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Tillage reduction and cover cropping for enhanced soil quality and weed management in western Washington organic vegetable farms

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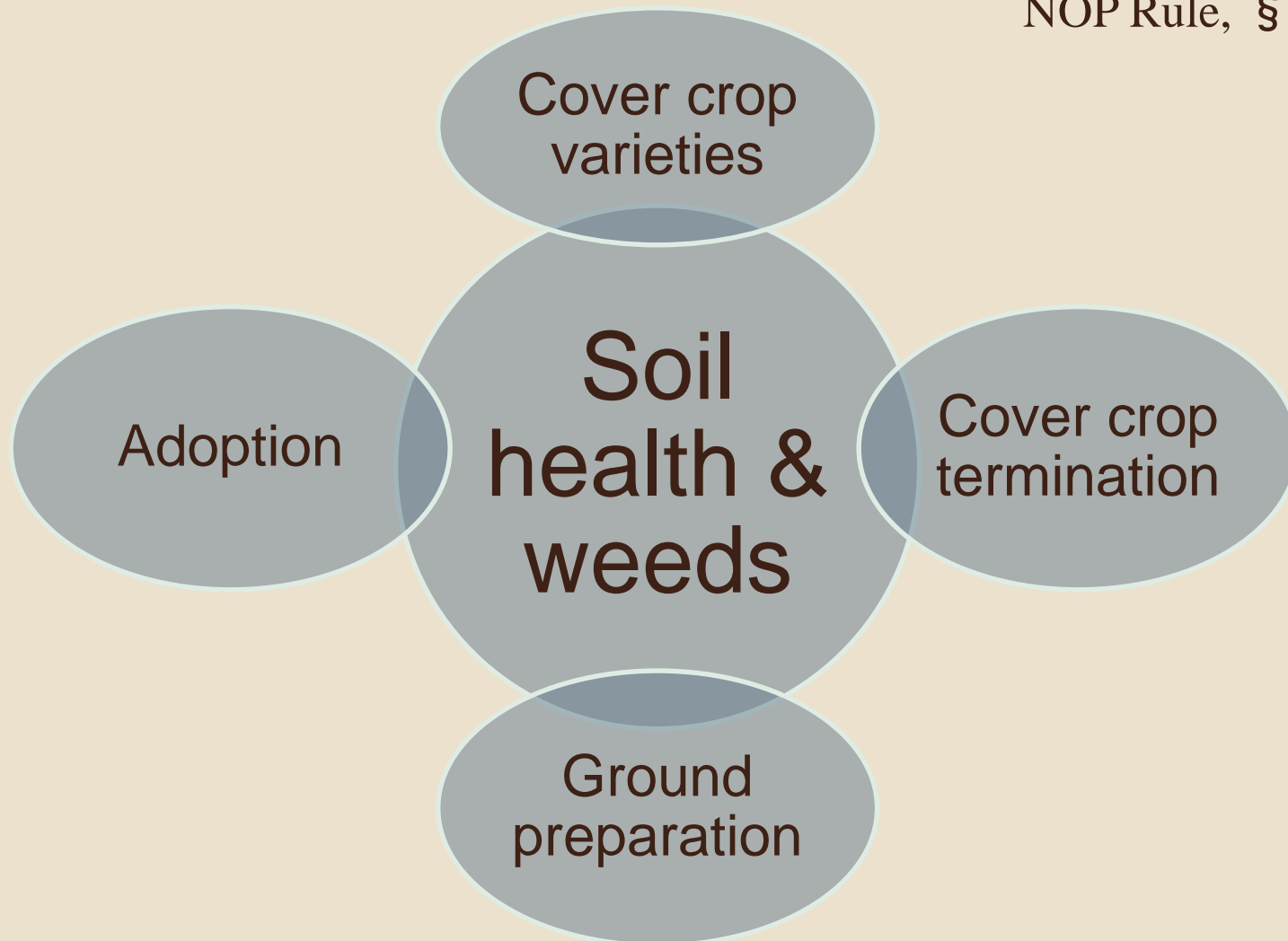
Steve Hallstrom-LetUs Farm



2015
International
Year of Soils

Organic producers must implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil.

NOP Rule, § 205.203



Presentation outline.

- 1. Reducing tillage to maximize diverse soil functions**
- 2. Selecting cover crops and cover crop management practices for reduced tillage**
- 3. Long-term reduced tillage experiment: soil quality, soil temperature /moisture/ light penetration, soil respiration, residue decomposition, labor, yield**



2015

International
Year of Soils

What does tillage do?

- Manage residue
- Manage weeds
- Prepare seed bed
- Aeration
- Modify moisture
- Modify temperature

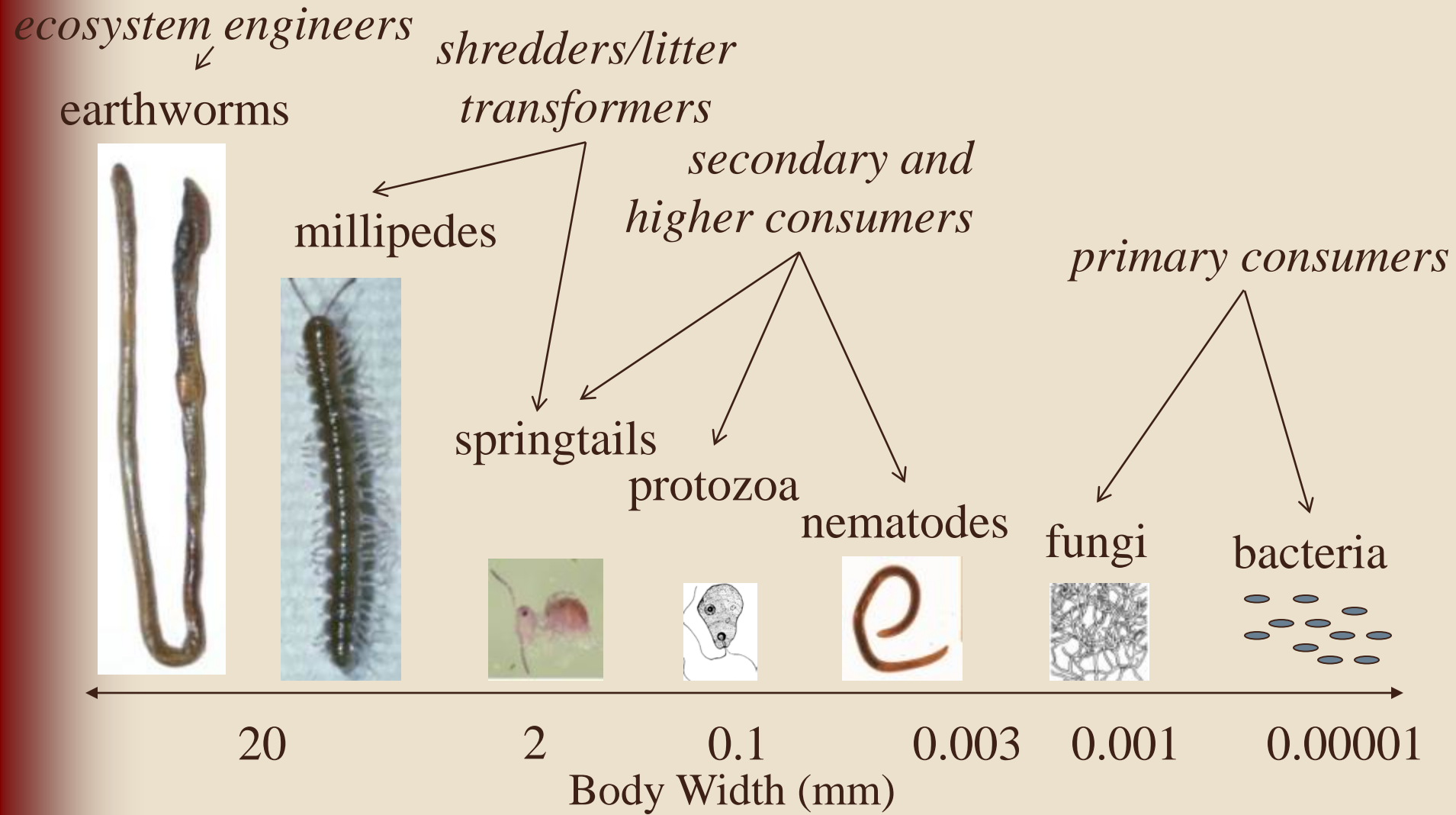


Management practices to encourage beneficial soil functions

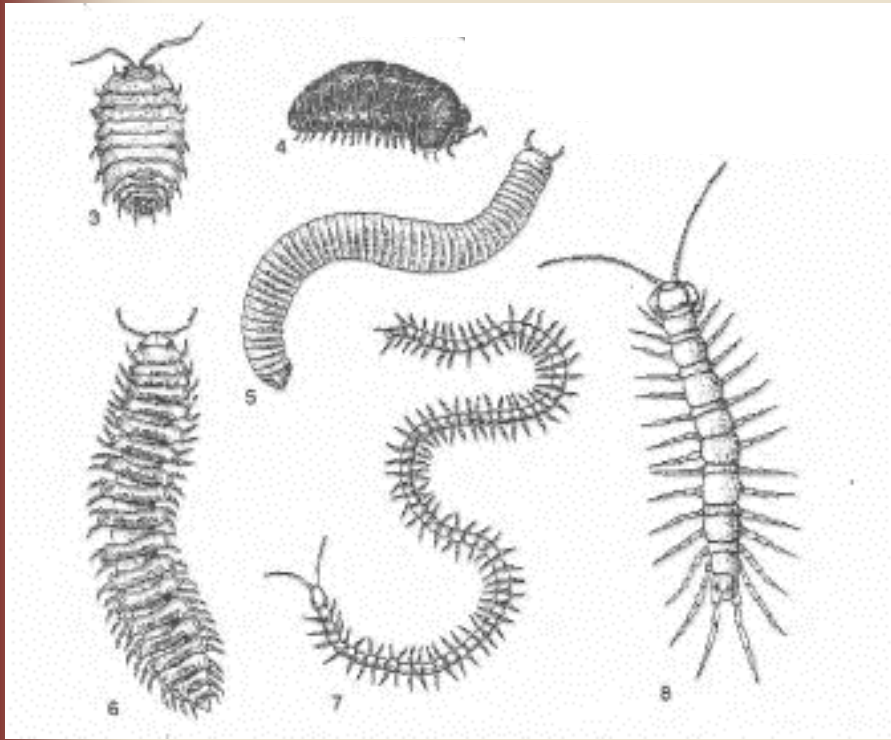
- Use plant diversity to increase the diversity in the soil biota
- Keep a living root growing throughout the year
- Keep the soil covered as much as possible
- Manage more by disturbing less



Groups or guilds of soil organisms and their relative sizes



Litter transformers speed decomposition through an “external rumen;” reduce size of debris, encourage colonization, and disperse material and microbes



Wolters and Ekshmitt, 1997



Earthworms are “ecosystem engineers”; changing their environment to suit their physiology.



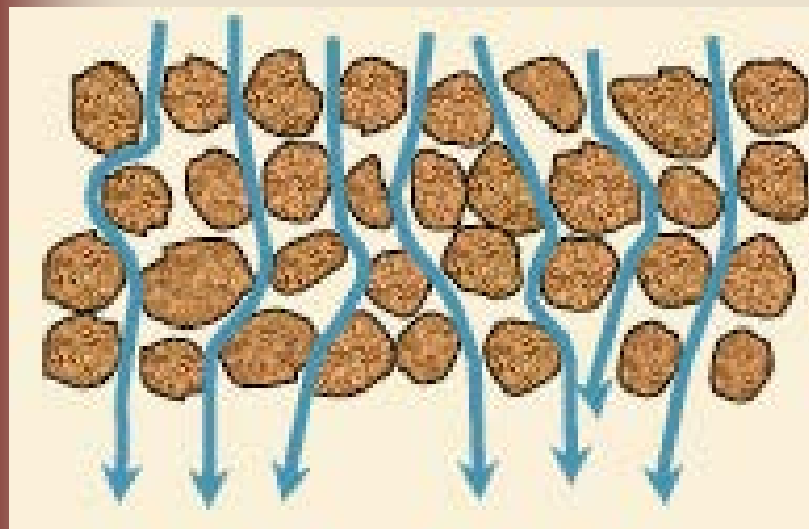
Earthworms increase aggregation in three ways:

1. By physically compacting smaller soil particles together
2. By creating fecal pellets – which are themselves durable aggregates
3. By coming to the soil surface to gather organic matter to take down into their burrows.

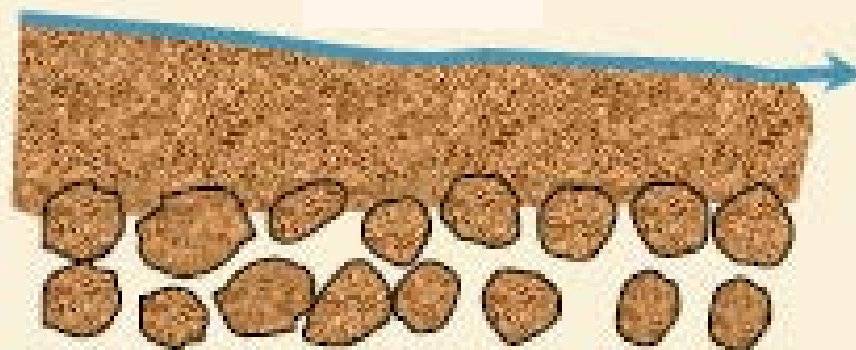


Increased aggregation allows water to infiltrate easily during a down pour and drain afterward to let air in.

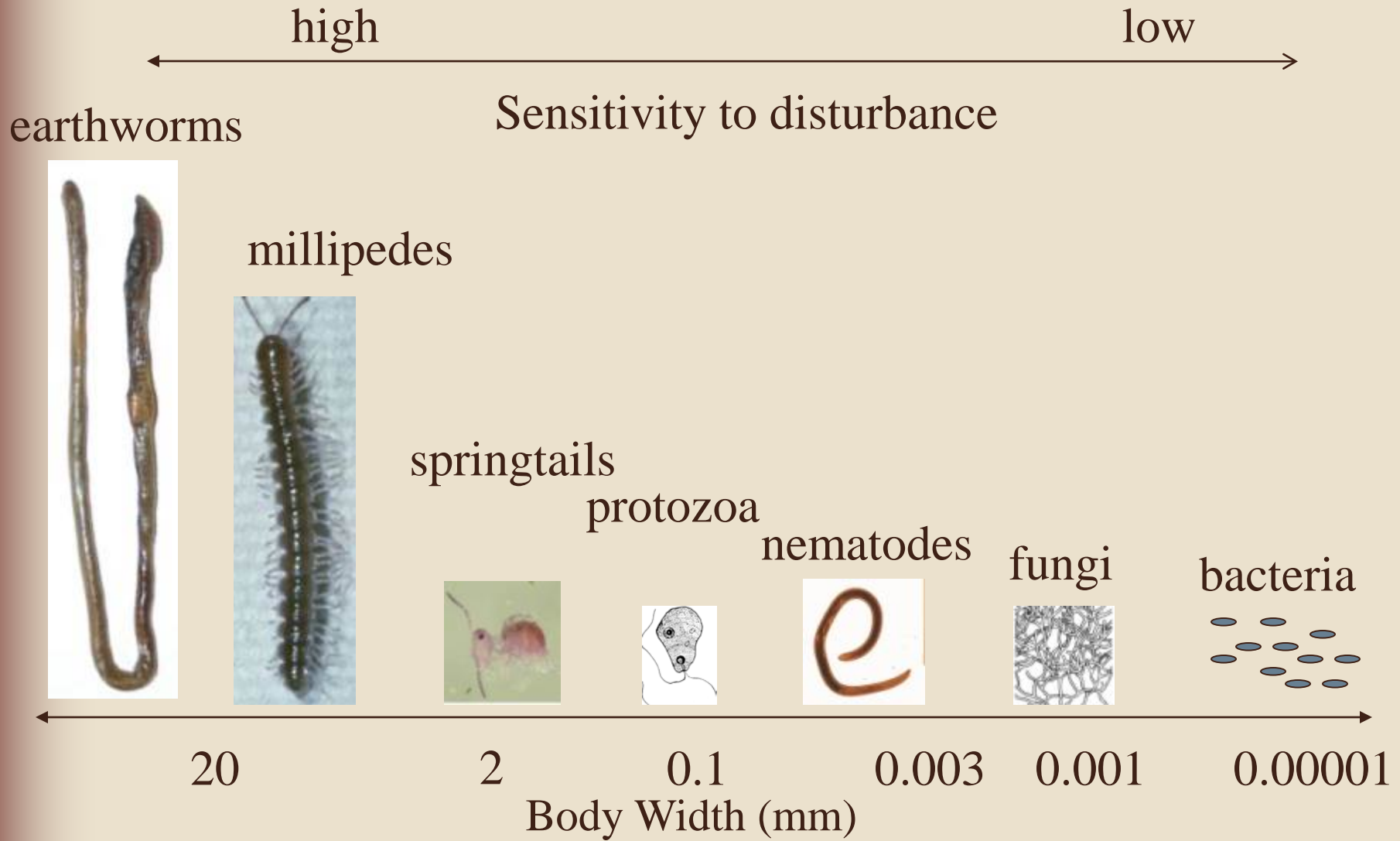
Infiltration



Runoff



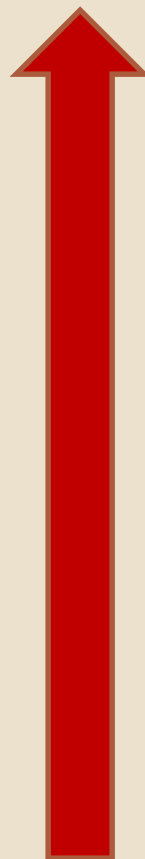
Larger-bodied organisms are more sensitive to disturbance



Why reduce tillage?



Soil Compaction
Erosion
Surface Crusting
Dust
Sediment
Fuel Use
Greenhouse Gases



Organic Matter
Soil Organisms
Soil Structure
Aggregate Stability
Water Holding Capacity
Water Infiltration
Carbon Sequestration
Field Access
Profitability?

In selecting winter over crops for reduced tillage we look for large biomass and early development in spring



Cover crop selection for reduced tillage in organic production

- 2008-09 On farm- cereal rye
- 2009-10 WSU Puyallup- barley, wheat
- 2010-11 WSU Puyallup- barley, vetch
- 2011-12 WSU Puyallup & Mt Vernon,
3 on-farm sites 19 varieties and
mixes: barley, rye, oats, vetch,
peas, triticale
- 2012-13 WSU Puyallup & Mt Vernon 4 on-
farm sites: 16 varieties and mixes
rye, barley, vetch

Cover crops were terminated with a flail mower or roller/crimper.

Mowed
cover
crop

Rolled
cover
crop



Zadoks Stages of grain development



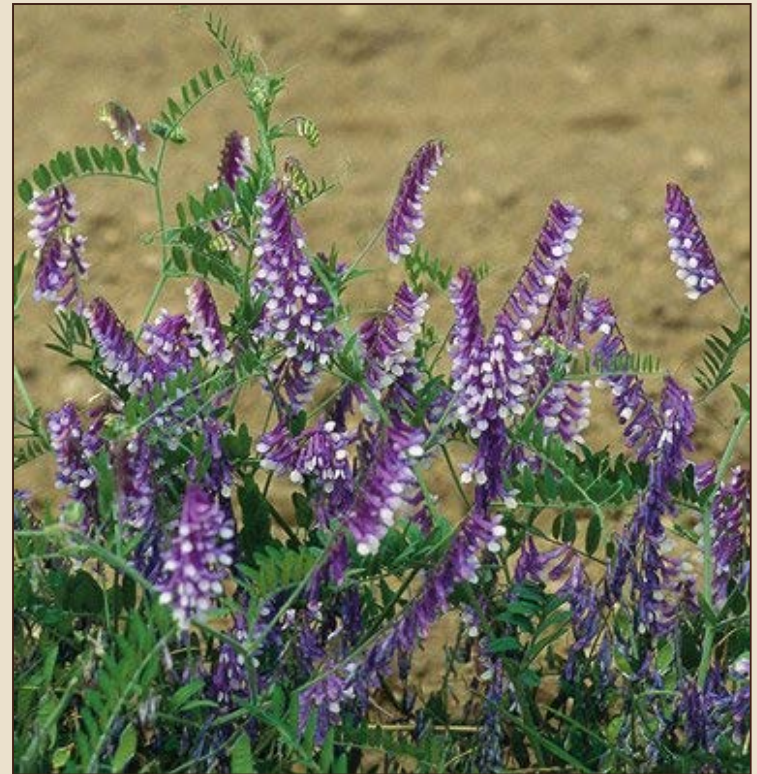
“Early” = Late anthesis
69



“Late” = Early milk
73

Zadoks et al., 1974

Mischler vetch development

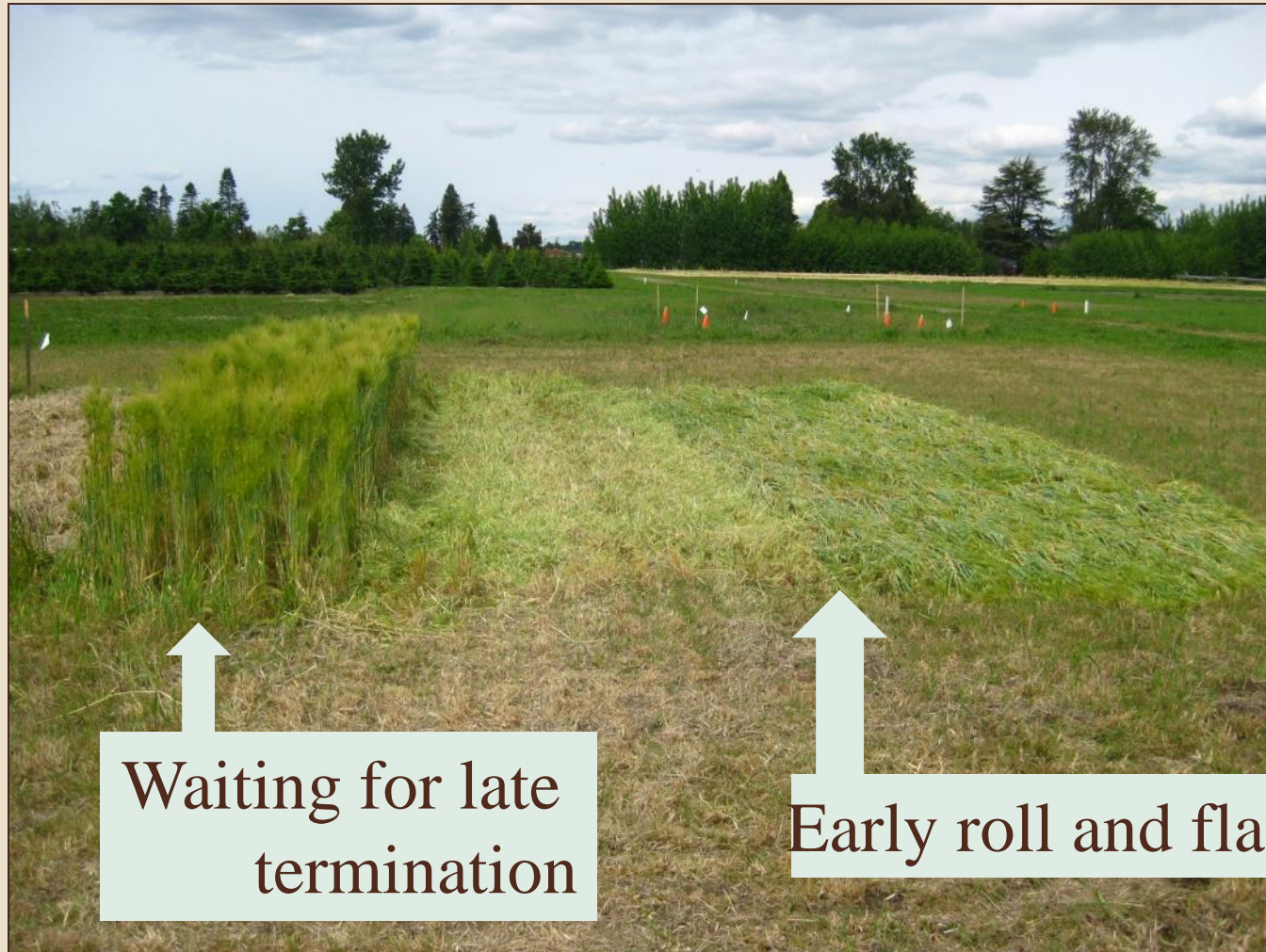


“Early” = 60% flowering “Late” = 100% flowering

Mischler et al., 2009



Timing of termination “Early” or “Late”



Rolling effectiveness

Year	Cover crop	Percent of cover crop mulch standing		
		"Early"	"Late"	"Early"/"Late" Mean
2012	Aroostook rye	8 b	0 a	--
	Common rye	10 b	10 a	--
	Strider barley	68 a	20 a	--
2013	Aroostook rye	--	--	3 c
	Common rye	--	--	19 b
	Strider barley	--	--	86 a



2012 Termination time $p < 0.0001$
2013 not significant

2013 Cover crop $p < 0.0001$

Aroostook rye, common vetch, and hairy vetch types produced large biomass

		2012	2013
Cover Crop		biomass lbs/acre	
Grain	Aroostook rye	8030	6160
	Common rye	5710	6500
	Strider barley	7490	7050
Mix	Strider+Purple	5710	4100
Vetch	Common	5260	4370
	Hairy	4910	6780
	Lana	3030	4190
	Purple Bounty	4910	5170

To roll or to flail?

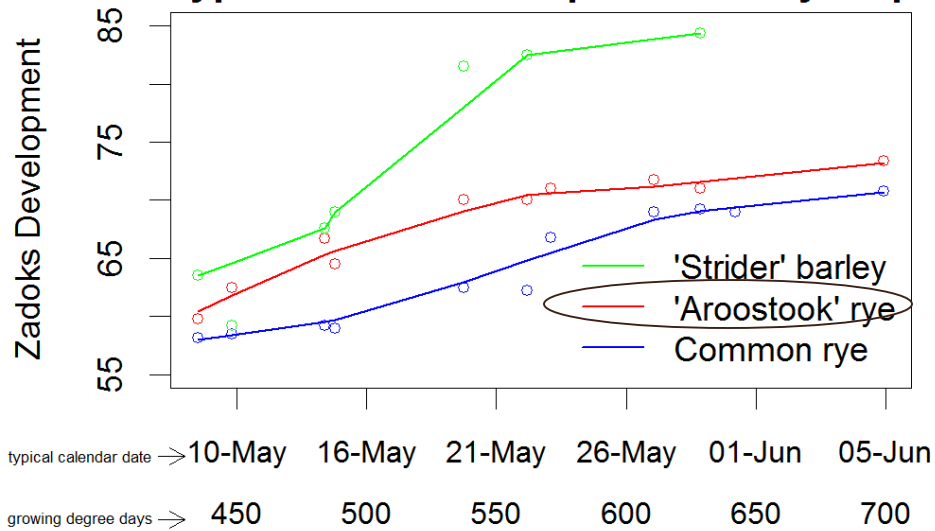
Grain cover crop	-% weed cover -	
	Flail	Roll
Aroostook rye	17	7
Common rye	41	29
Strider barley	24	19
Cover crop average	27	19



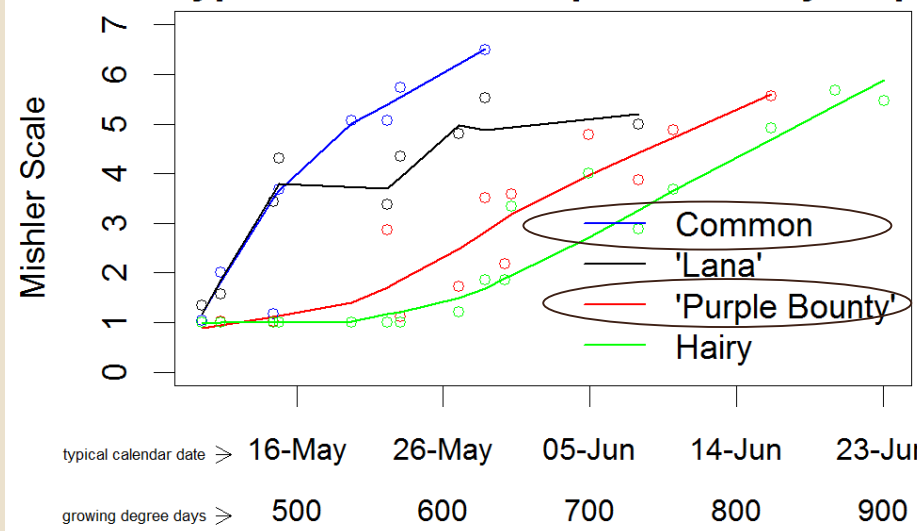
Termination type
 $p=0.007$

Selection trials have helped us identify superior varieties for management in reduced tillage.

Typical Grain Development at Puyallup



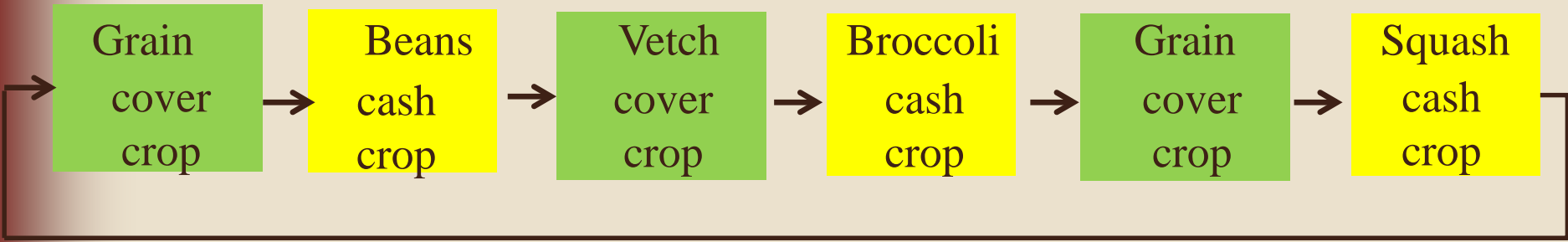
Typical Vetch Development at Puyallup





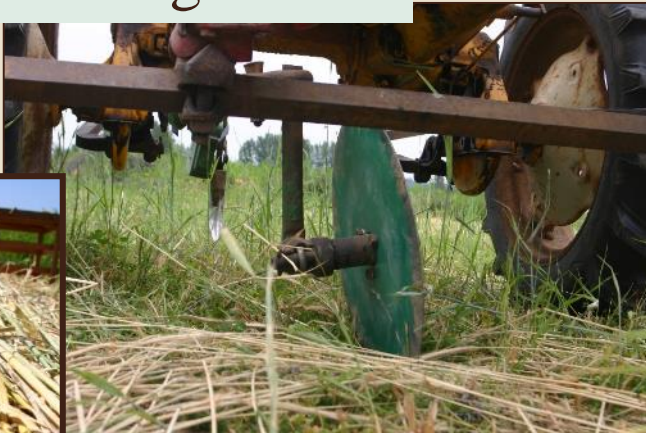
Long-term experiment includes 5 treatments & 3 crops (squash, broccoli, beans)

Squa	Broc	Bns	Broc	Squa	Bns	Broc	Bns	Squa	Squa	Broc	Bns	Squa	Broc	Bns
flailing + no-till			flailing + strip till			flailing + complete till			roll/crimp + strip till			roll/crimp + no-till.		





No Till "Planting Aid"



Strip Till







Water infiltration



Penetrometer to measure compaction



Bulk density; an indication of compaction.



Microbial biomass, soil
respiration, nutrient availability.



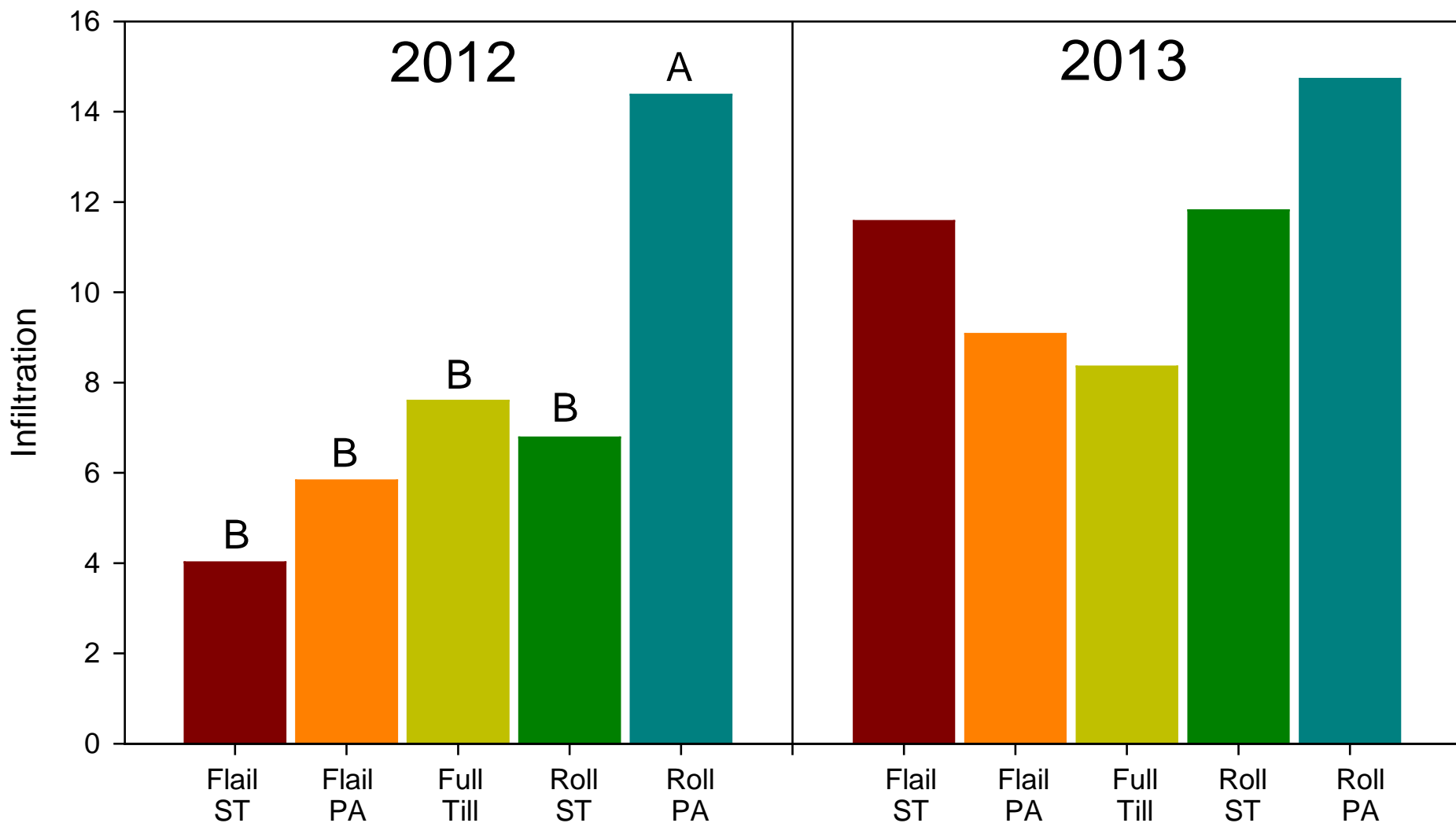
Cover crop decomposition is studied with buried or surface-placed mesh bags.



Earthworms can be coaxed from the soil with a skin irritant, or physically removed.

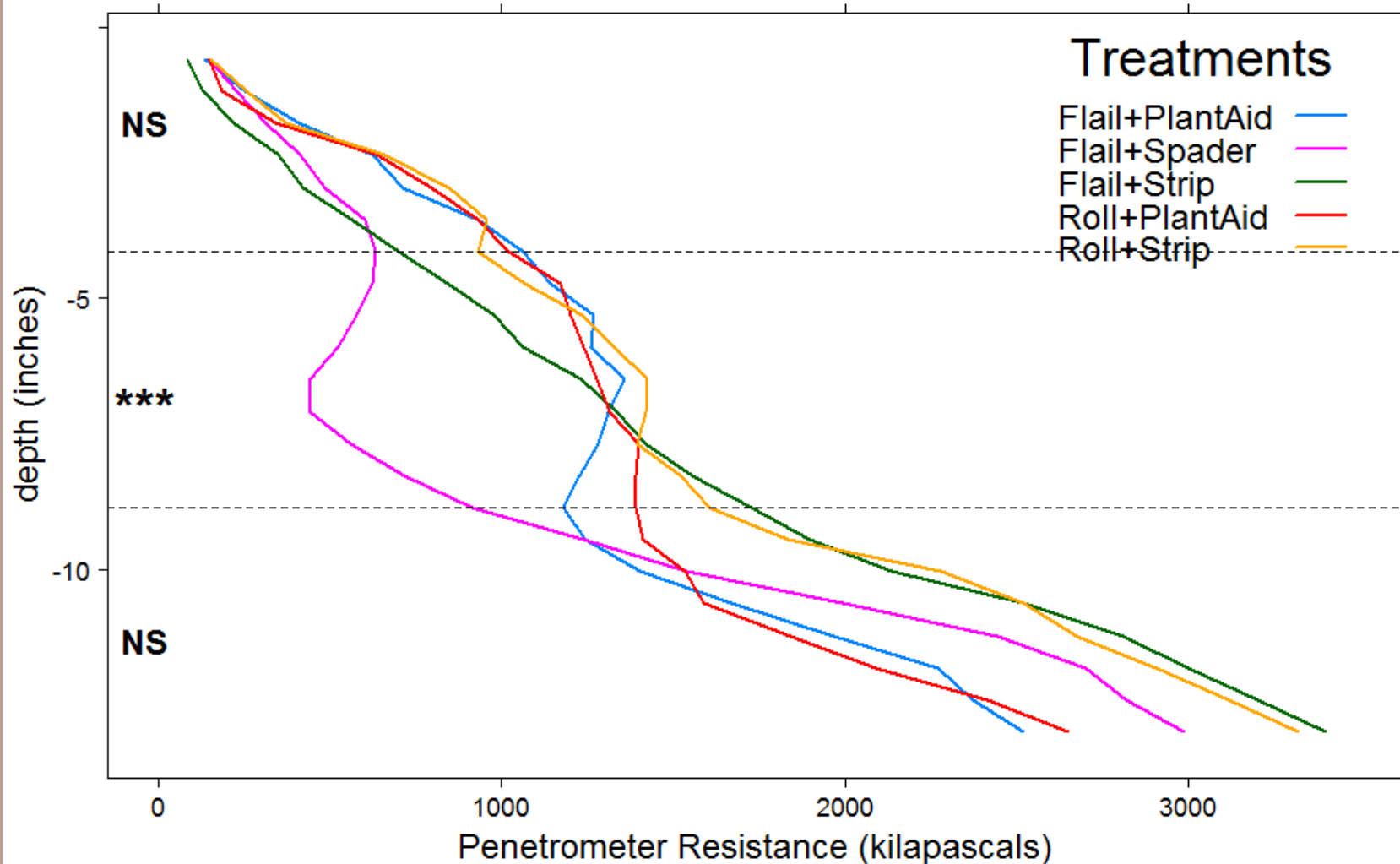


Infiltration

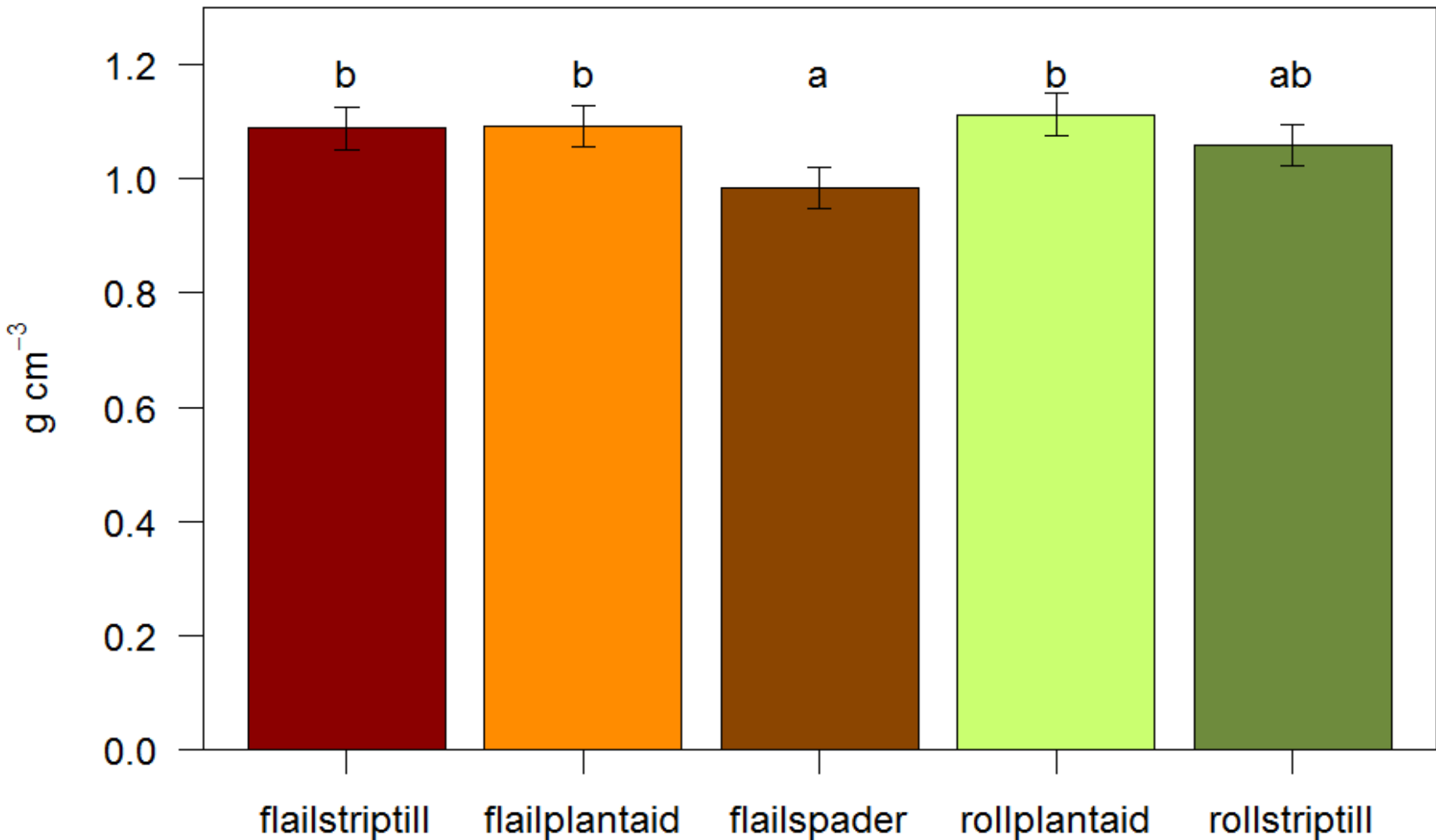


Soils were more compact at the surface in reduced tillage

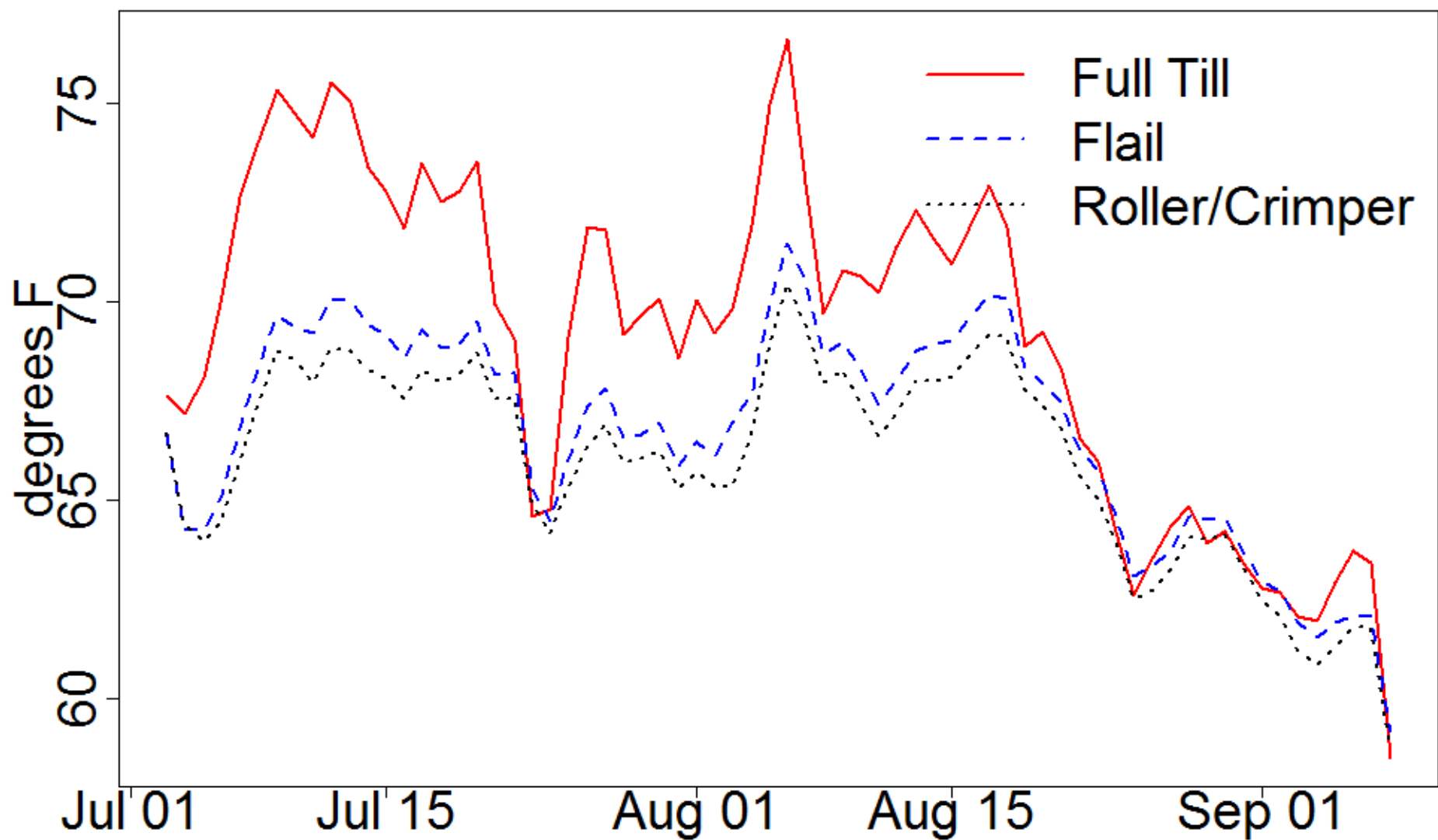
Soil Compaction with Different Reduced Tillage Treatments, 25 July 2012, Puyallup



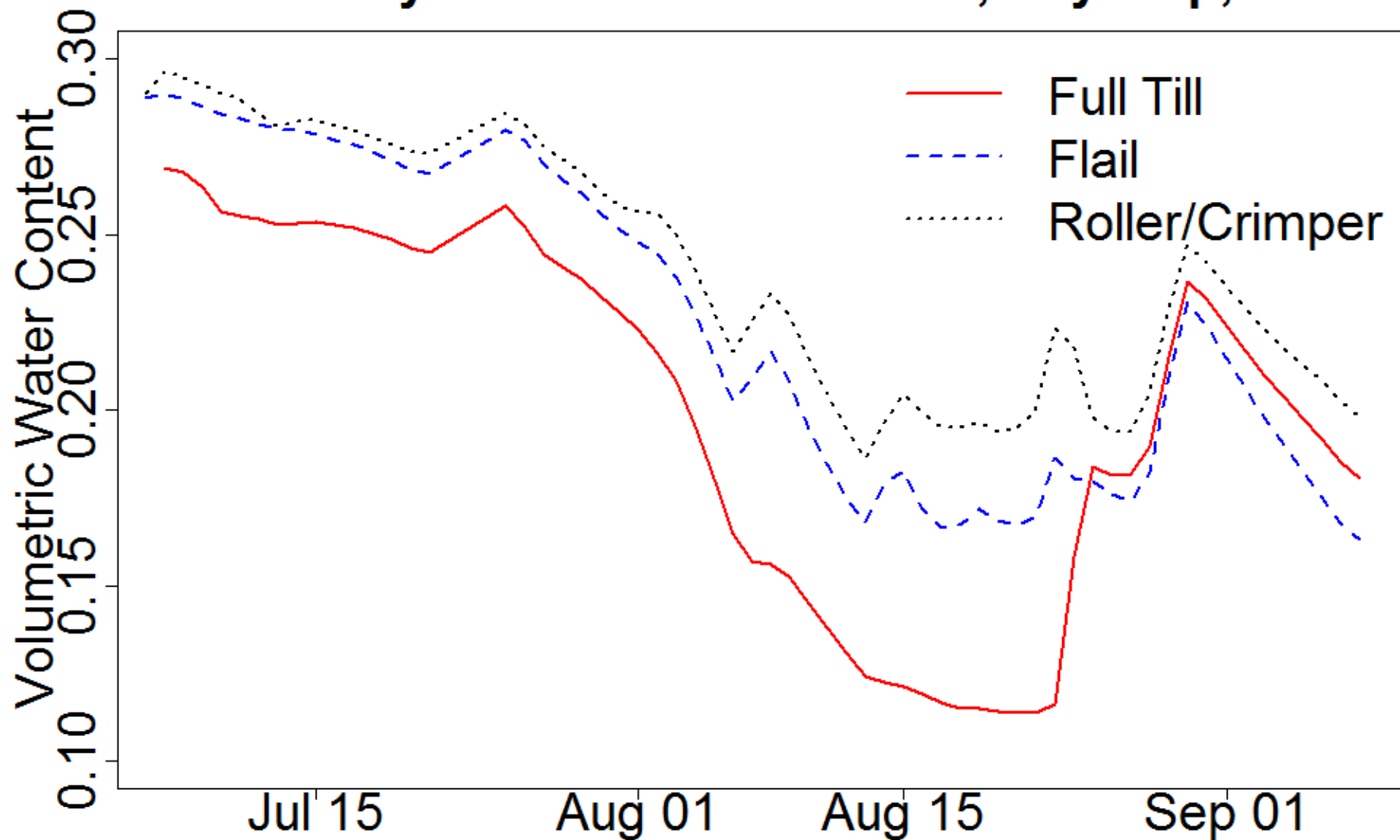
Bulk Density by Treatment, WSU Puyallup 2012-2014



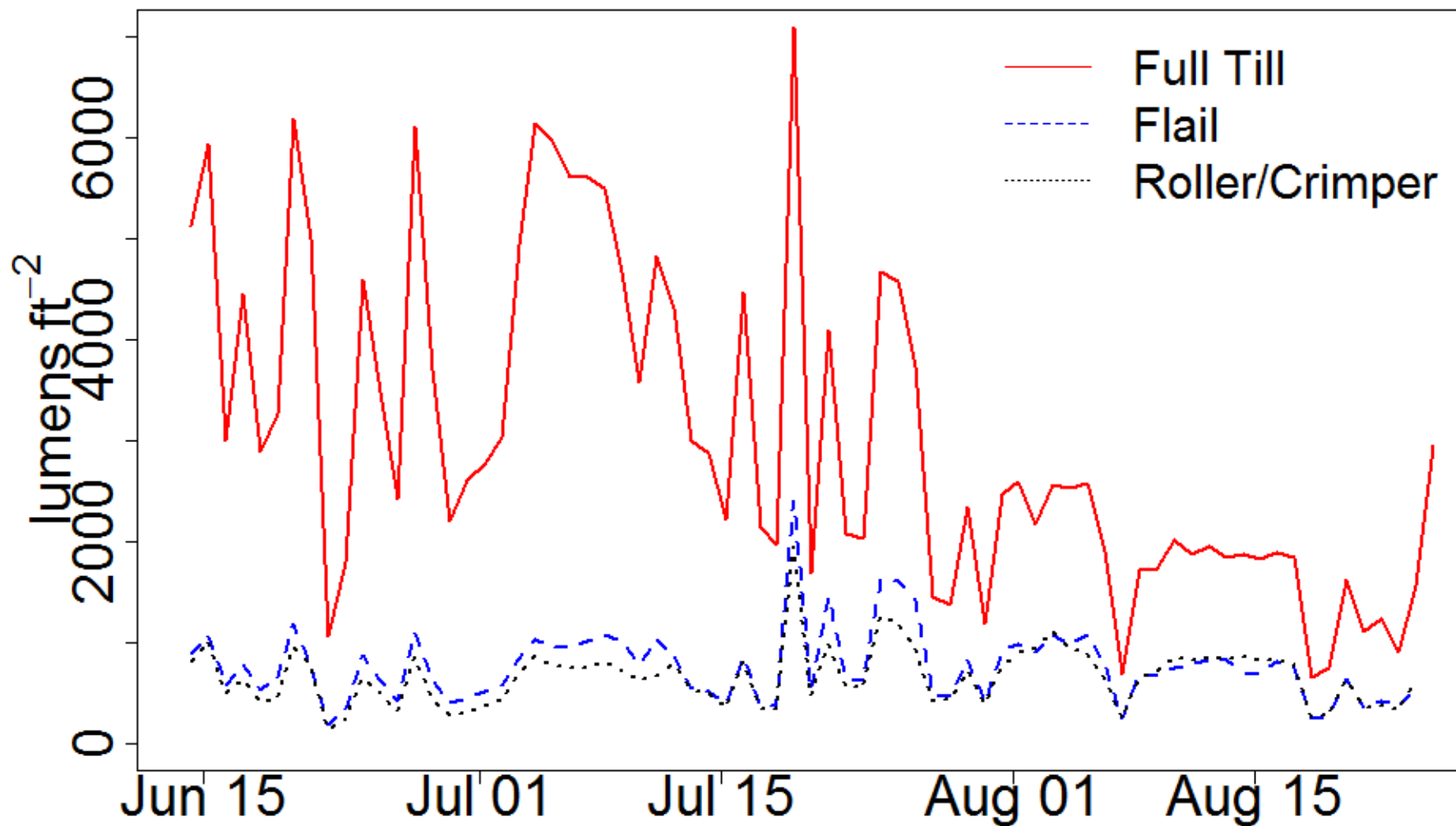
Mean Daily Soil Temperature at 10cm, Puyallup, 2012



Mean Daily Soil Moisture at 10cm, Puyallup, 2012

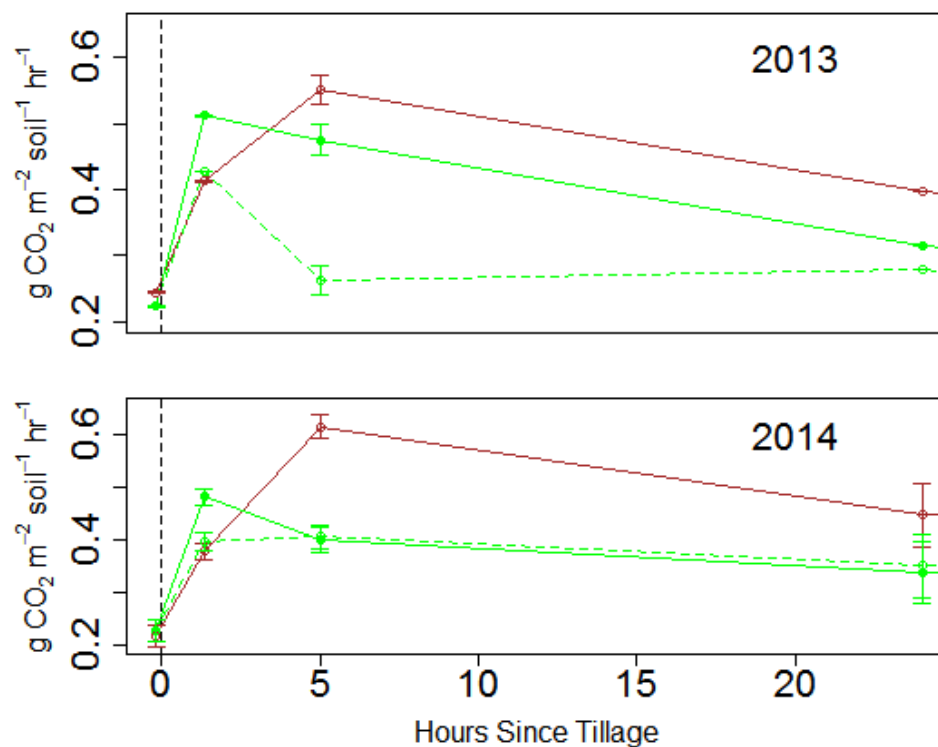


Mean Daily Light by Termination, Puyallup, 2012



More carbon dioxide is emitted from tilled plots, then no-till plots on the day of tillage....

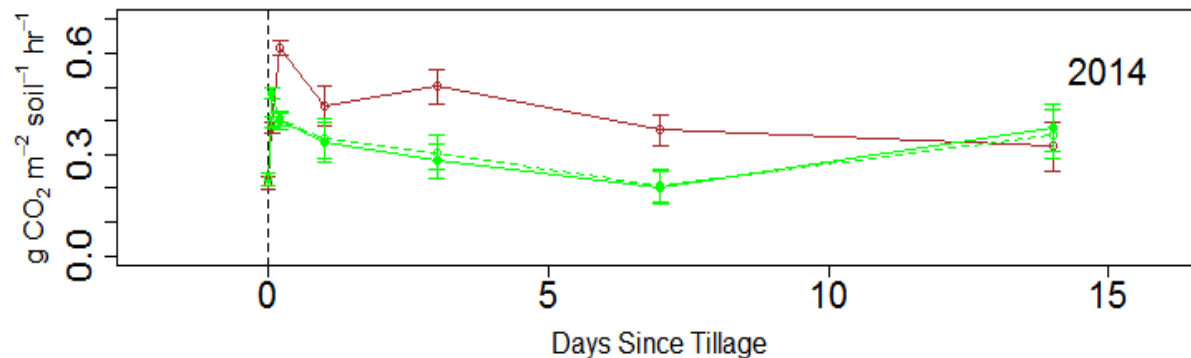
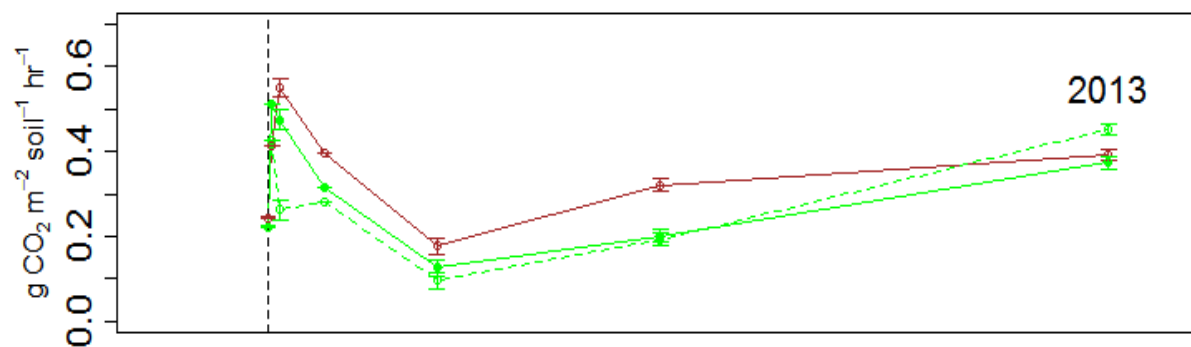
In-Situ Respiration On Day of Tillage



- Flail+Spader
- - Roll+Planting Aid, Out of row
- Roll+Planting Aid, In-row

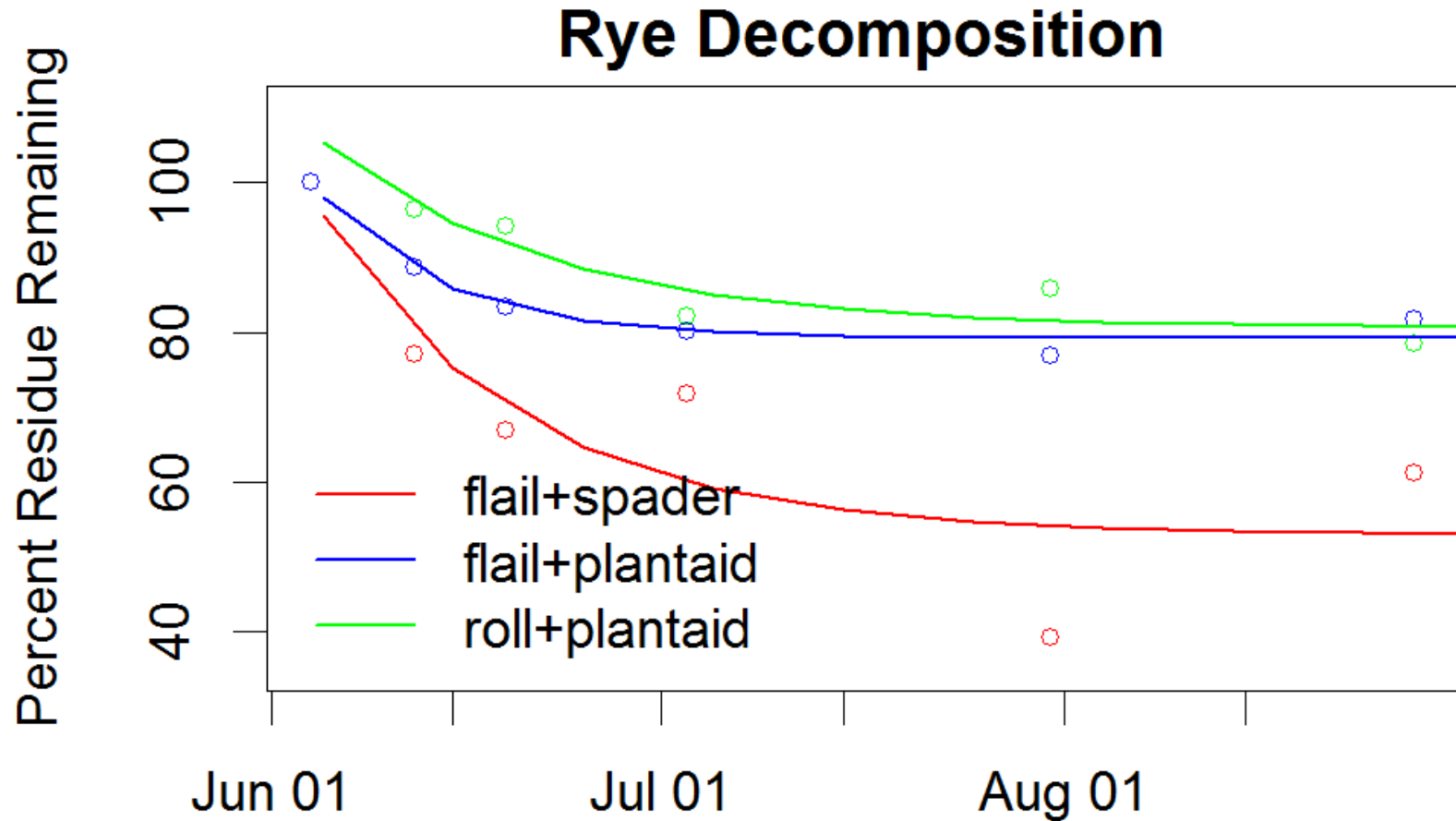
....and over the next 7 days

In-Situ Soil Respiration Following Tillage

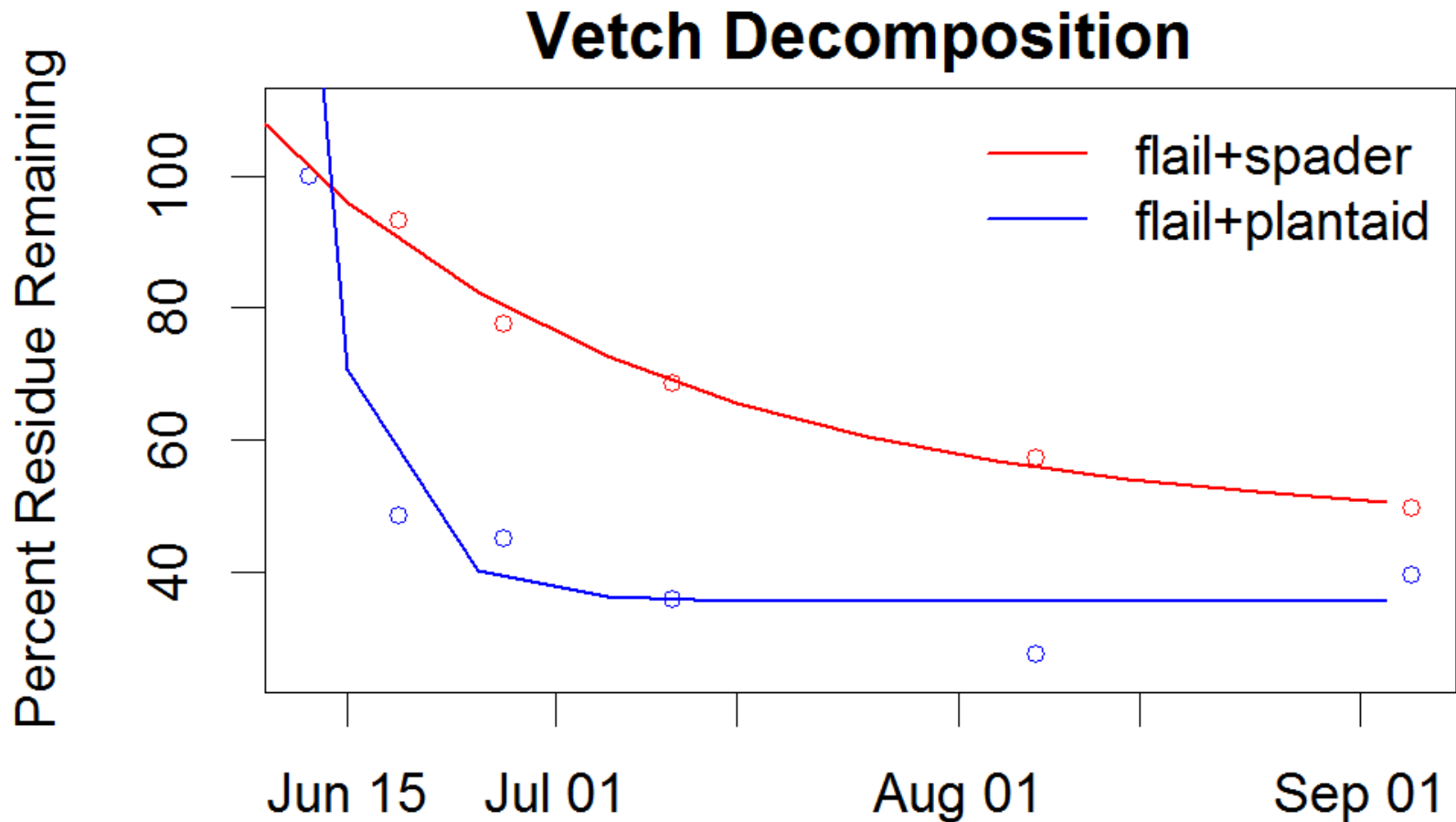


- Flail+Spader
- - -○- - Roll+Planting Aid, Out of row
- Roll+Planting Aid, In-row

Rye decomposition was slightly more rapid with flail mowing than rolling and much more rapid when incorporated by tillage



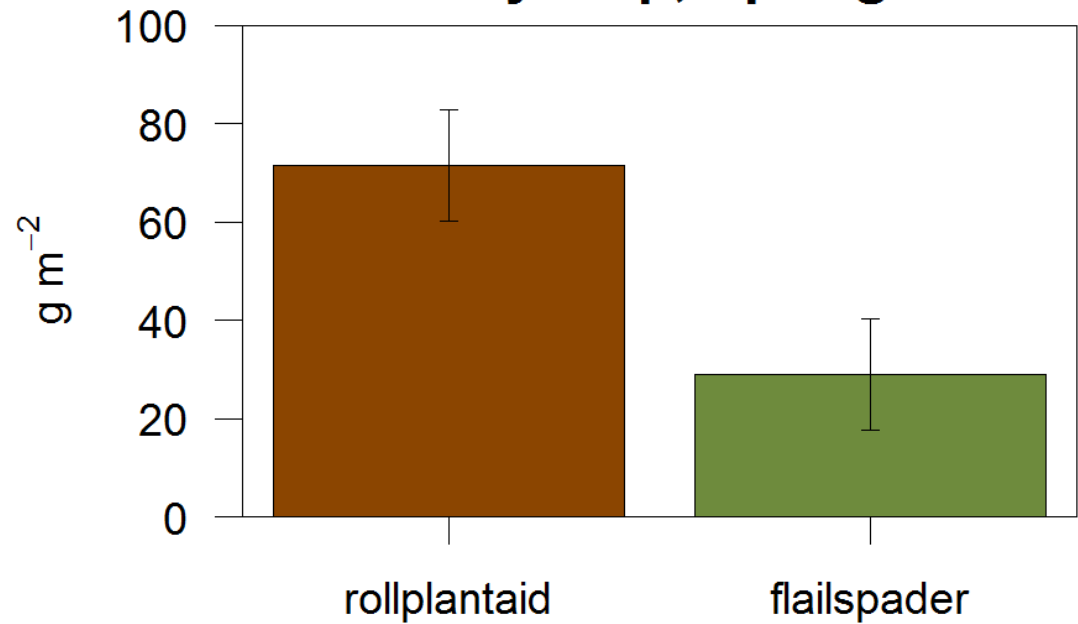
Vetch decomposition was more rapid early in the season when incorporated versus being left on top of soil



Earthworm biomass was larger in reduced tillage treatment compared to full—till treatment.

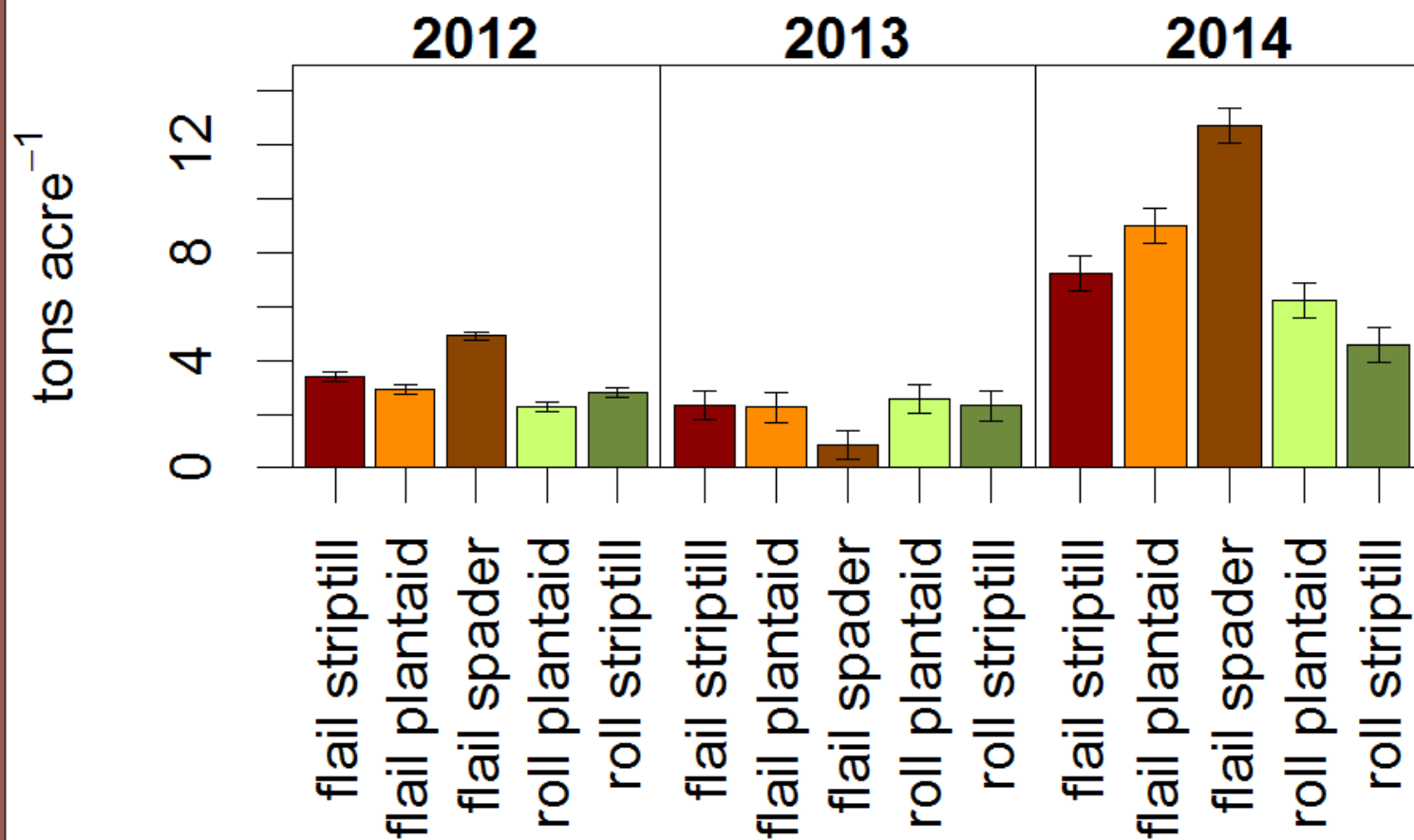


**Total Earthworms
WSU Puyallup, Spring 2015**



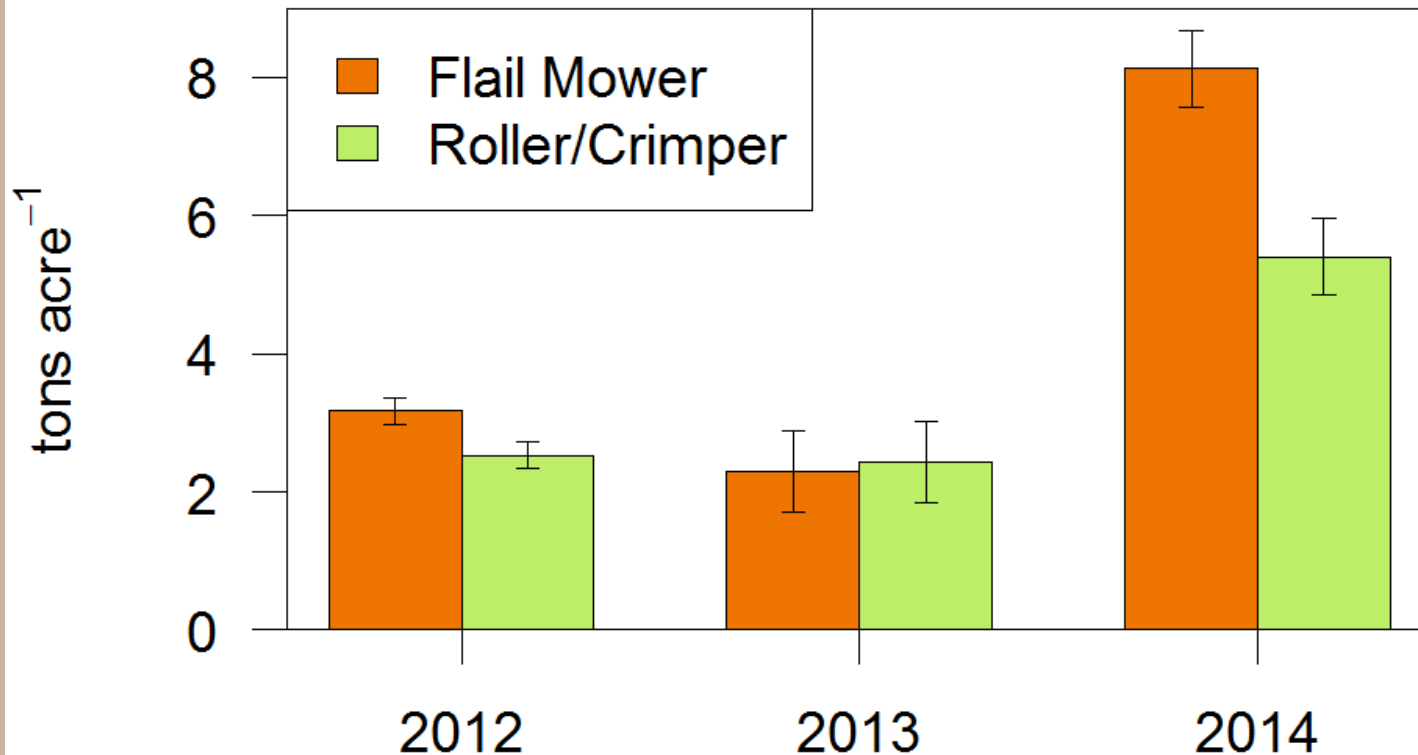
Squash yields were larger in the fully tilled treatment in 2 out of 3 years.

Squash Yield, Puyallup 2012-2014



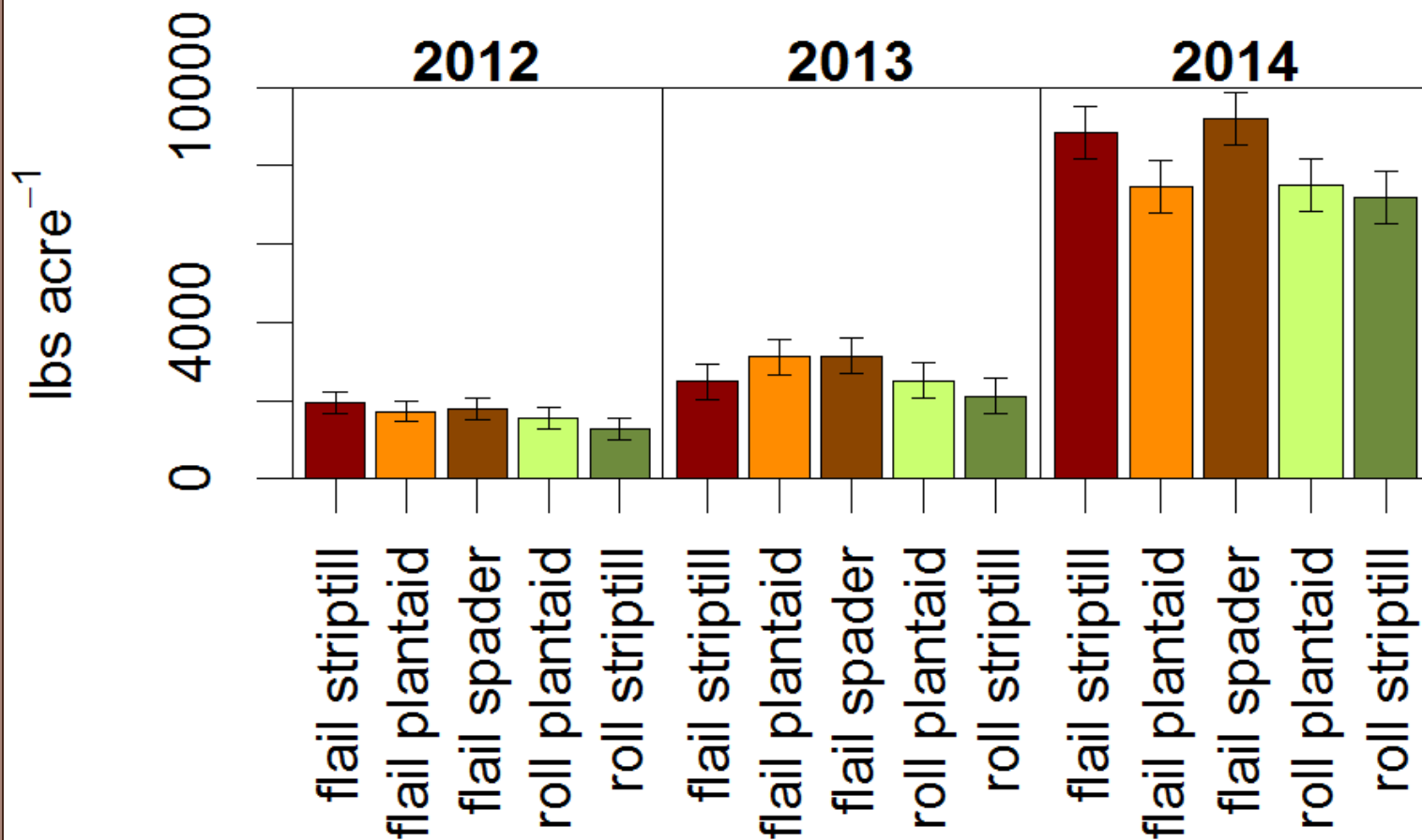
Among reduced tillage treatments, flail mowed treatments yielded more squash 2 out of 3 years.

Squash Yield by Cover Crop Termination in Reduced Till Treatments



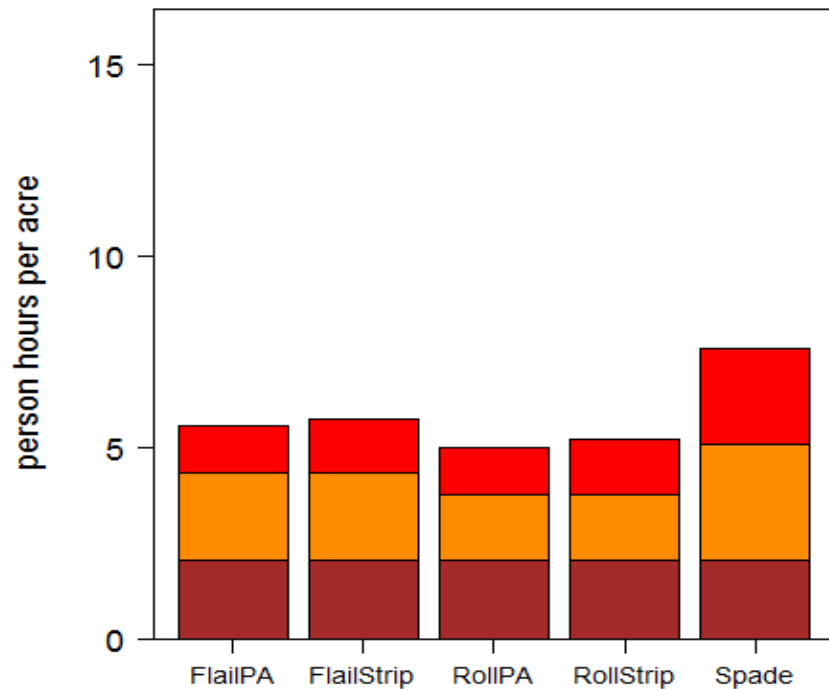
Broccoli yields have been similar in reduced tillage and fully tilled treatments.

Broccoli Yield, Puyallup 2012-2014

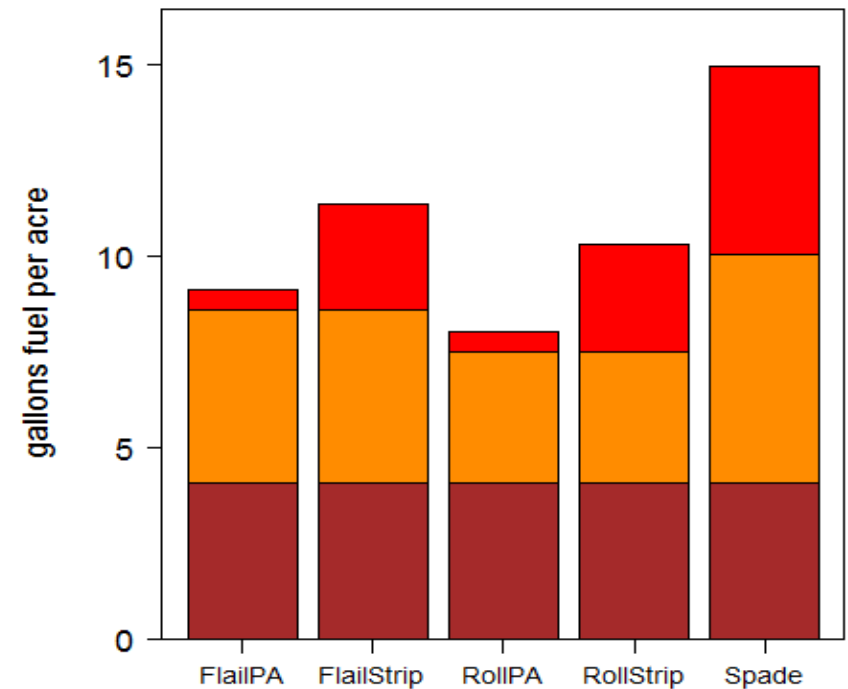


Flailing and spading utilized more fuel than alternative

**Annual Tractor-Labor by Treatment
Squash, 2012-2014**

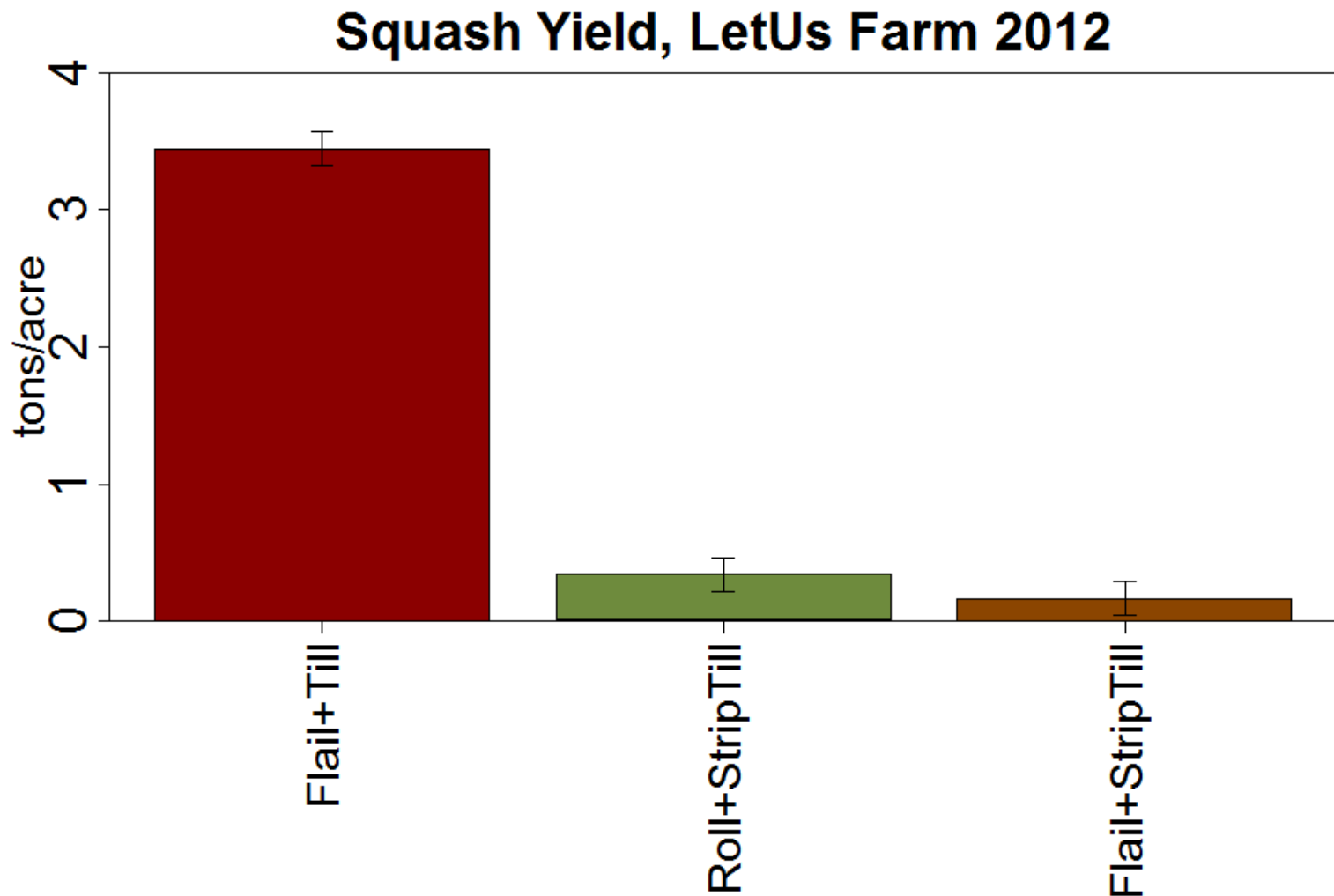


**Annual Fuel Usage by Treatment
Squash, 2012-2014**

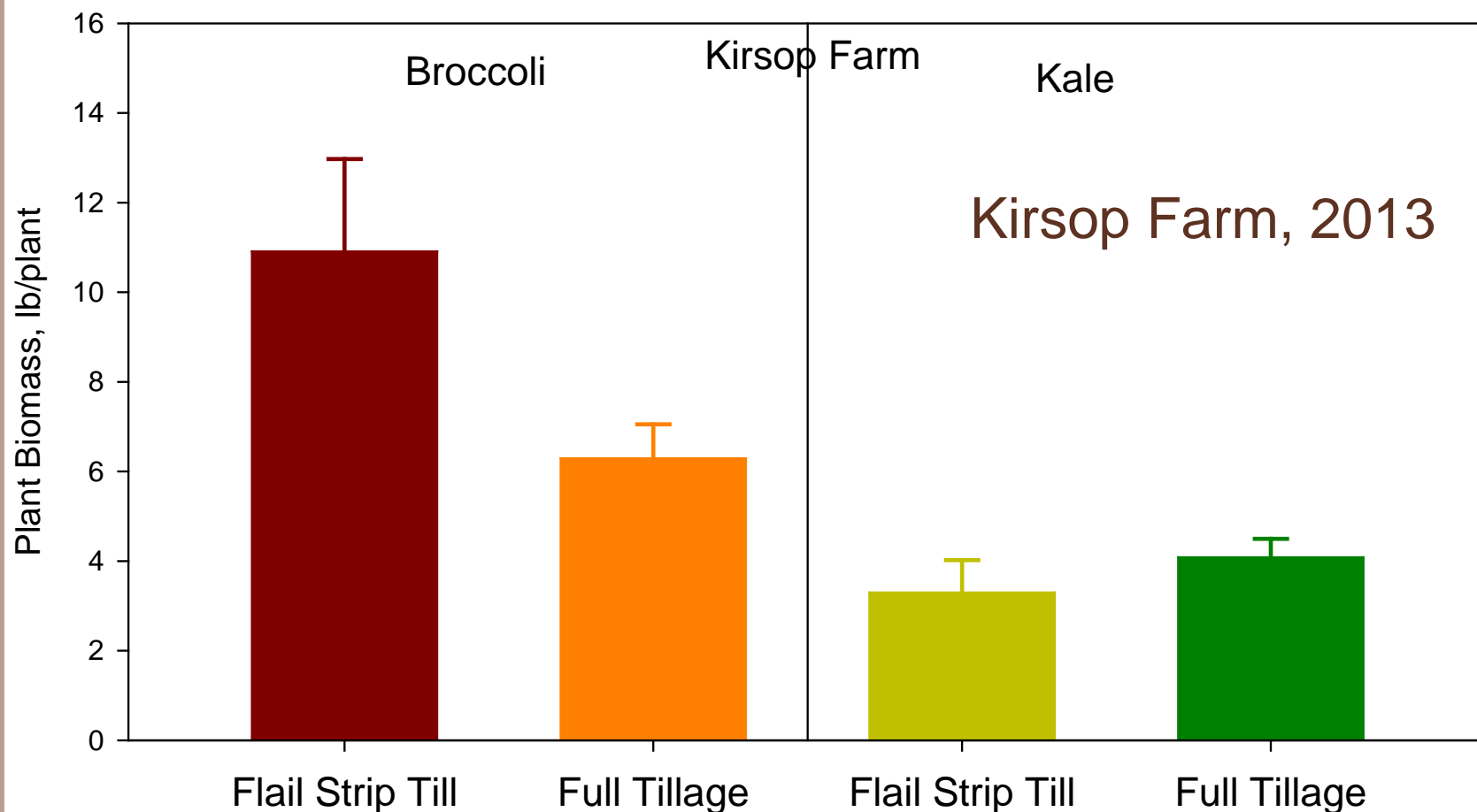


■ Soil Prep Cover Crop
 ■ Cover Crop Termination
 ■ Soil Prep Cash Crop

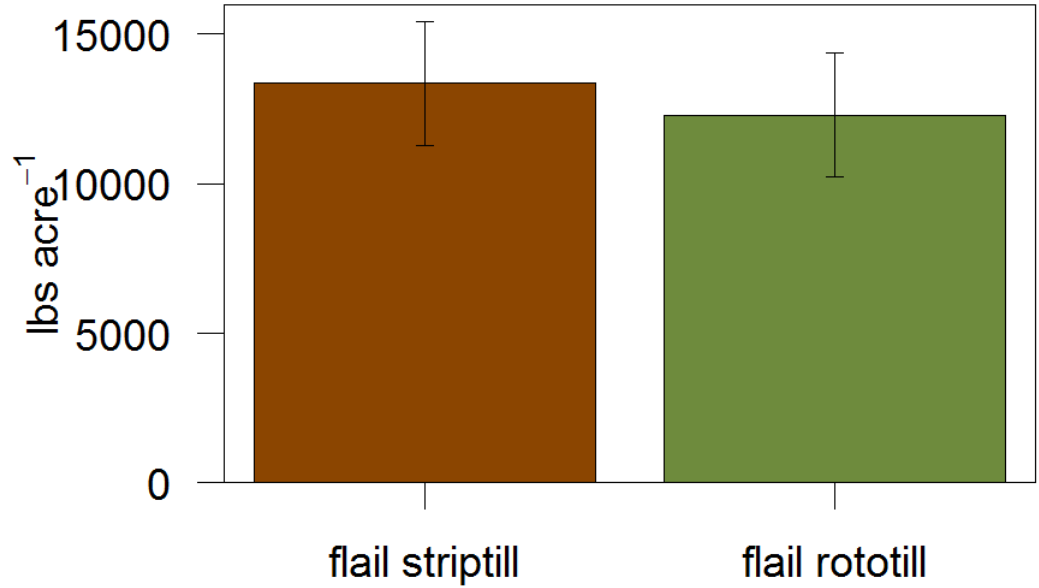
Reduced tillage did not succeed at Let Us Farm with a silt loam soil



Reduced tillage has been promising at Kirsop Farm with broccoli and kale planted into flailed vetch in a loamy sand.

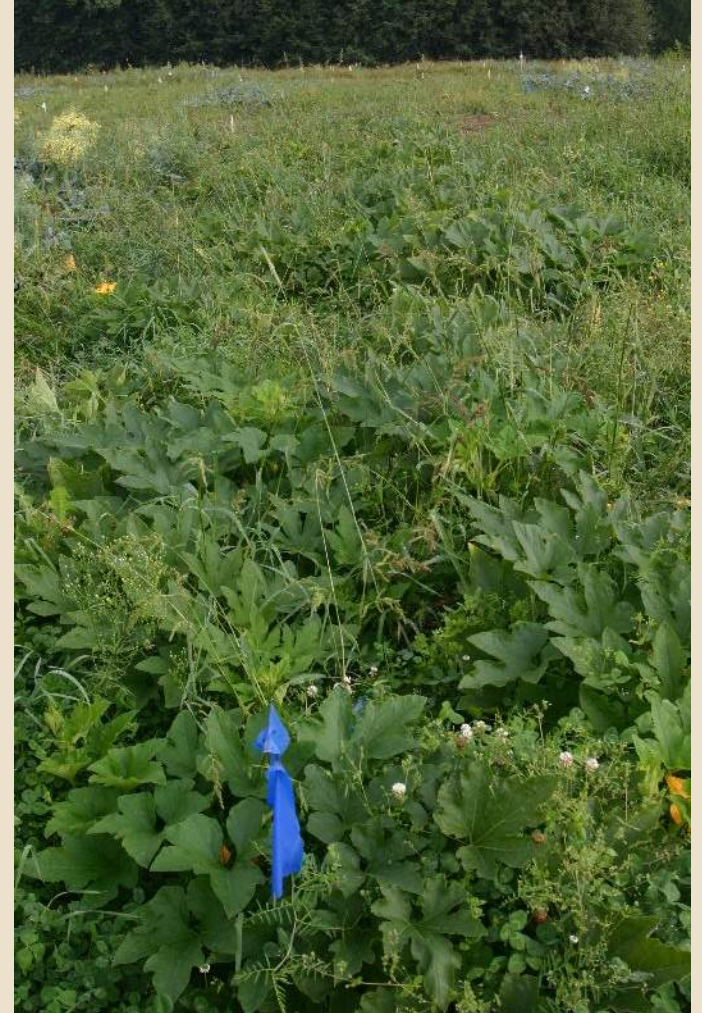


Broccoli Yield Kirsop Farm, 2014



Flail mowed mulch at Kirsop

Conclusions and direction forward:
Grower interest continues, but so does skepticism.



Thus far we have looked only at rotational reduced tillage.
We will examine continuous conservation tillage for organic.



No-till rye cover crop planting



Tilled rye cover crop planting

February 5, 2015

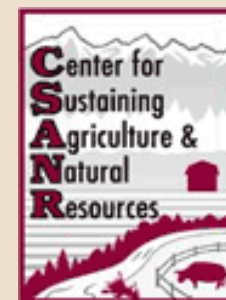
More aggressive strip tillage to: 1) handle high cover crop residue, 2) increase cultivation options, 3) warm soils, and 4) improve rooting conditions in a narrow zone.



Power-driven walk-behind tiller, modified to produce a 9" strip

Our research is supported by Federal and State Grants and in-kind donations

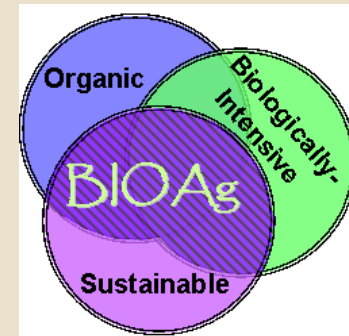
- Primary support from Western Region Sustainable Agriculture and Education
- Early support by WSU Center for Sustaining Ag and Nat Resources BIOAg
- Cover crop seed: ProGene Plant Research, Othello, WA
Doug Collins
WSU Small Farms Program
dpcollins@wsu.edu; 253-445-4658



Resources:

Wayman, S. & Collins, D.P., 2013. *For the life of the soil: Farmer perspectives and experiences adopting reduced tillage organic agriculture. Tilth Producers Quarterly*, 23(4), pp.1,4-5

Wayman, et. al. 2014. *The influence of cover crop variety, termination timing, and termination method on mulch, weed cover, and soil nitrate in organic reduced-tillage. Renewable Agriculture and Food Systems. FirstView: 1-11.*



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