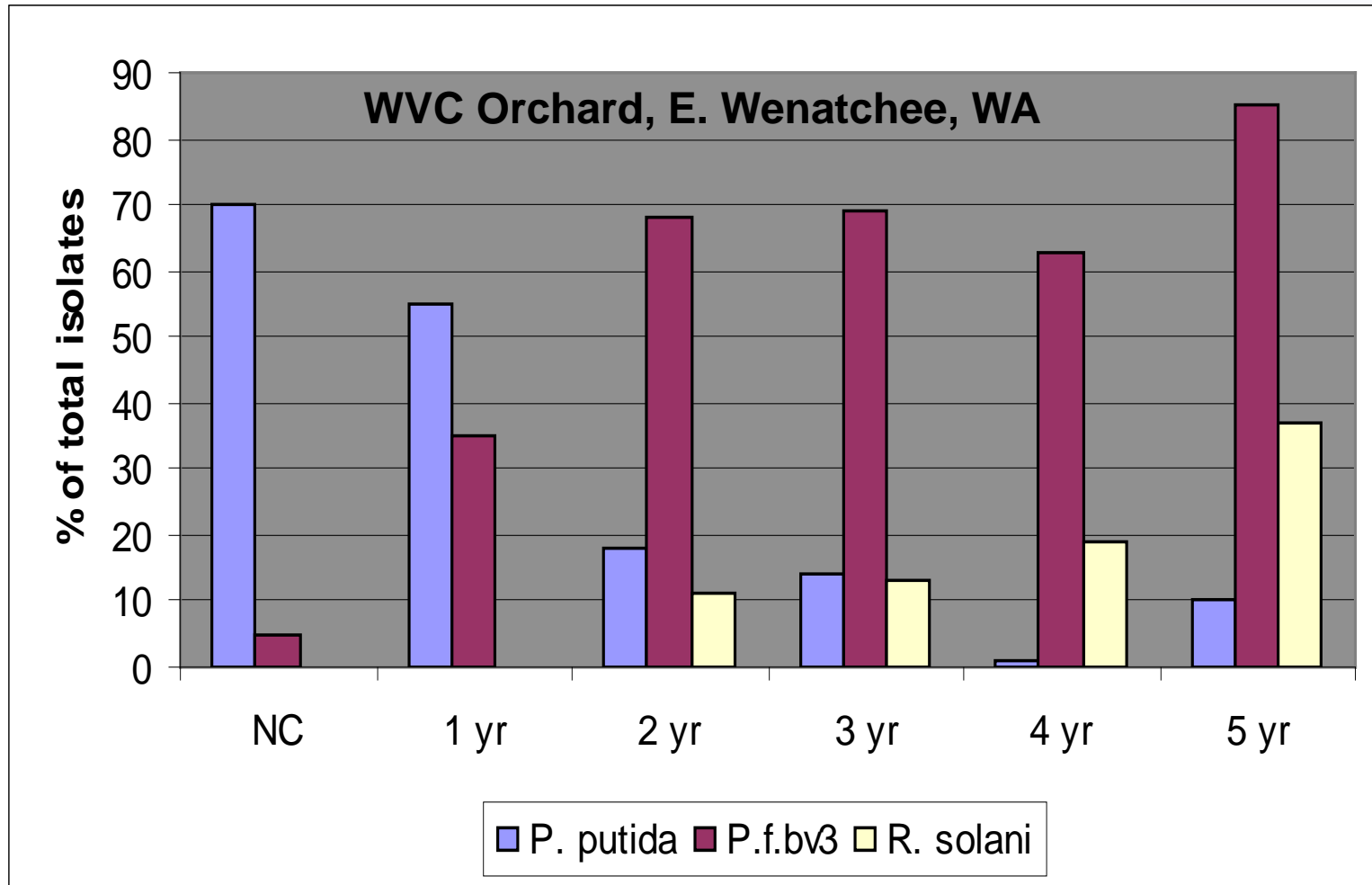
- Growth after one year
- Trees 14' apart, 'virgin' soil did not have apple previously
- No fumigation

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



(M. Mazzola)

Changes in Relative Recovery of Specific Microorganisms with Increasing Age of Orchard Blocks

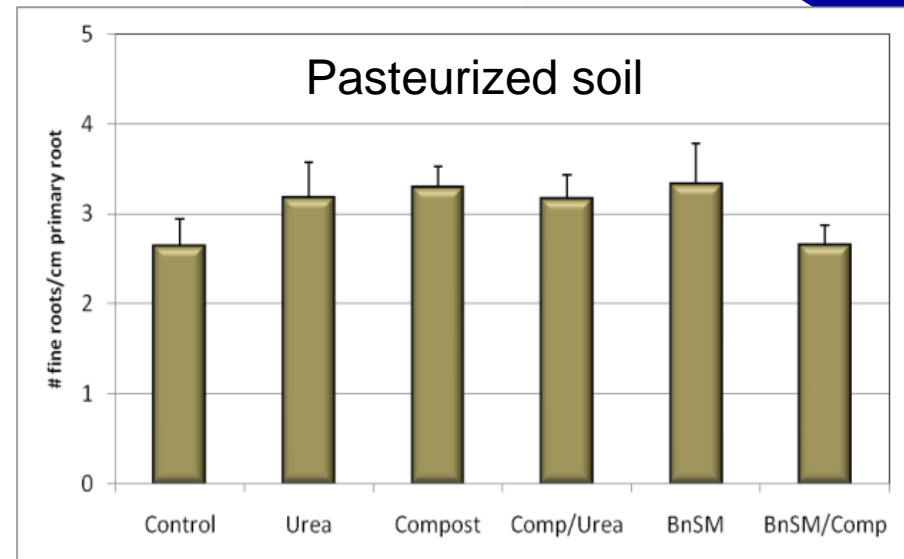
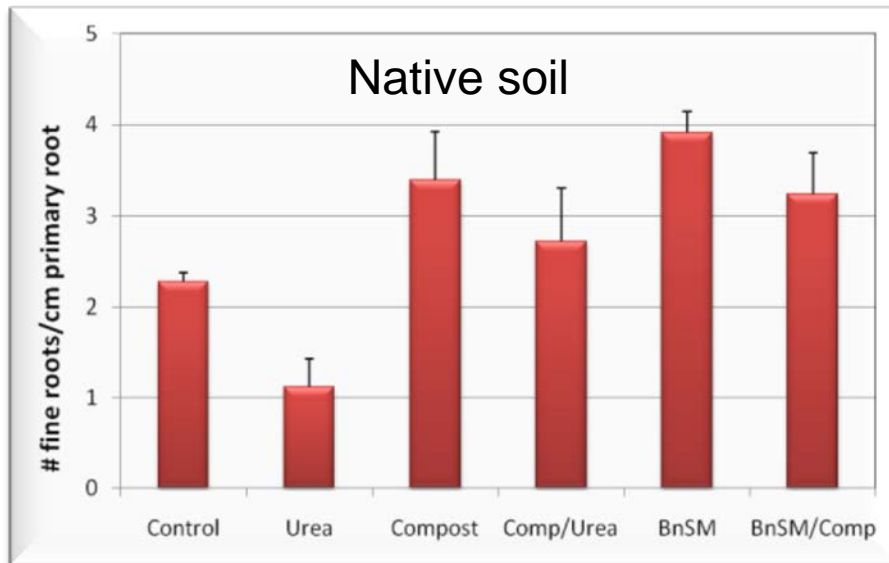


Growth of 'Gala' Apple Seedlings in CV Orchard Replant Soil Following Planting with Different Wheat Cultivars



(M. Mazzola)

Effect of Nitrogen Type on Apple Root Development

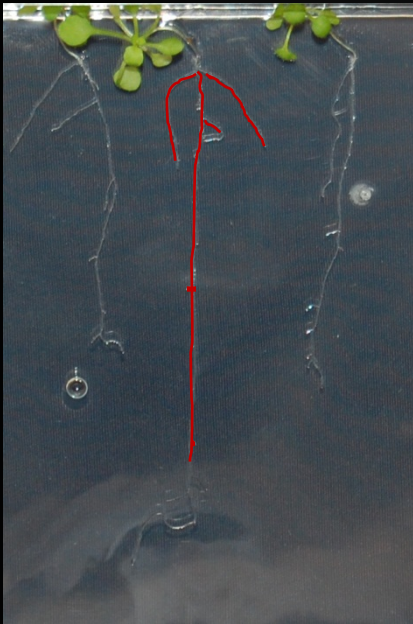


➔ Positive and negative effects of amendments on fine root development are indirect and likely function through the resident soil biology.

(Courtesy: M. Mazzola)



Microbial-induction of lateral root development

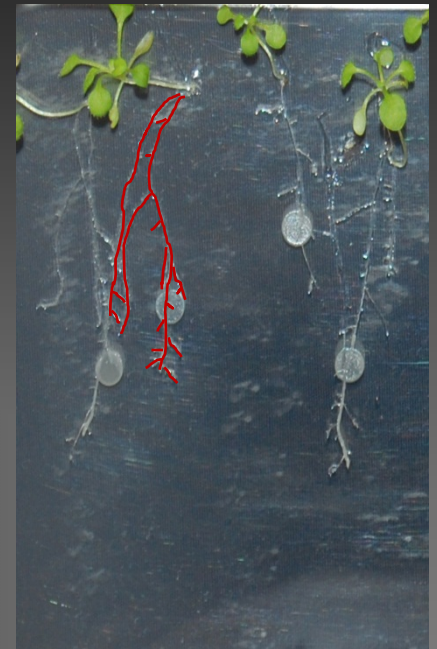


Control



Pseudomonas fluorescens SS101

**Inoculating soil with specific organisms
may induce increased rooting.**



Streptomyces sp. 71

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

Mulch Trial

- **Mature commercial organic apple orchard**
- **Fine sandy loam soil, prone to moisture stress**
- **Tillage vs wood chip mulching in tree row**
- **Mulch effects:**
 - +23% trunk growth (2 yr)**
 - +40% fruit yield (cumulative 3 yr)**
 - +35% gross revenue minus weed control cost (3 yr)**
- **Mulch had Net Present Value of \$2152/ac over tillage**

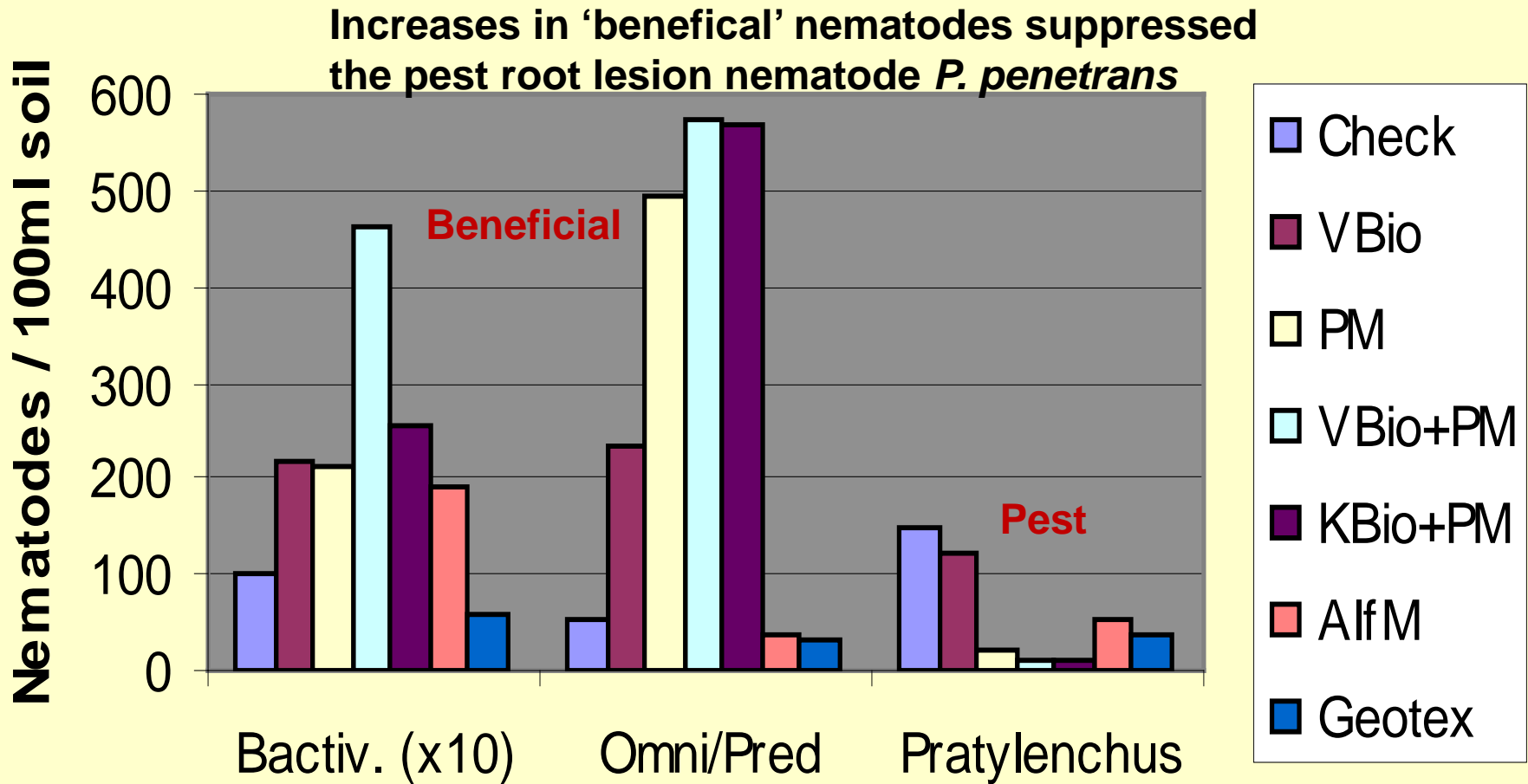
Orchard Mulching Trials Summerland, BC

5th Leaf Spartan / M.9

	<u>TCSA</u> (mm ²)	<u>Roots</u> (g/0.018m ³)	<u>Yield</u> (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)

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



‘Mow & Blow’ Mulch Trial

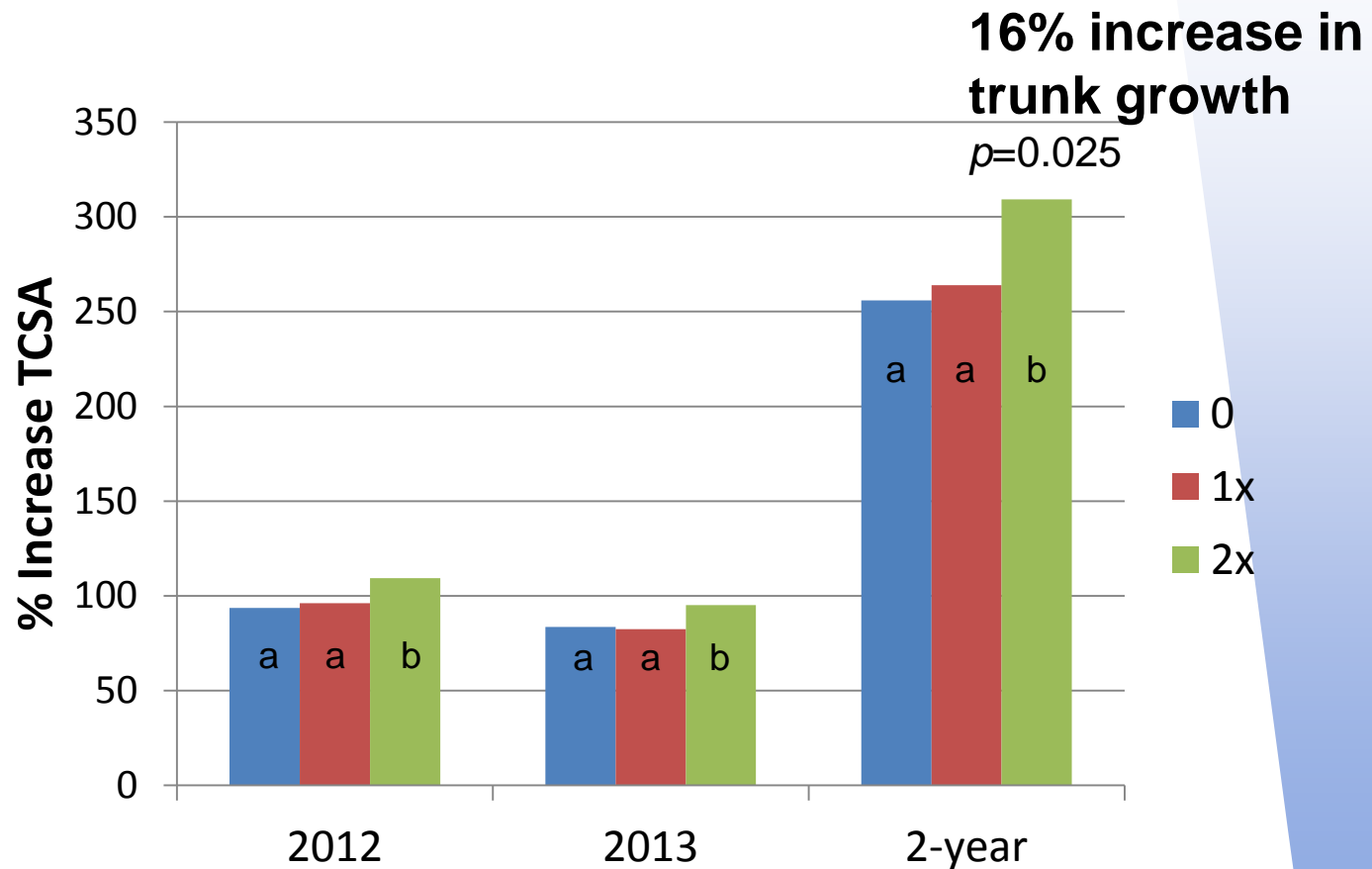
Quincy, WA

- **‘Fuji/M.9’ 2nd and 3rd leaf**
- **Tall fescue forage grass mix, mowed weekly**
- **1x rate = 0.5-1.0 lb/ft² DM**
- **About 10% of clippings retained after 2 yr**
- **2x rate led to significant increase in tree growth**
- **Clippings add 25-50 lb K/ac; 50 bin/ac apple crop removes 56 lb**



'Mow & Blow' Mulch Trial

Quincy, WA



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.



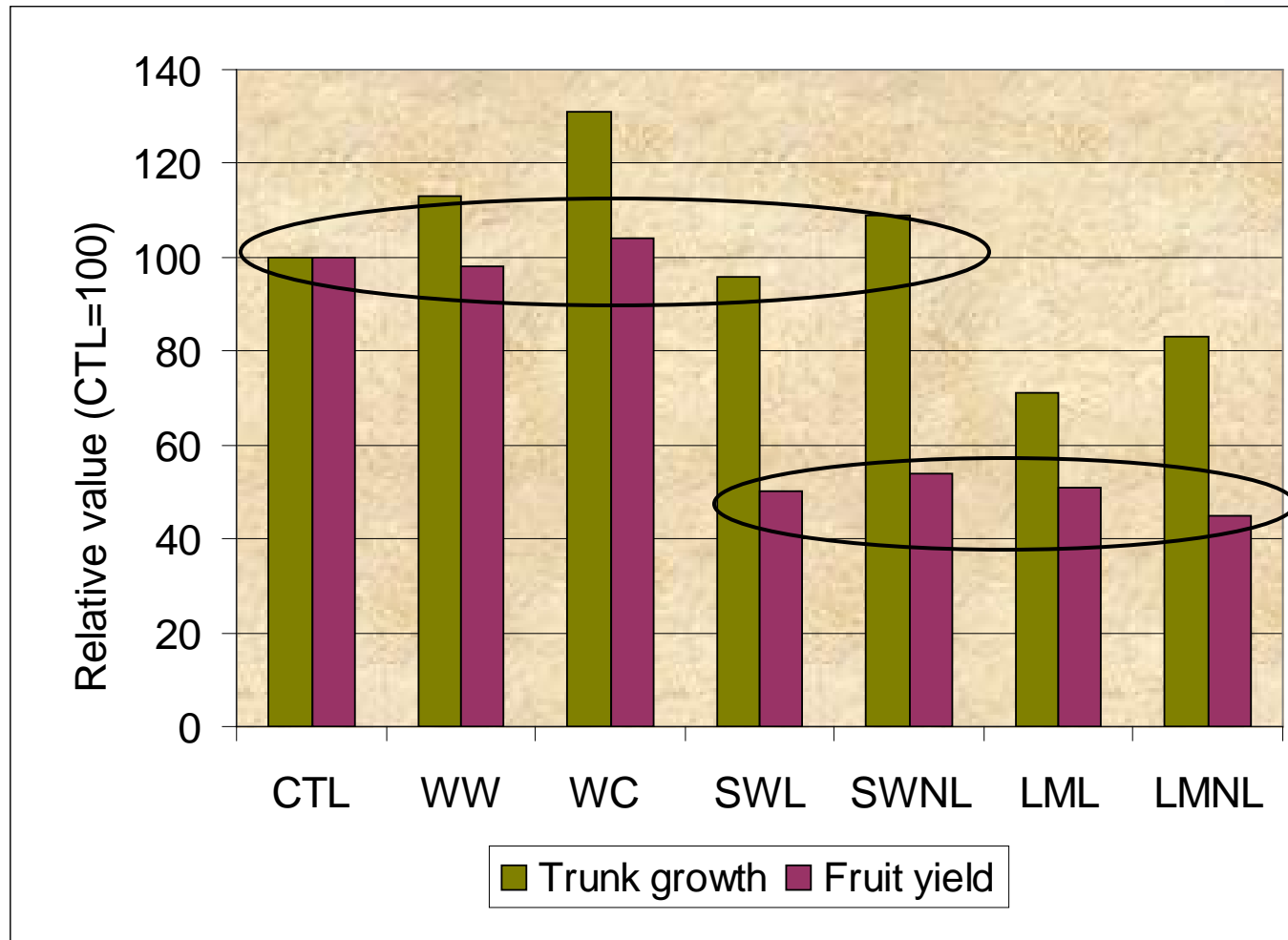
'Prairie' Kura clover



Thyme in Sandwich system

TCSA and Fruit Yield

WVC Orchard – Pinova/M7, 3rd leaf



Growing N in the Orchard

Side Discharge/Mulching Mower

- Reduced passes with mower
- Reduced passes with weed sprayer
- Reduced irrigation

(H. Huntley)

Year 3, 2010



Alfalfa



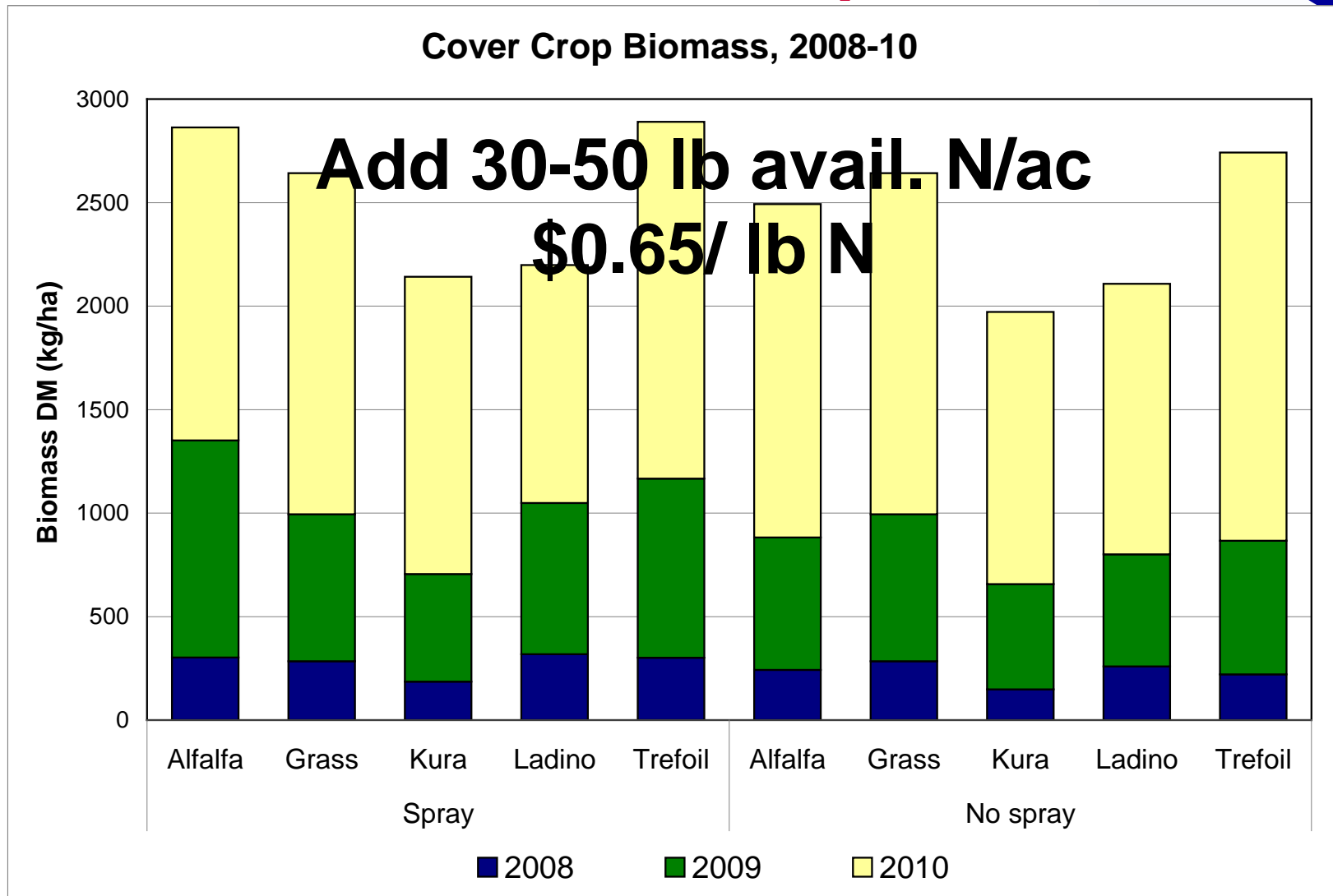
Trefoil

39 days after mowing

Direct seeded

Morgan Orchard

Cumulative Cover Crop Biomass





Falcata alfalfa, Prosser – July 2013

NRCS Cover Crop Trial

- 3 sites near Prosser, WA
- Planted Sept 2012
- USDA-NRCS Plant Materials Technical Note No. 23

<http://www.nrcs.usda.gov/wps/portal/nrcs/publications/plantmaterials/pmc/west/wapmc/pub/>



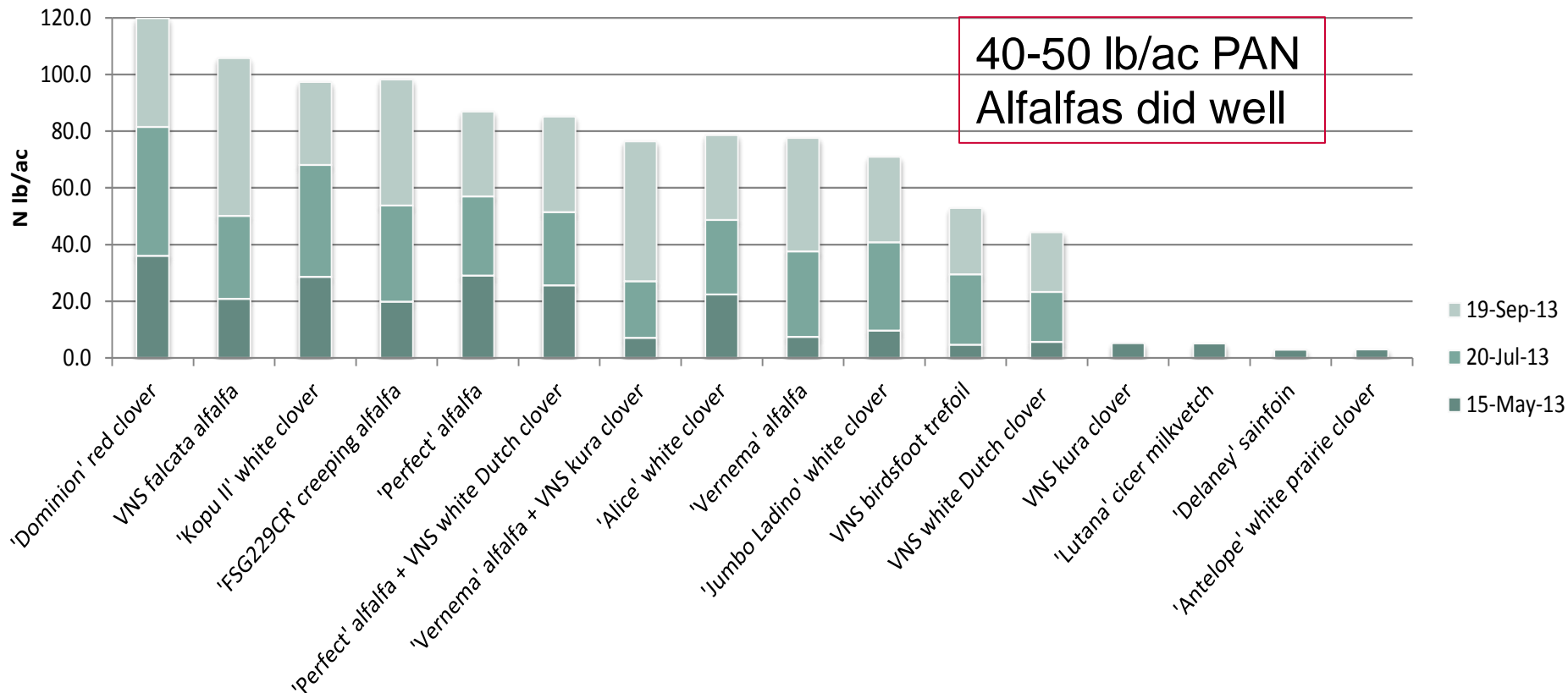
'Kopu II' white clover, Prosser – May 2013

Legume Cover Crops for N

Nitrogen Contribution

7' planted legume strip

Partial Cover Crop Nitrogen Contribution (N lb/ac) at Alvarez Orchard
Sampled 15 May, 20 July and 19 September 2013



Pest Reduction

Cover crops can control tree vigor through regulation of N and water.

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

Apple (BC) – much less aphid infestation with white clover/grass cover vs. rye, herbicide strip, weed barrier; clover mix competed with trees, reduced vigor, which reduced aphids (*Haley & Hogue, 1990*)

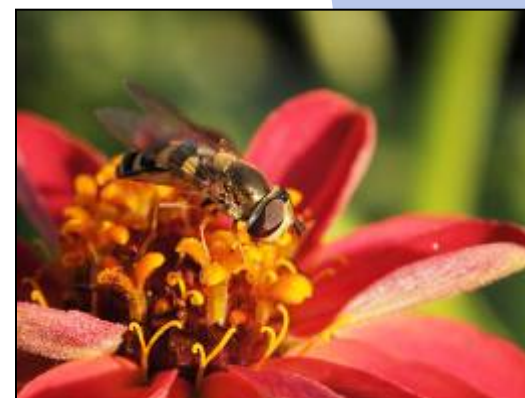
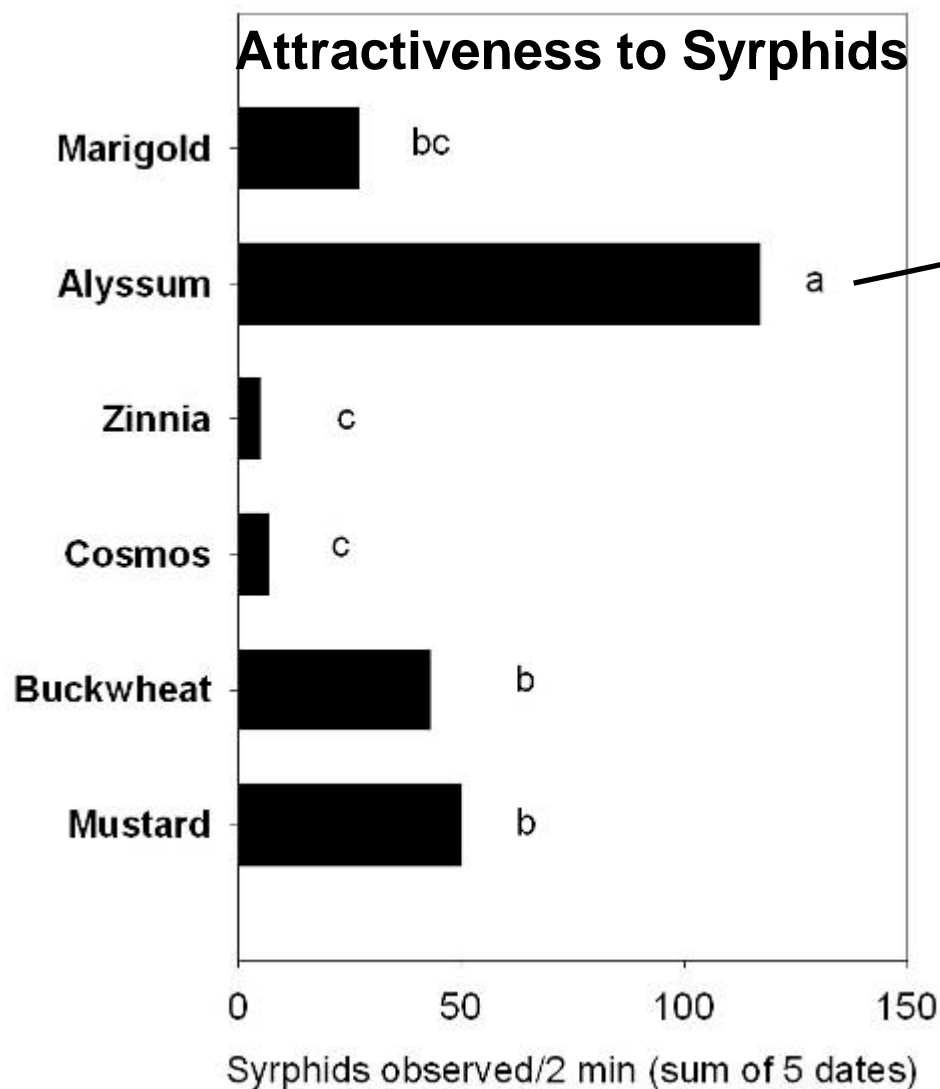
Pest Reduction

Successful examples usually involve a specific pest-predator relation.

Pecans (GA) – control of pecan aphid with convergent lady beetle; grow cover crop of hairy vetch; produced two generations of lady beetles, reaching 143,000/acre; migrated from ground cover (senescing) to pecan trees at time when aphids are reaching peak levels; effective biocontrol achieved (*Tedders, 1983*)

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 WAA



WAA=woolly apple aphid

(E. Beers)

Insectary Plantings - Alyssum



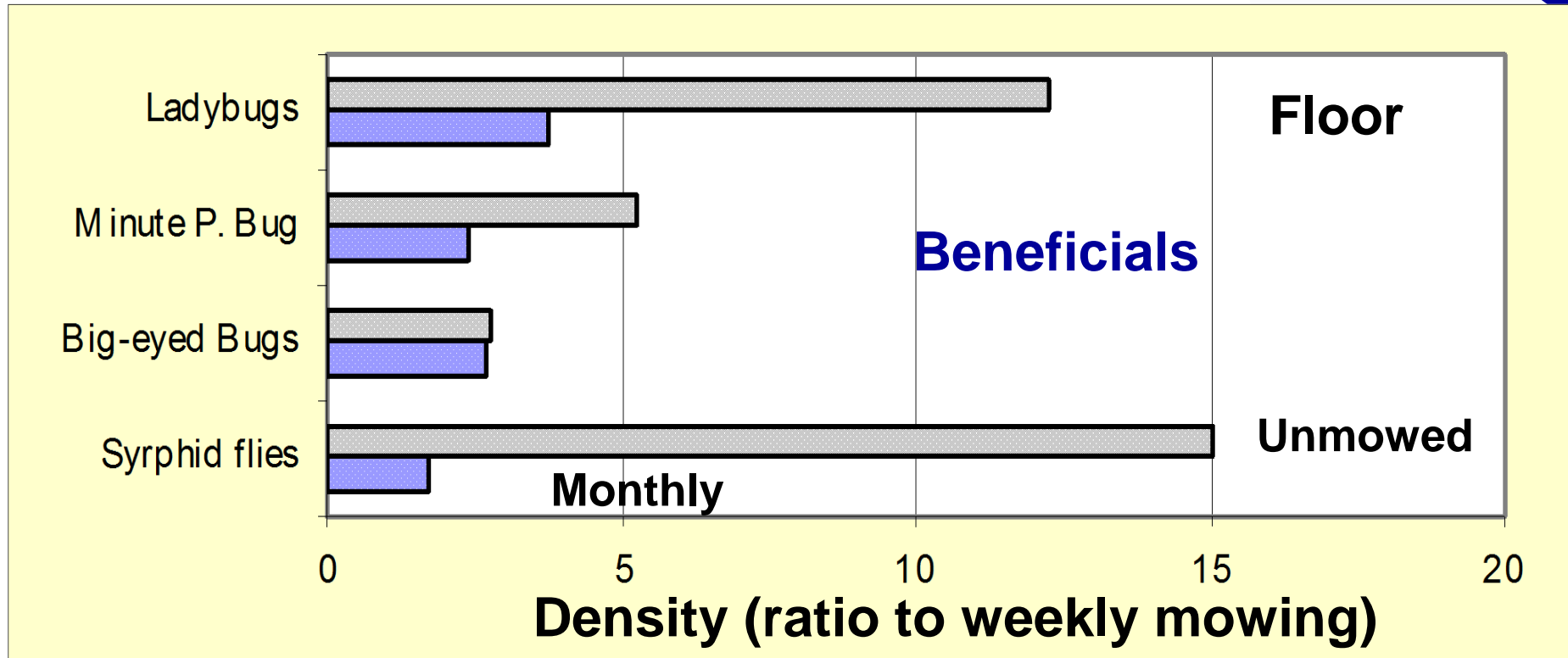
L to R: Mike Hargrove, Betsy Beers, and Fred Plath in his orchard near Wapato planted with an alyssum cover crop (July 2009)

Blooming Alyssum



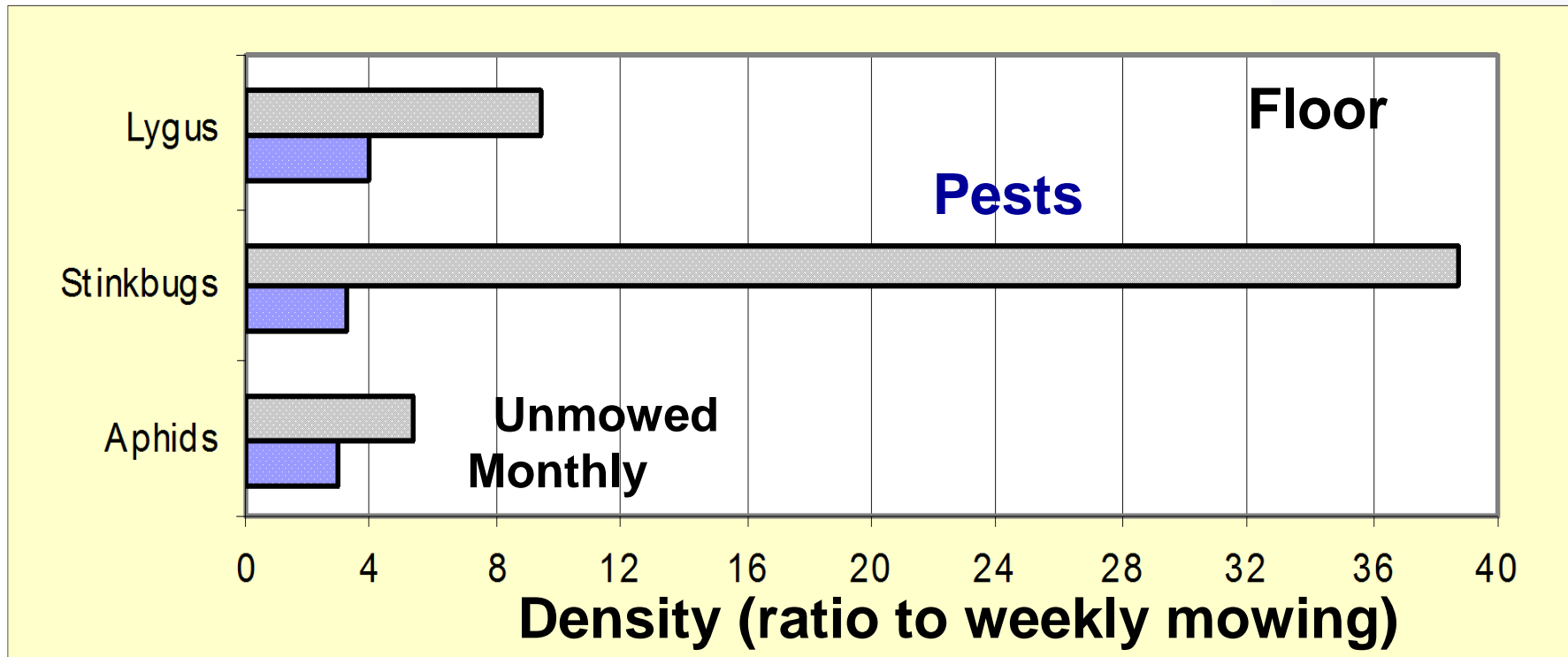
(E. Beers)

Effect of mowing on insect fauna in pears Hood River, OR



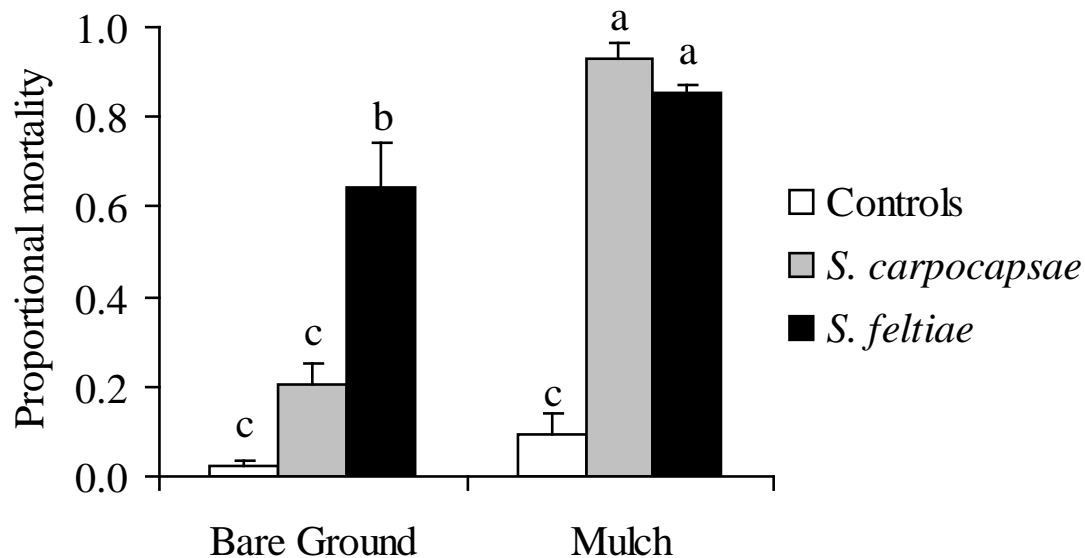
(Horton, 1998)

Effect of mowing on insect fauna in pears Hood River, OR



(Horton, 1998)

Effect of wood chip mulch and nematode species on codling moth larvae mortality - September



Airblast Sprayer Application

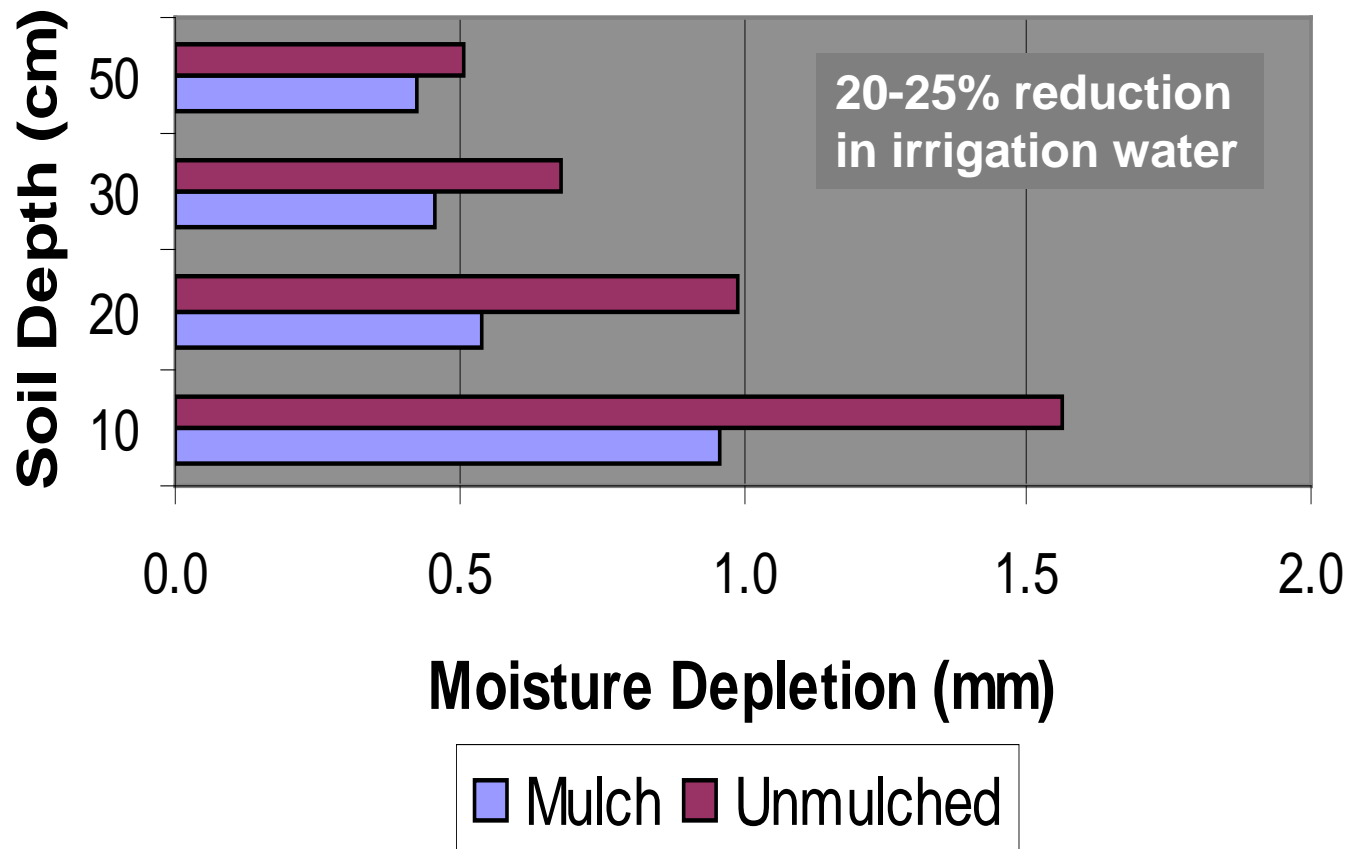
	<u>Mean % mortality</u>
Under Mulch	94-99
Logs on trees	17-47
Tree bands	6-42

Water Conservation



**Water shortages may be more
common in the future**

Effect of Orchard Mulching on Soil Moisture Depletion



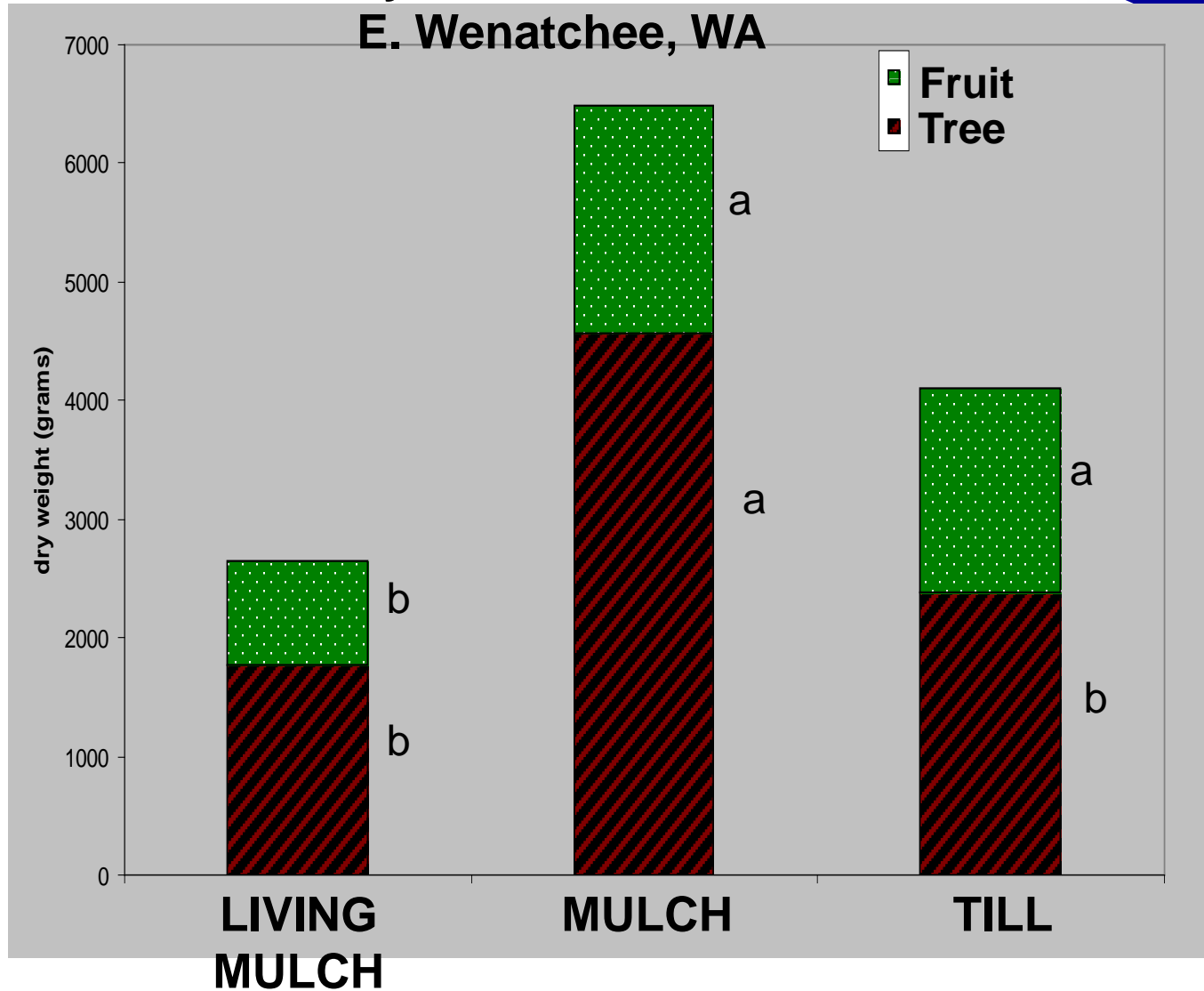
Goal: “Happy Trees”



Total Biomass

3-yr Pinova/EMLA.7

E. Wenatchee, WA



Yield Efficiency
(g fruit/g tree DM)

0.78

0.41

0.50

(D. TerAvest)

Knowledge Gaps

- **Is there an ideal soil quality?**
- **Manipulation of rhizosphere**
- **Nutrient flow through orchard**
- **Pest ecology in complex systems**
- **Pest / nutrition interactions**
- **Chemical ecology of plants**

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



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

http://csanr.wsu.edu/pages/Organic_Agriculture