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# Orchard Floor Management


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Center for Sustaining Agriculture & Natural Resources

**Organic Orchard Floor Management Workshop -- October 11, 2016**

# Orchard Floor Management

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

# 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 1-2°F
- bare, compacted wet soil raised minimum air temperature by as much as 4°F

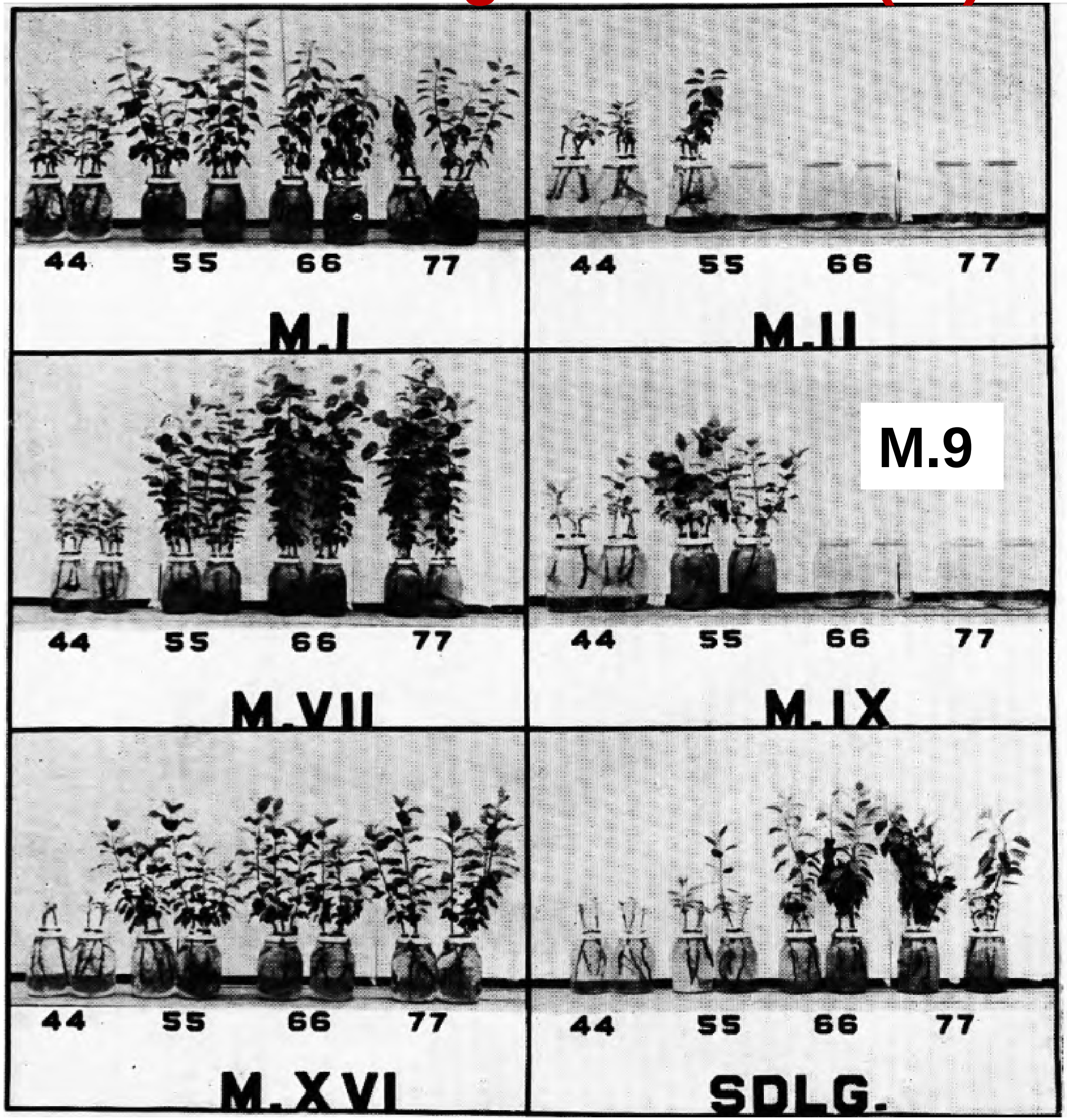
*(Skroch & Shribbs, 1986)*

# Microclimate

## Soil Temperature:

- Proposed optimal temperatures for apple roots of 64-77$^{o}$F. Above 86$^{o}$F seemed to be deleterious.
  *(Gur et al. 1974)*
- Is a significant genetic component. M.9 died at 66, 77$^{o}$F; Roots matured fast, browned, sloughed, and were infected by pathogen.
  *(Nelson and Tukey, 1956)*
- Soil temperature <59$^{o}$F delayed bud break, fewer flower clusters on ‘Braeburn’/M.9.
  *(Greer et al., 2006)*

# Root temperature study with Malling clones using water bath (ºF)




(Nelson and Tukey, 1956)

# Microclimate

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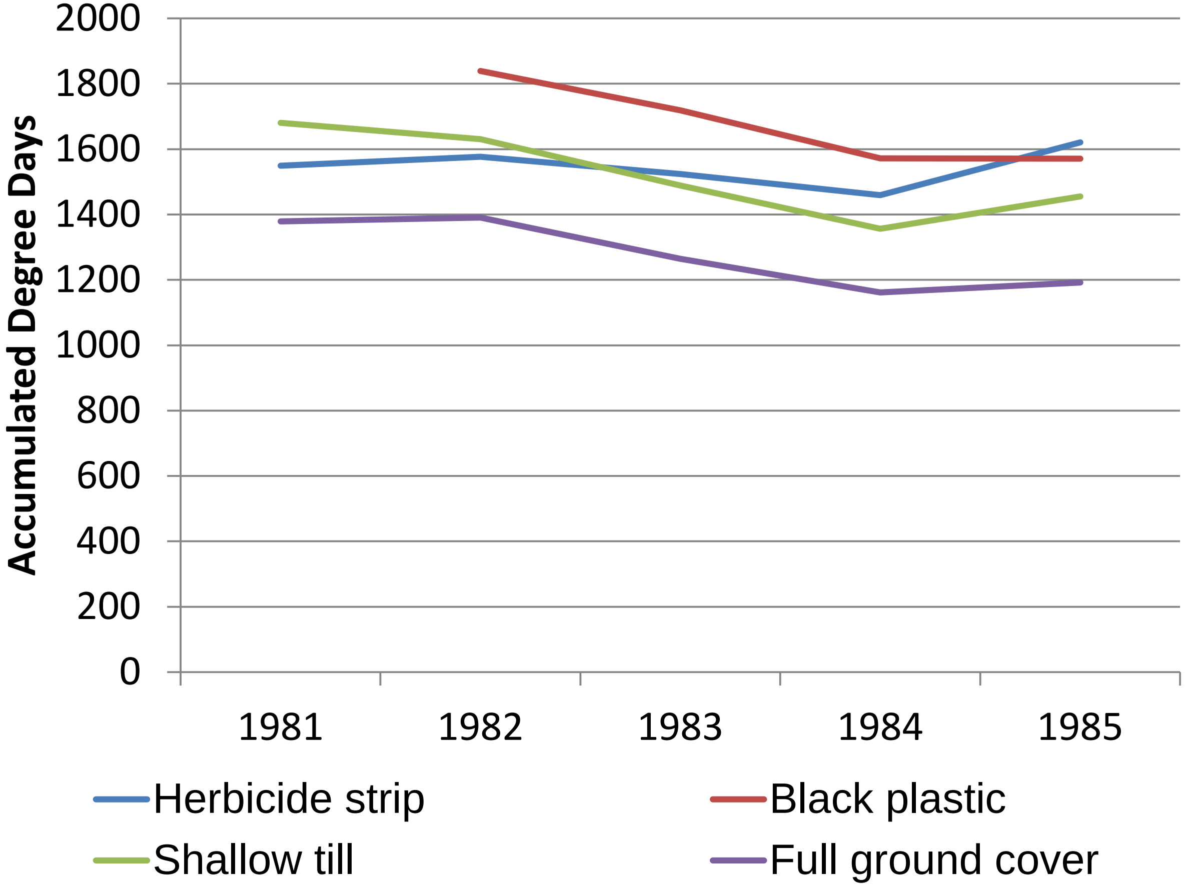
## Soil Temperature:

- Proposed optimal temperatures for apple roots of 64-77$^o$F (18-25C). Above 86$^o$F (30C) seemed to be deleterious. (Gur et al. 1974)
- Soil temperature <59F (15C) delayed bud break, less flower clusters on ‘Braeburn’/M.9 (Greer et al., 2006)
- Is a significant genetic component. M9 died at 66, 77F; Roots matured fast, browned, sloughed, and were infected by pathogen (Nelson and Tukey, 1956)
- Black fabric in tree row of apple. Elevated soil temps, often daily maximum was >82$^o$F at 8” depth. Negative effect on leaf Zn. Yield and tree growth same as herbicide strip. *(Neilsen et al., 1986)*

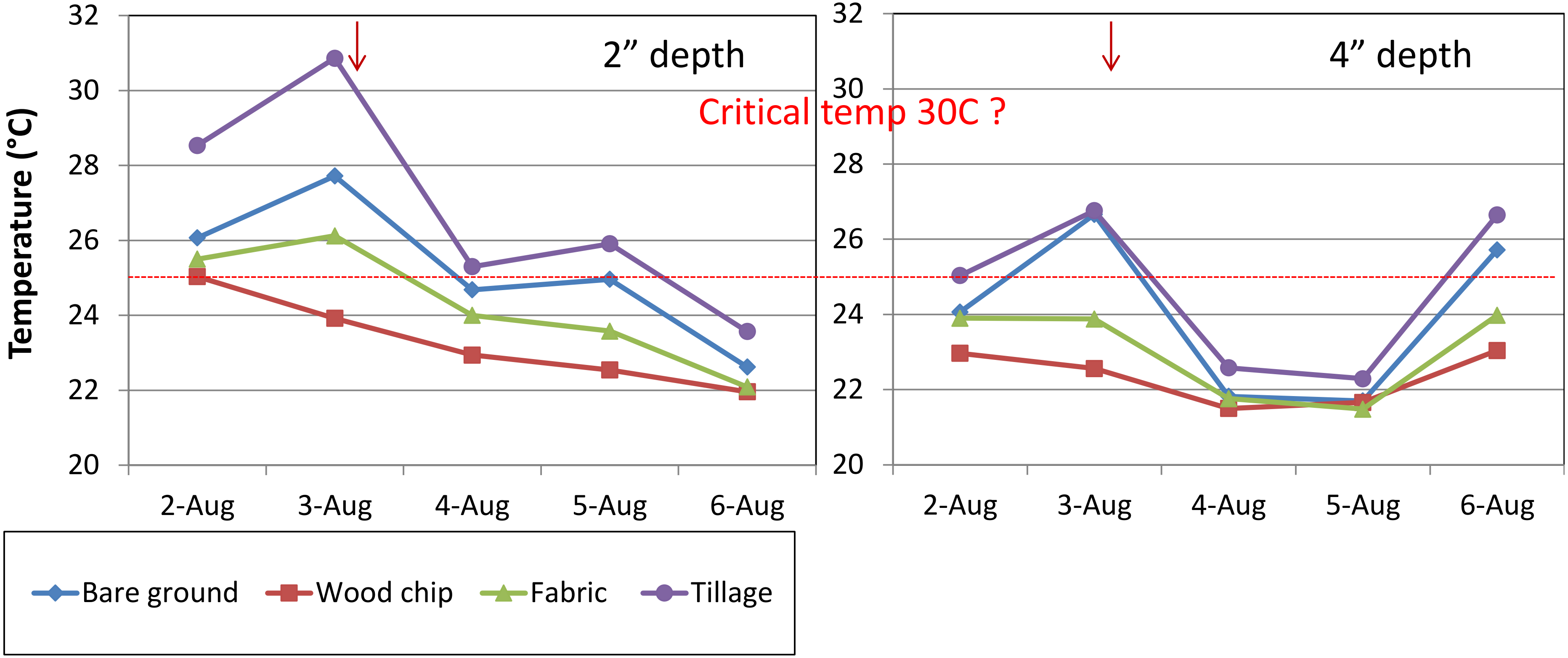
# Neilsen et al., 1986. Accumulated degree days >10C at 8” (20 cm) depth, Red Delicious/M.26, Summerland, BC



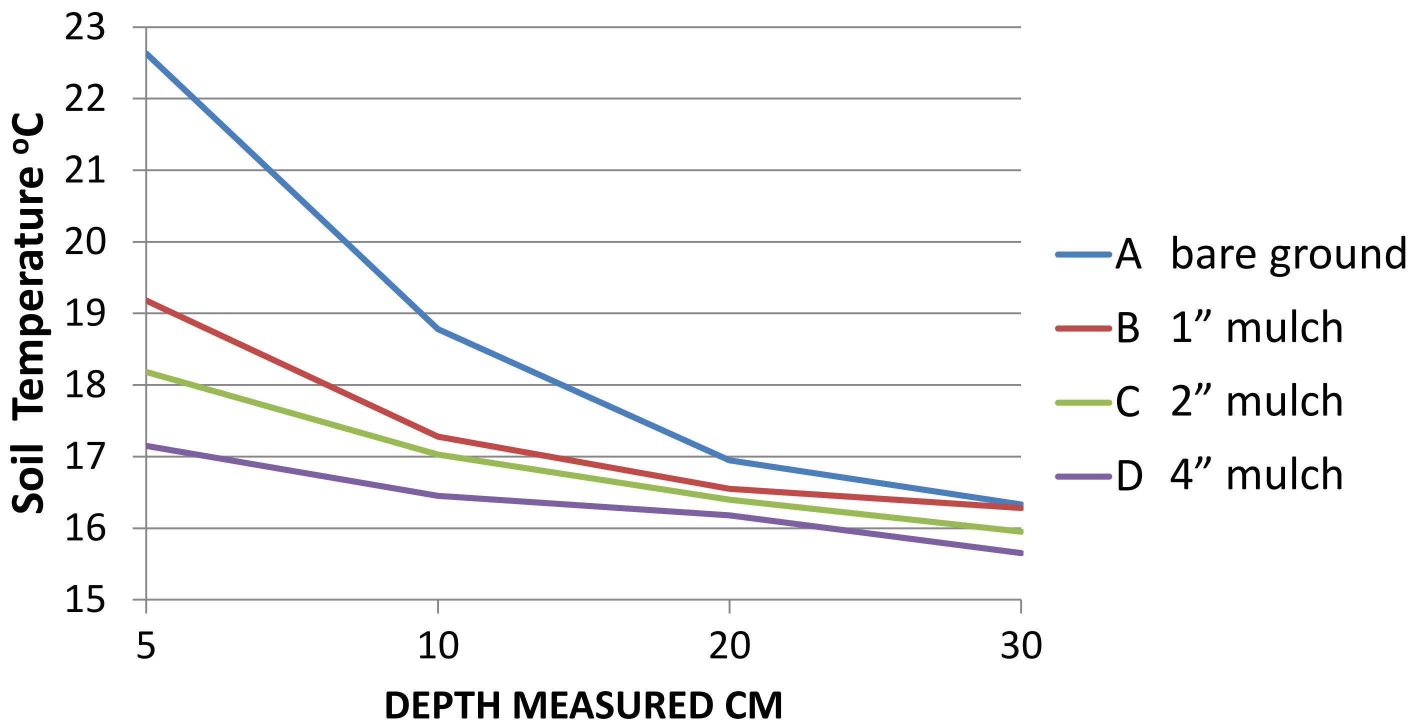

Black plastic had similar effect at 38” (1 m) depth

# WSU Sunrise Orchard, August 2010

## Mid-day Soil Temperature



# WSU Sunrise Orchard, June 6, 2011



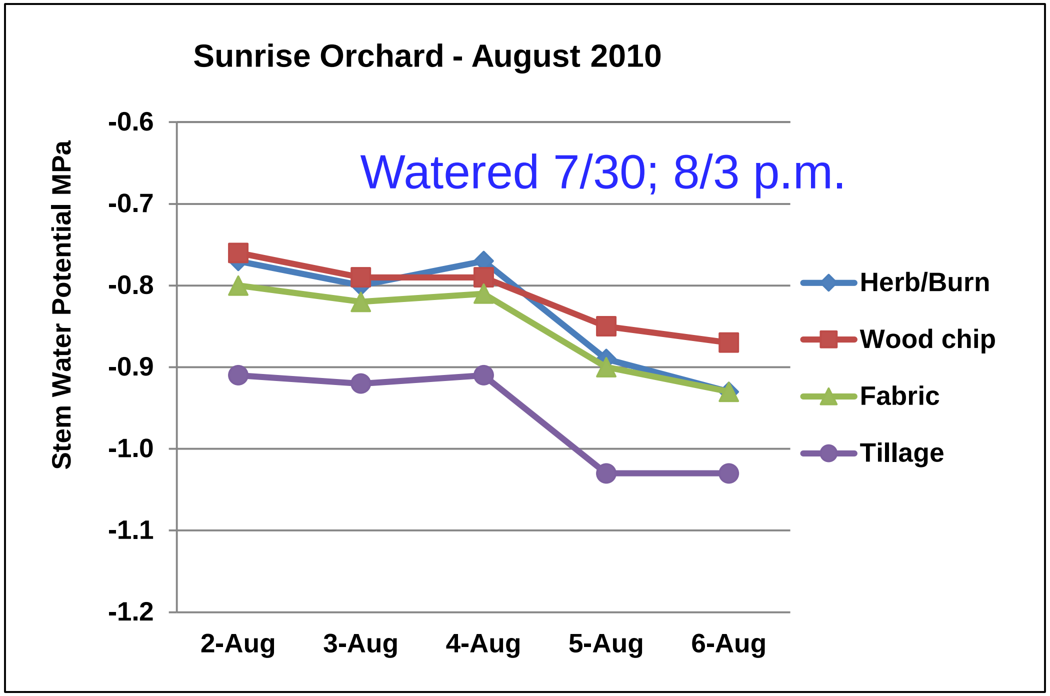

Air temperature 80F (26.7 C), 11am

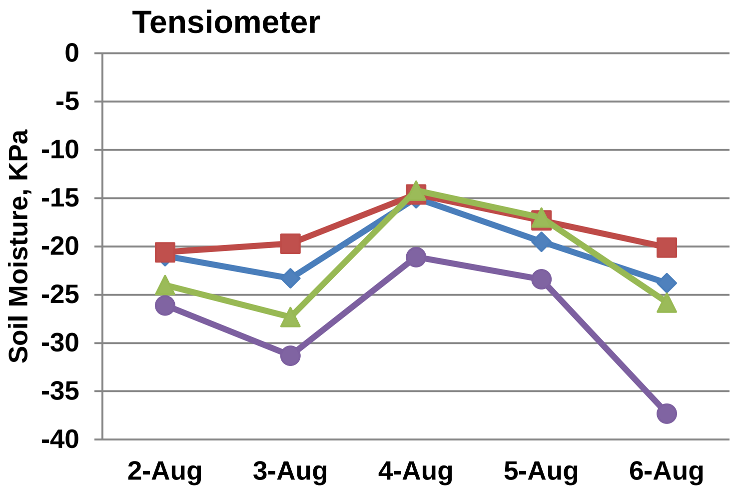
# Water Relations

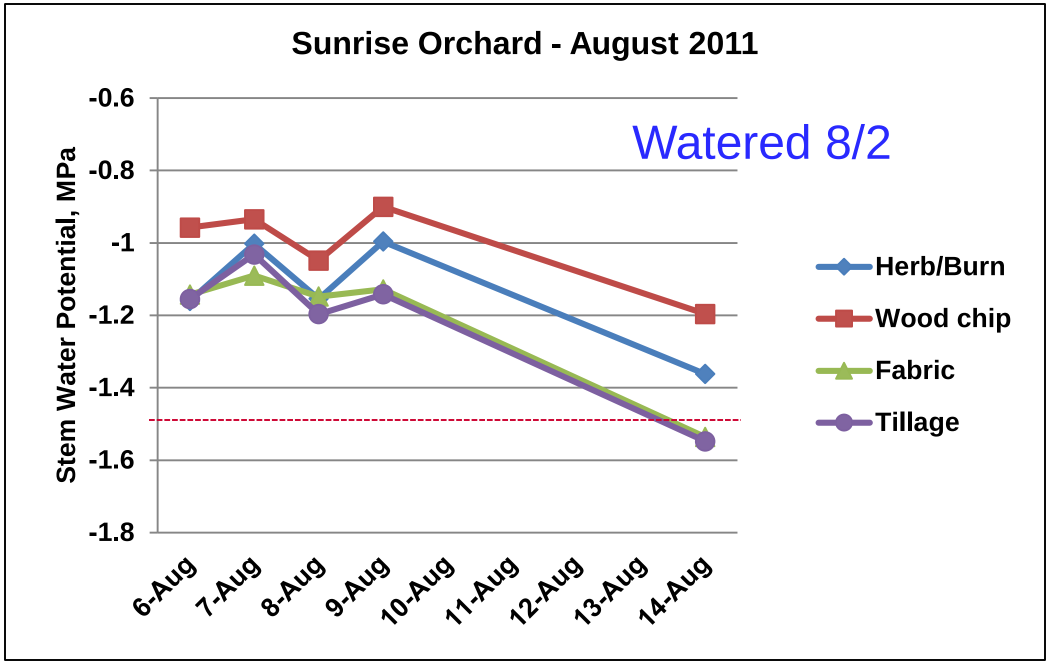
- soil moisture availability:  mulch > bare soil > minimal cultivation > grass > legumes > continuous cultivation
- mowing decreases water use
- tillage dries soil
- ‘Golden Delicious’ midday stem water potential range -10 to -28 KPa; yield loss started around -15 KPa; Israel (Gur)
- ‘Gala’ in Geneva, NY; SWP -7 to -11 Kpa
- Evaporative effect lessens with increasing tree size, canopy

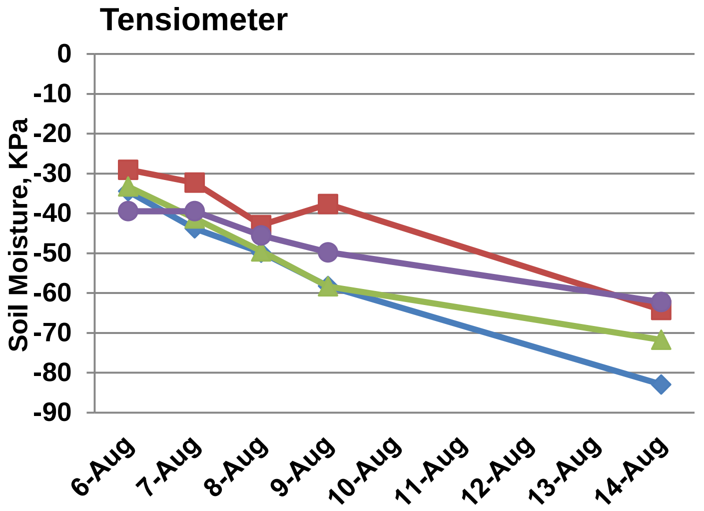
*(Skroch & Shribbs, 1986; Naor et al., 1995)*

# Mid-day Stem Water Potential



# Water Relations

- **Did not induce water stress by tilling trees for first time in August**

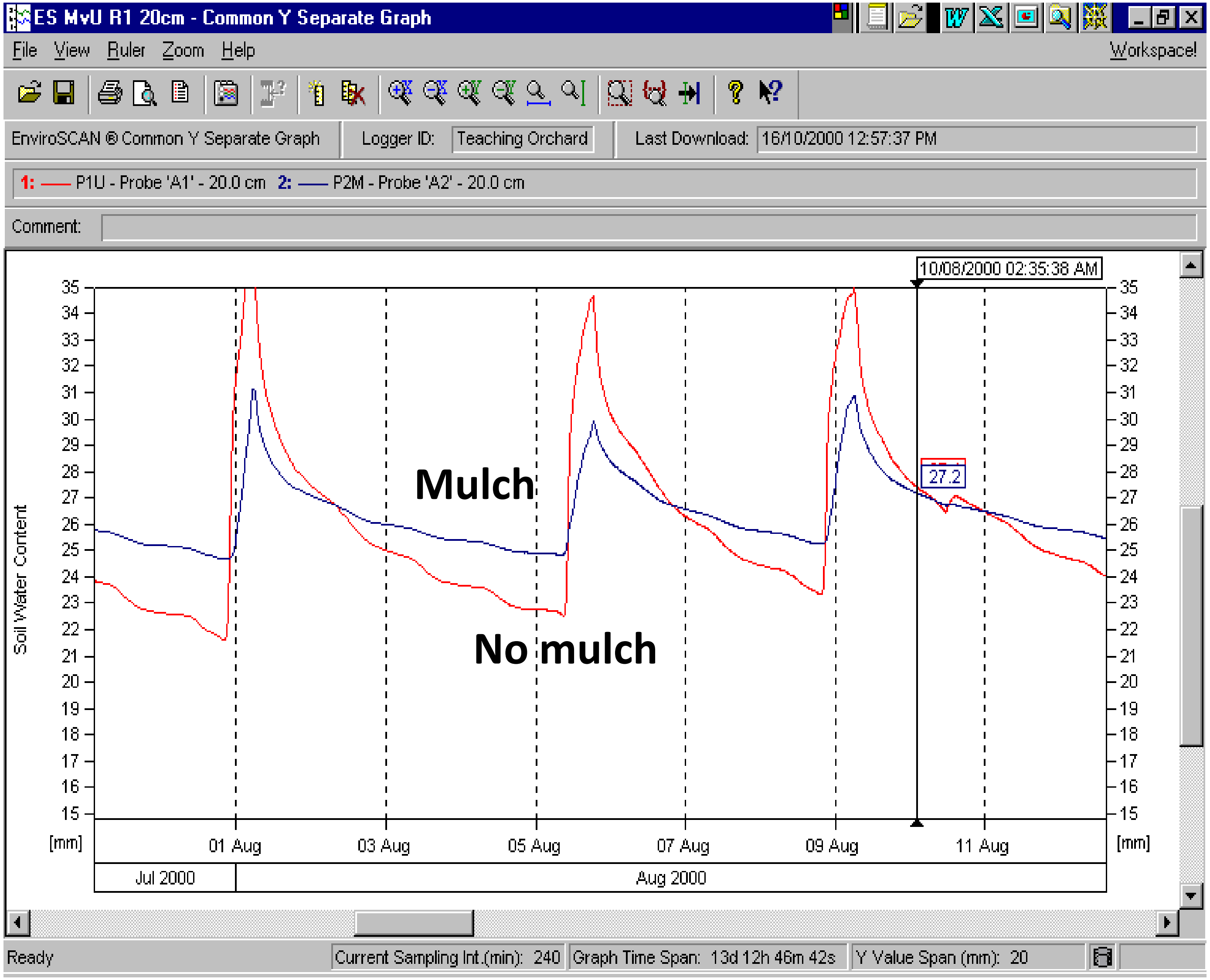
I I I

| | 7/11 | 7/12 | 7/13 | 7/16 | 7/24 |
|---|---|---|---|---|---|
| | Stem Water Potential (-Kpa) | | | | |
| Untilled | 16.4 | 16.7 | 11.4 | 11.8 | 10.5 |
| Till 1 side (3”) | 16.0 | 16.3 | 11.2 | 10.8 | 10.5 |
| Till both sides (3”) | 15.7 | 16.1 | 10.8 | 11.5 | 10.6 |
| Till both sides (1.5”) | 16.0 | 16.5 | 11.1 | 11.7 | 10.9 |
| *p* = | 0.87 | 0.85 | 0.84 | 7/11 | 0.86 |

Irrigation 7/5, 7/12, 7/17; afternoon temps 85-95F

- **Mulch consistently moister than bare ground; 20-25% water savings over season**

# WVC – Enviroscan Results




**Wood chip mulch led to 20-25% less moisture depletion between irrigations.**

# Rodents

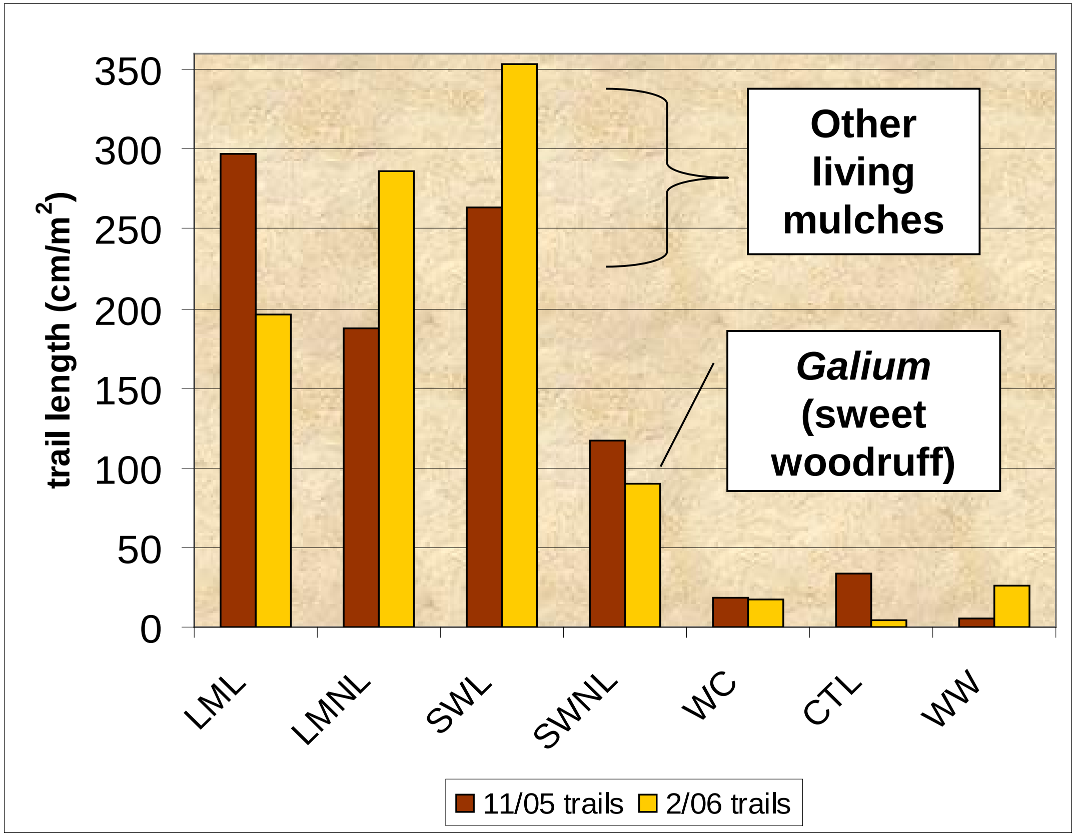
- **Limiting factor for many orchard floor practices**
- **Voles – need both habitat (cover) and food; food shifts to woodier material in winter**
- **Organic control options – minimize habitat; Vit D3; bait stations (e.g. oats + plaster of paris); mousetraps; raptor perches; cats; other??**
- **Risk management for 4-5 year population cycle, heavy snow winter**
- **Increased risk – mulches (straw, fabric); tall vegetation; legumes near tree trunks (e.g. white clover)**

# 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

## Why control weeds ?

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

# Orchard Weed Control Options

| | Pro | Con |
|---|---|---|
| Herbicides | Control weeds around trunk; rodents; no tree, root damage; low cost | Resistance, leaching, soil quality loss; effectiveness, cost (org herbicides) |
| Mowing | Fast, inexpensive | Short-term suppression; still have competition, habitat |
| Tillage | Effective; rodents; low cost | ↓ 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 |

*(Granatstein & Mullinix, 2008)*

**How to combine strategies? Change system with age of orchard?**

# Weed Control Costs in Organic Orchards

| | $/acre/yr | Year |
|---|---|---|
| Flame weed + hand hoe | 208 | 2014 |
| Weed fabric (10 yr, open/close) | 420 | 2014 |
| | | |
| Flaming (5x) | 113 | 2012 |
| Tillage (5x, Wonder Weeder) | 115 | 2012 |
| Wood chip mulch (3 yr life) | 400 | 2012 |
| Org. herbicide (4x) | 508 | 2012 |
| Mowing | 210 | 2010 |

For more details, see the on line presentation
http://treefruit.wsu.edu/videos/weed-control-in-orchards/

# Mulches

- Can impact soil (water, temperature, biology, nutrients), weeds, fauna (nematodes)
- Effects on trees: ↑ tree growth, ↑ fruit yield, ↑ fruit size, lower leaf N
- Generally more than pay for themselves
- Wood chips have had fewest problems
- Weed control variable, <1 to 3 yr; not effective for perennial weeds
- Challenges: finding the material, hauling, spreading
  - Solution? Mow and blow, utilize prunings; add flaming, “tillage” to extend weed control life

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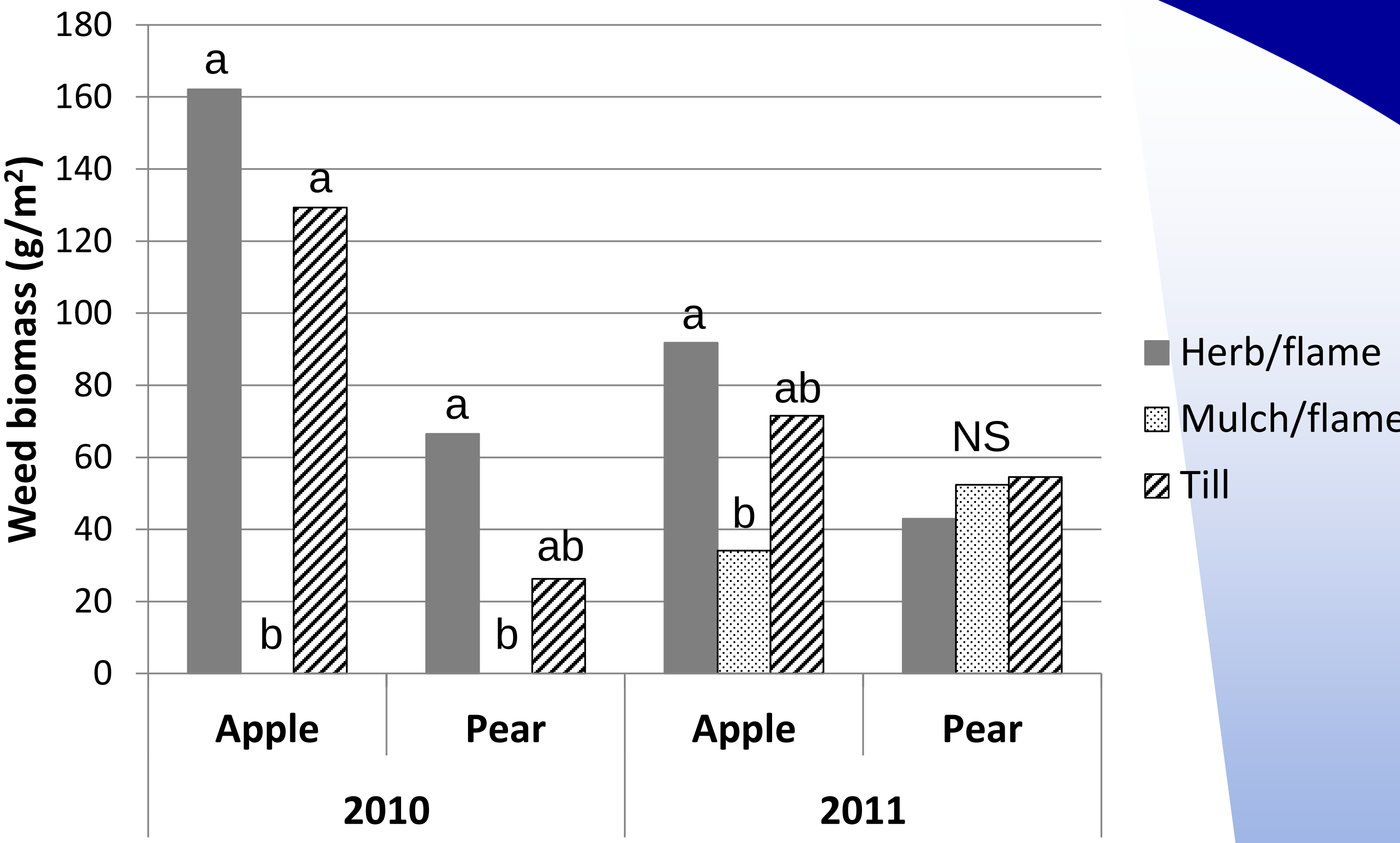
Spreading wood chip mulch

# Weed Biomass




Weed biomass (dry matter) in the tree row. Columns with the same letter are not significantly different ($p<0.05$) for that orchard.

# Yield Effects - WA

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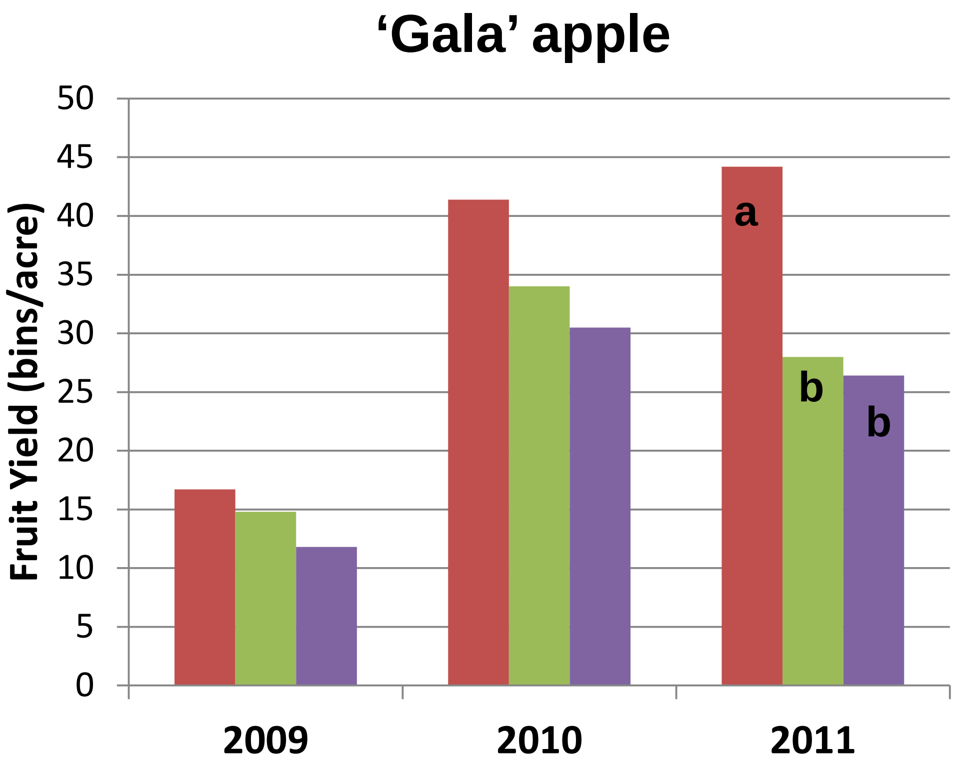


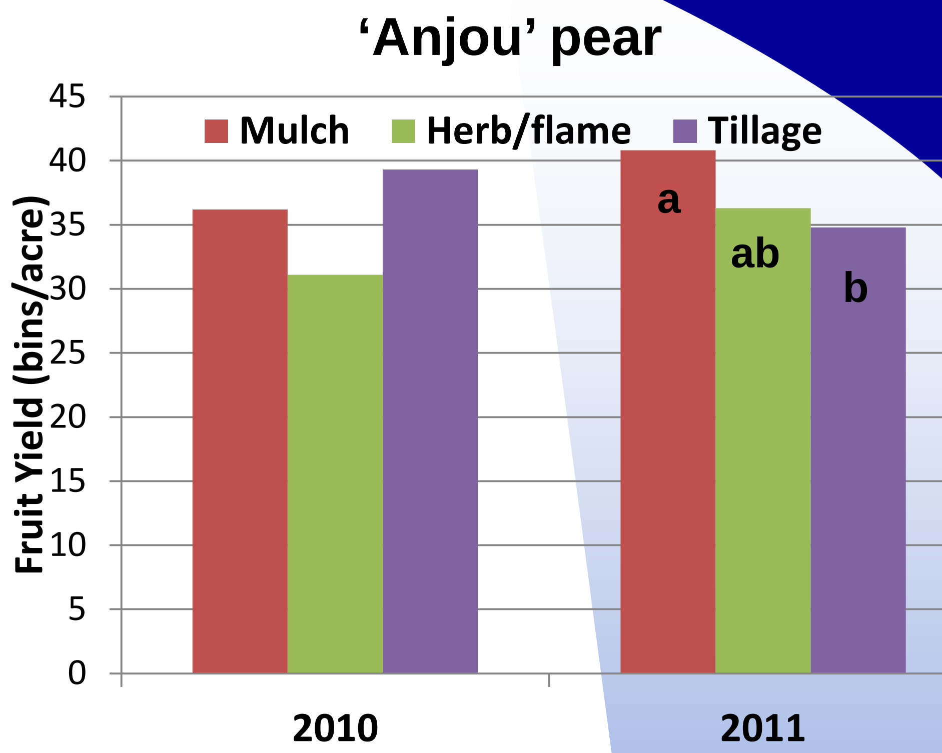


| *p*= | 0.08 | 0.07 | 0.02 | 0.20 | 0.04 |
|---|---|---|---|---|---|

**Commercial organic orchards, large-scale field plots**

*(Granatstein et al., 2014)*

# Grower Returns

8+ yr ‘Gala’/M.26, sandy soil

| | 2009 | 2010 | 2011 | 3-Yr Rel to Till |
|---|---|---|---|---|
| | Apple Returns* ($/ac) | | | |
| Mulch | 2,320 | 8,440 | 12,764 | +4,777 |
| Herb/flame | 1,971 | 6,193 | 9,638 | -946 |
| Tillage | 2,942 | 6,843 | 8,963 | 0 |

Mature ‘d’Anjou’ pears, good soil

| | 2009 | 2010 | 2011 | 3-Yr Rel to Till |
|---|---|---|---|---|
| | Pear Returns* ($/ac) | | | |
| Mulch | 9,580 | 12,636 | 9,377 | +1,432 |
| Herb/flame | 10,274 | 10,621 | 8,141 | -1,125 |
| Tillage | 10,676 | 11,182 | 8,302 | 0 |



*Gross bin returns minus weed control costs and picking costs

*(Granatstein et al. 2014)*

# Mulching Sweet Cherry

- The Dalles, OR;  'Bing'/Mazzard block (32 yr old)
- Wood chip mulch with compost blend applied October 2014 every other row; total cost ~$1,600/acre (70 yd/acre = 1" depth in tree row)
- Increased cherry size next July 2015; added revenue $2,600/acre; net gain $1,000/ac
- Internal mulch; bought large flail mower to recycle larger pruning wood that being hauled out and burned; reduced costs of hauling prunings paid for flail in one season

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# '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/ft$^2$ DM**
- **About 10% of clippings retained after 2 yr**
- **2x rate led to 20% increase in tree growth**
- **Clippings add 25-50 lb K/ac; 50 bin/ac apple crop removes 56 lb**


Nobili side delivery flail mower (Italy) and planted cover crop

# Sweeping flailed prunings onto the tree row as an internal source of mulch.

# Tillage


Wonder Weeder
JUL 27 2002


Weed Badger


AEDES
Weed brush

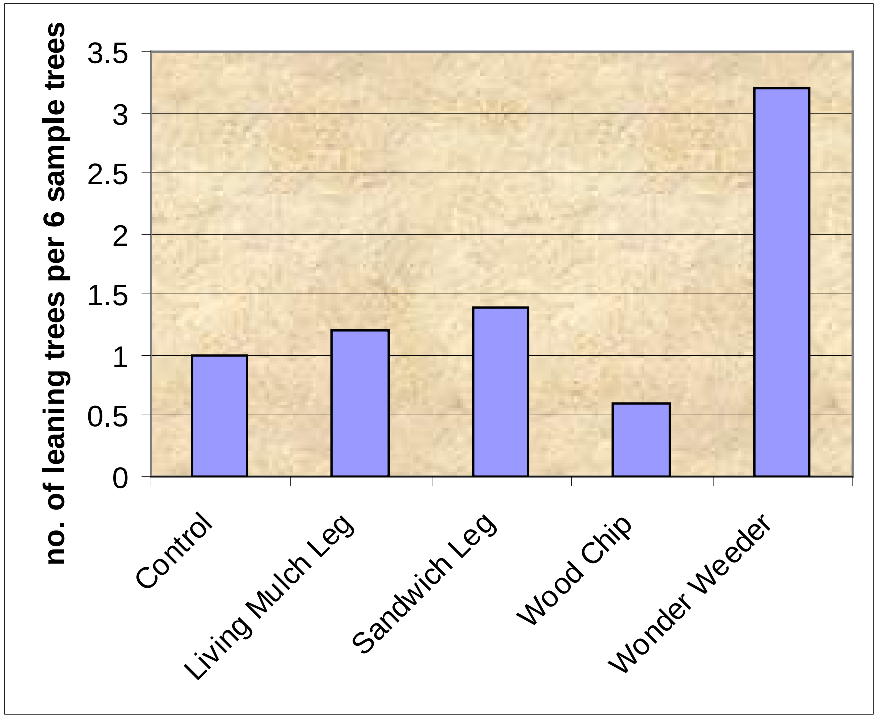

Ladurner

# Tillage

- Broad spectrum weed control
- Relatively low cost
- Incorporates organic amendments, speeds nutrient mineralization
- Helps disrupt rodent habitat
- Challenges: root pruning, trunk damage, soil OM oxidation, soil structure breakdown
  - Solutions? Lower disturbance machines (weed brush); organic amendments can compensate for OM loss; add "tillage" to mulching (hi-residue cultivators)

# IMM clean cultivation: root pruning?

2006 tree leaning count



# Tillage Effects

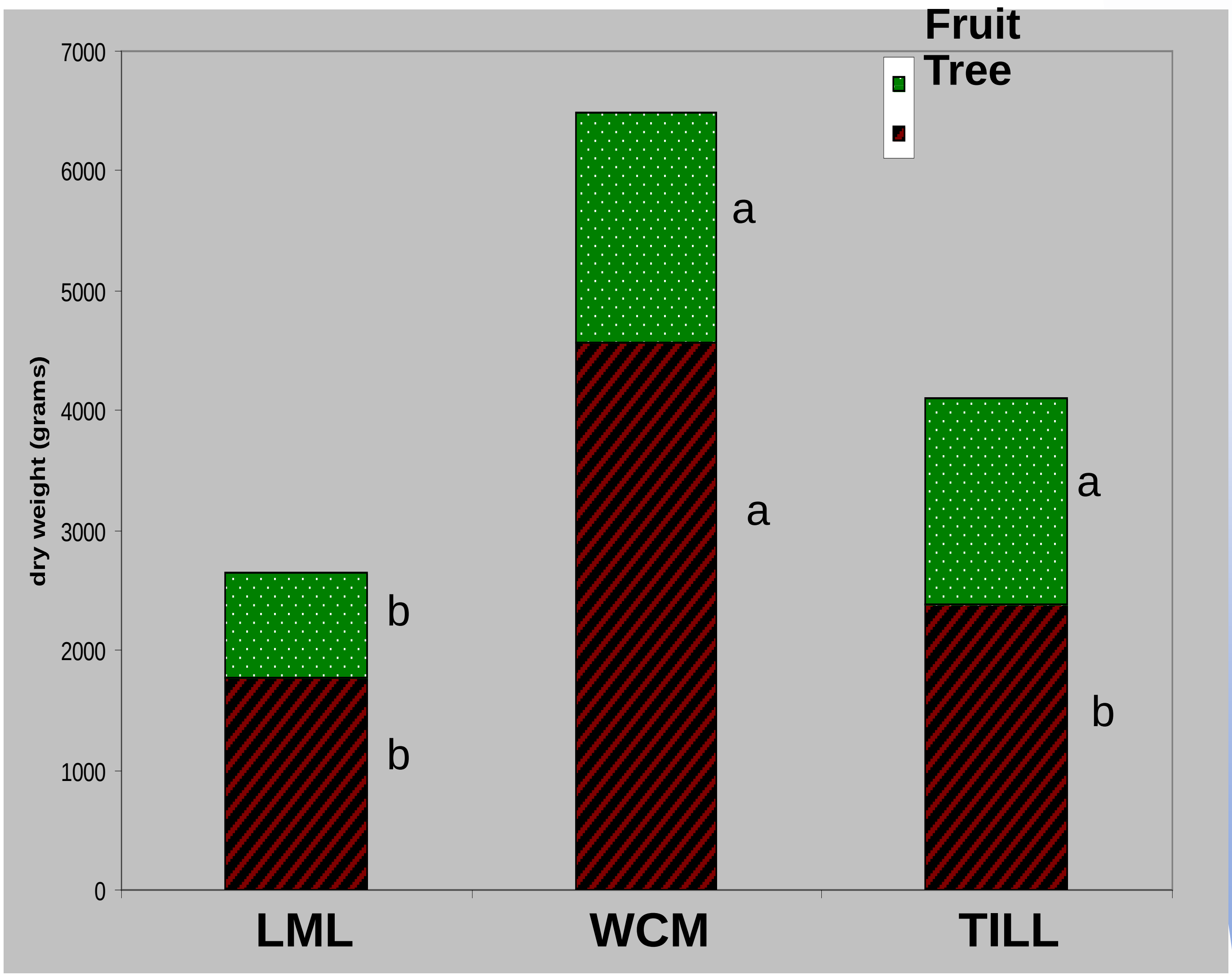
| Treatment | Stem Circ. (mm) | Pruning Mass (g/2 trees) |
|---|---|---|
| Herb. Strip | 100.3 a | 604 a |
| Mech. Cult. | 85.2 b | 234 b |

**3-yr old high density apple, South Africa**

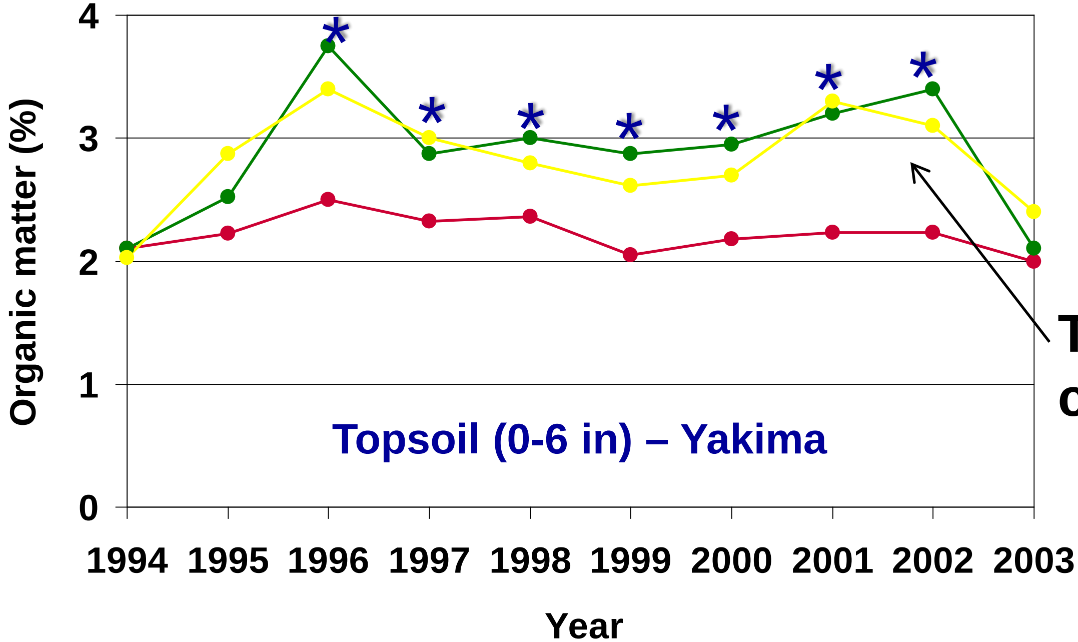
***(Wooldridge and Harris, 1989)***

# Total Biomass

## 3-yr Pinova/EMLA.7
## E. Wenatchee, WA



# Soil Organic Matter




**0.4 t/ac compost**

**Tillage for weed control**

| CA strawberries – paired fields | | |
|---|---|---|
| Biological property | 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 *** |

**8-10 t/ac compost**

*Courtesy: P. Andrews*

# Weed Fabric

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- Excellent weed control without soil disturbance
- Excellent habitat for voles
- Expensive to establish, but can increase early yields
- Mutually exclusive to other practices
- Challenges: excessive soil temperatures; no OM input unless opened; loss of soil quality; waste product at end of life
  - Solutions? Open fabric in winter; use white-on-black fabric to reduce heat, stimulate trees; biodegradable mulches; snakes!

# Weed Fabric in Sweet Cherry

**OSU, Hood River, OR – 2001-2007**

- **Fabric groundcover vs. bare ground in tree row (herb.)**
- **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**

***(Yin et al., 2007)***

*(H. Ostenson)*

# Sunrise Fabric Trial

- 2010-2012
- 6 yr old ‘Gala’/M9

| | 3 Yr Increase TCSA | 3 Yr Fruit Yield | Fruit size 2011* | Yield Eff. |
|---|---|---|---|---|
| | (%) | (kg/tree) | (g) | (kg/cm$^2$) |
| Black | 113 | 39.6 | 211 | 1.79 |
| White-on-black | 129 | 47.1 | 219 | 2.16 |
| *p*= | 0.13 | 0.08 | 0.05 | 0.005 |
| *no fruit size difference in 2010, 2012 | | | | |

Makus 2007. White-on-black provided excellent weed control and raised anti-oxidant levels in blackberry.

# Alley Vegetation

## Legumes for N Fixation


39 days after mowing; initially direct seeded

**Add 30- 80 lb avail. N/ac/yr;**
**US$0.70/lb N**

# What Might an Ideal OFM System Look Like ?

Narrow band cover crop - low competition, rodent repellent, beneficial insect habitat, bioremediation

+

Mulch on row edges

+

Legume in alley for N - mow and blow

+

Recycle prunings back to tree row

# What Might an Ideal OFM System Look Like ?

- Thin mulch - mow and blow + flailed prunings
- Supplemental weed control - organic herbicide, hi-residue cultivator, thermal, microwave, or other non soil disruptive
- Limited other vegetation in tree row for specific period
  ↑ C input, soil biota; flowers for beneficials; N capture
- Legume as part of alley mix to fix some N.

**OR**

Cover crop mix in tree in row

- Repel rodents, exclude weeds, fix N, support natural enemies, provide active carbon to soil biota, provide bioremediation of replant
- Need growth suppression mechanism – herbicide, mowing, growth regulator, growth habit

# Summary

- No perfect organic orchard floor management system
- All choices have trade-offs
- Need more clarity on effects of tillage on roots; new equipment options?
- Organic herbicide would be a game changer
- Can grow a portion of N need internally with legumes
- Need more work on novel plant-based solutions

Visit http://www.tfrec.wsu.edu/pages/organic/ for more details