



Tillage, Residue, and Nitrogen Management in Corn Production

Strip-Till Expo
Owatonna, MN – August 5, 2011

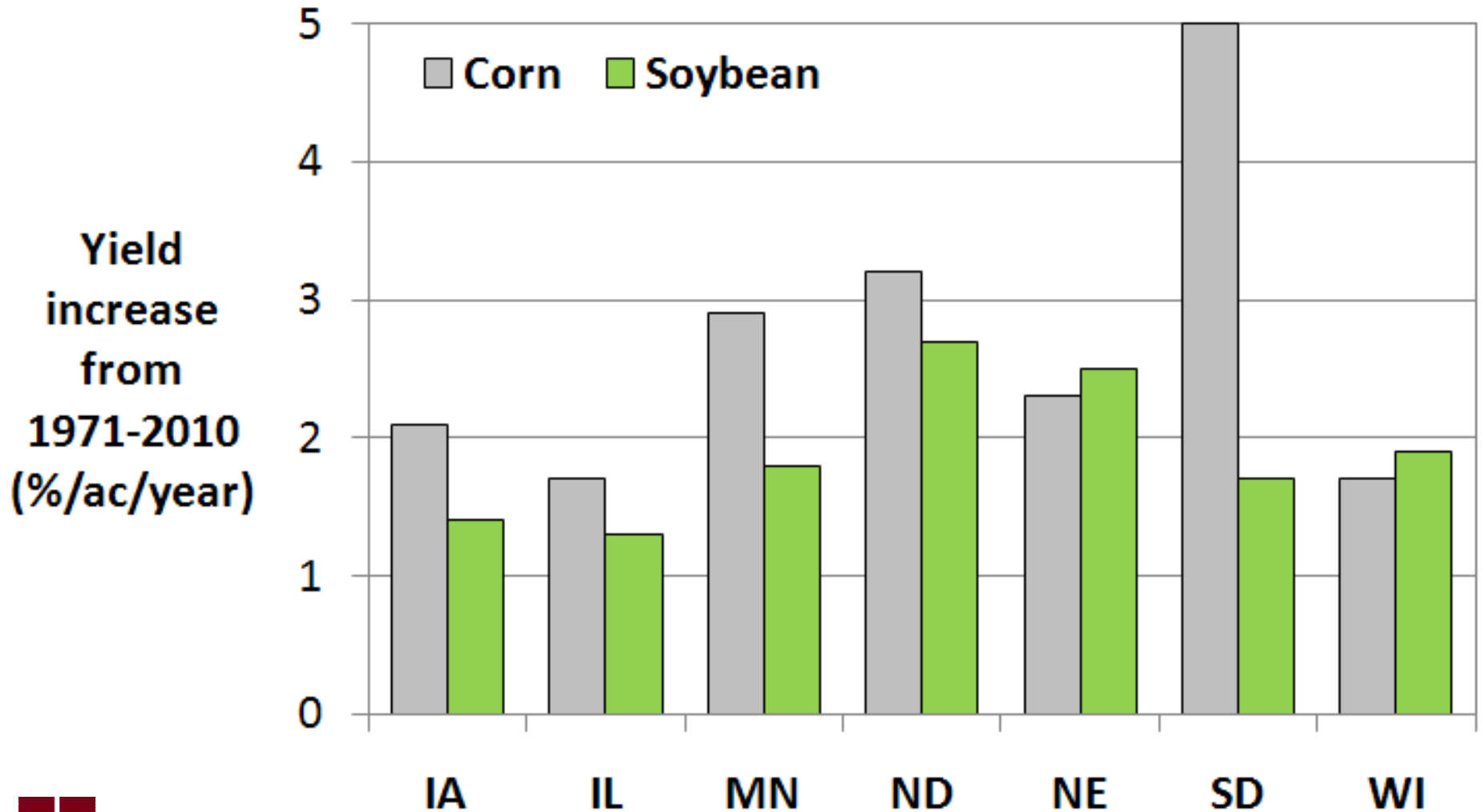
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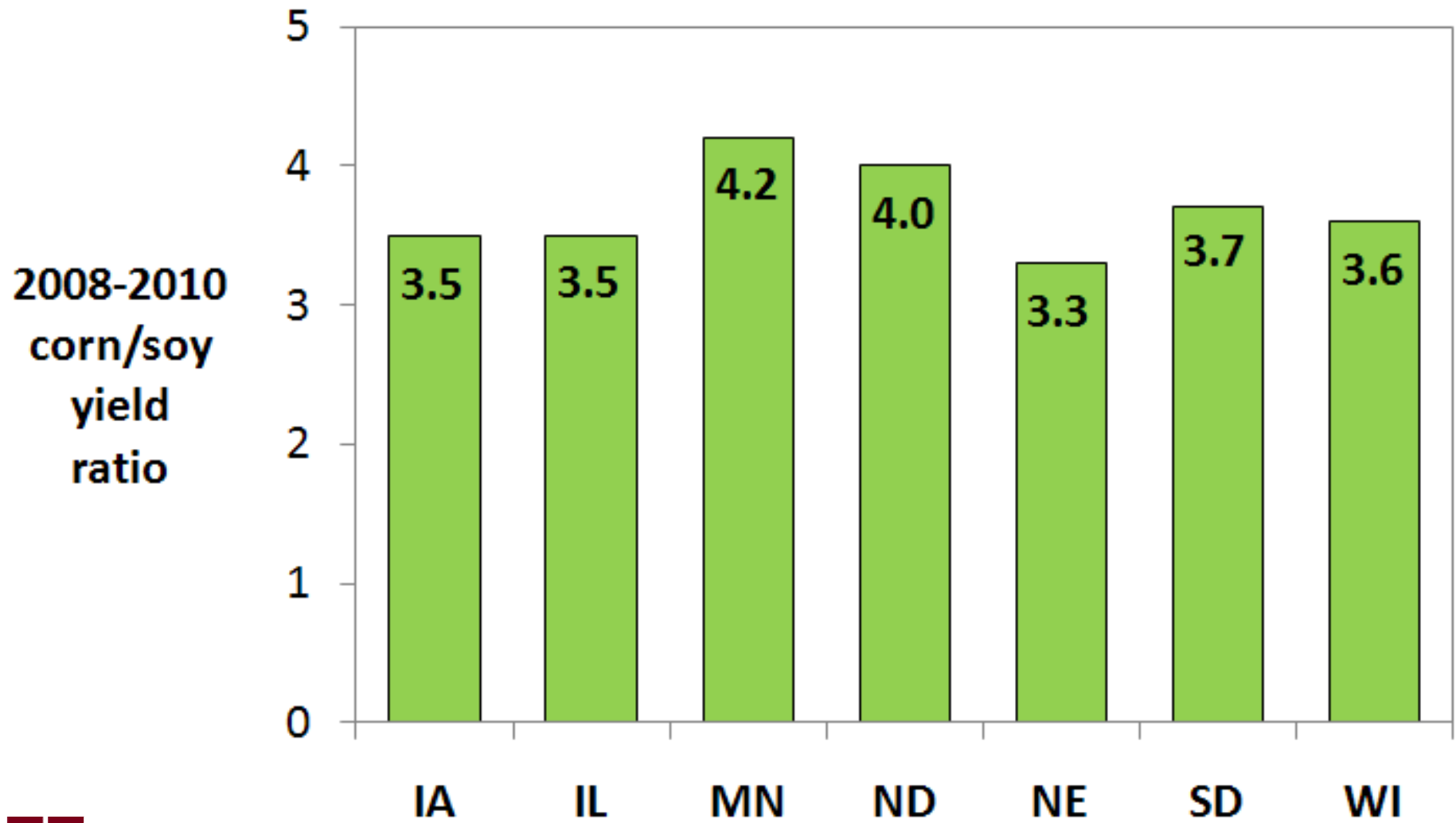
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Corn yield has increased more rapidly than soybean yield over the last 40 years



The northern Corn Belt appears better suited to corn than soybean

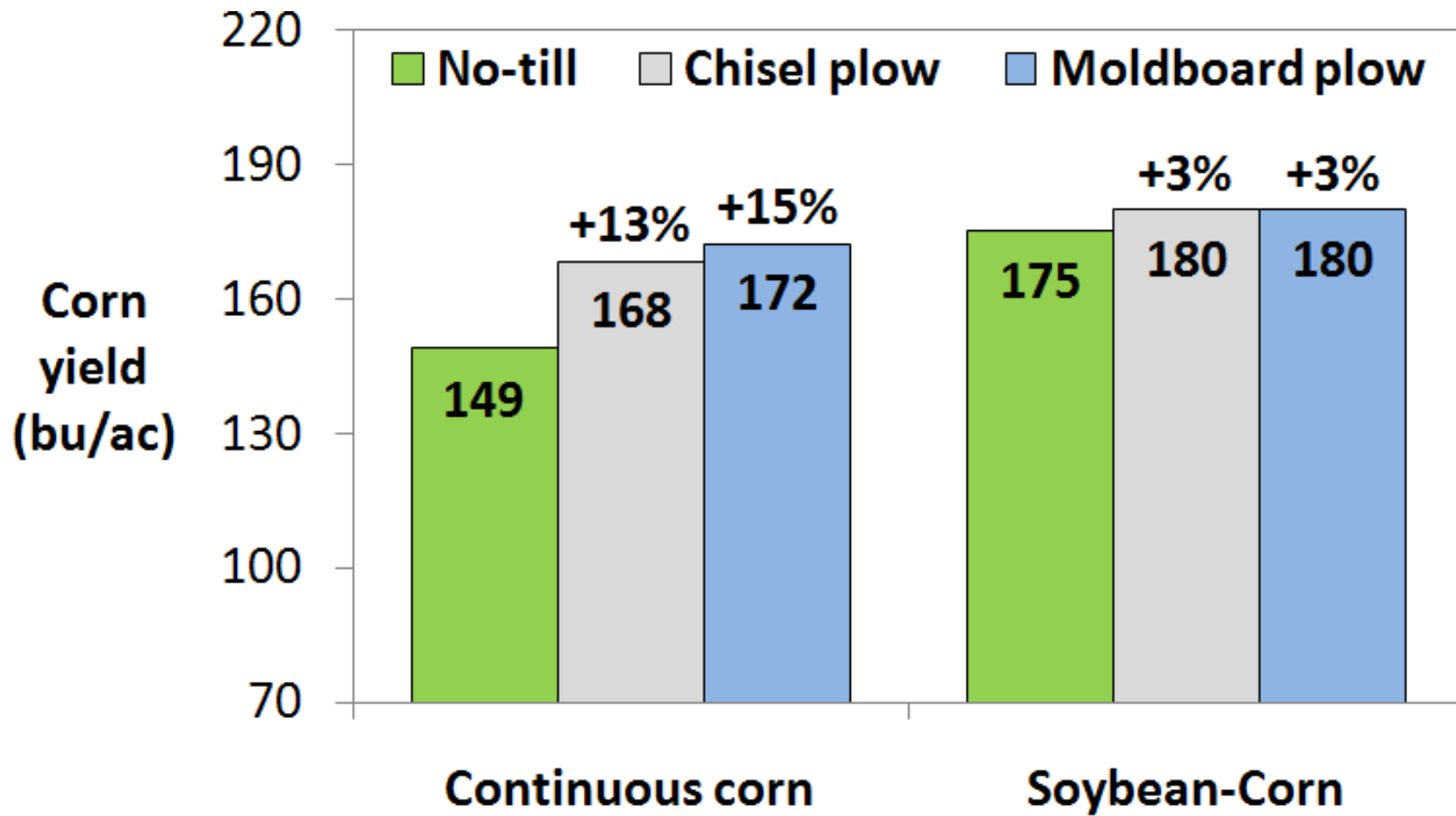


12 site-years in northern & central IL (2004-2007)

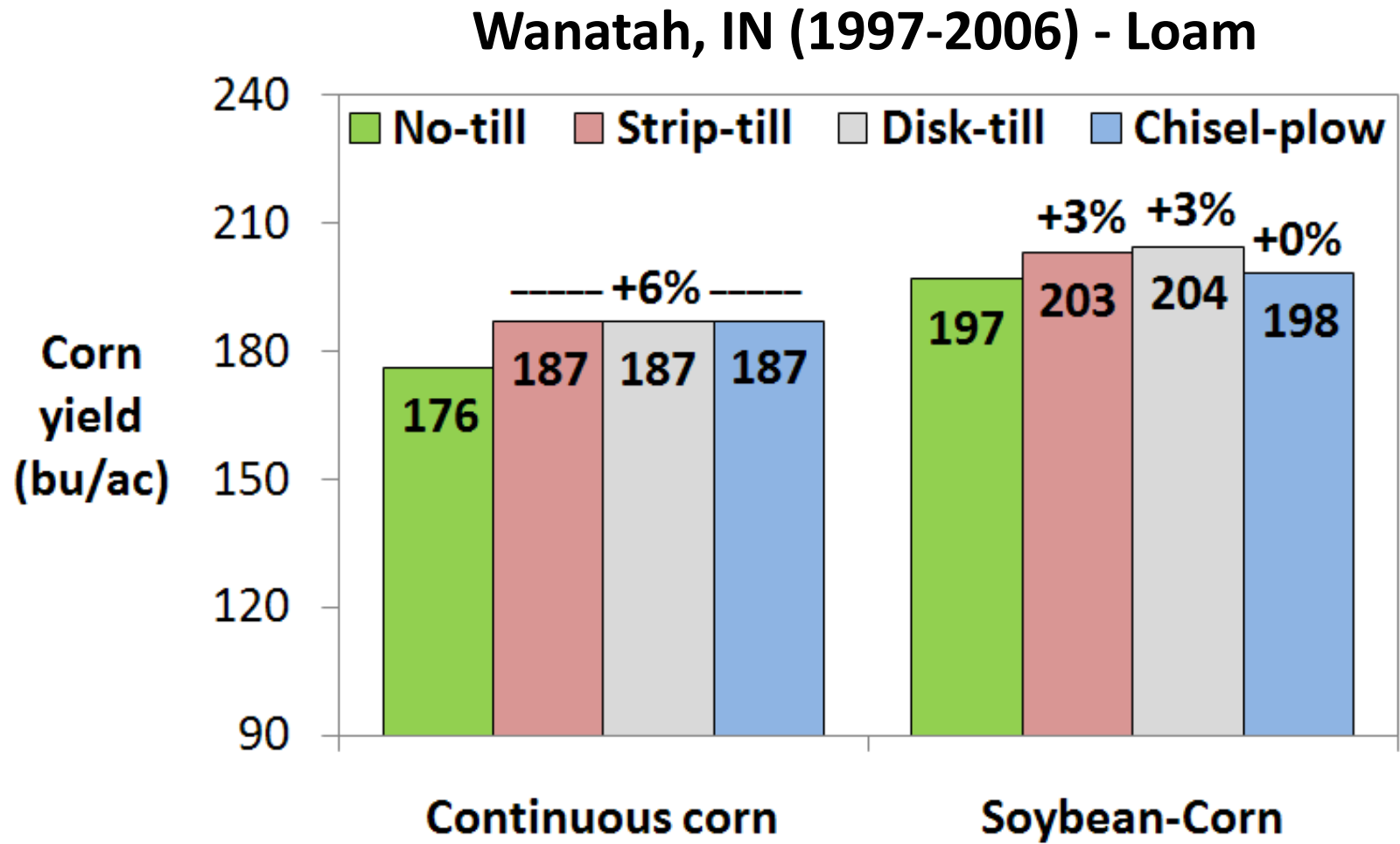
Crop and rotation		Yield (bu/ac)
Corn	Corn-soy	197
	1st-year corn in corn-corn-soy	196
	2nd-year corn in corn-corn-soy	184 (-7%)
	Continuous corn	178 (-10%)
Soybean	Corn-soy	54.9
	Corn-corn-soy	58.3 (+6%)

- 1) Crop rotation increased yield (5% in moldboard plow system).
- 2) Response to tillage was greater in continuous corn.

West Lafayette, IN (1975-2006) - Silty clay loam



- 1) Crop rotation increased yield by an average of 9%.
- 2) Yield with strip- and disk-till was equal or greater than that with chisel plow tillage in both cropping systems.



The Modified Mini-Moldboard Plow

- Popularized by Francis Childs in the late 1990s.
- Bottoms are cut down so they don't turn over as much soil.
- Incorporates residue vertically so more is left on the surface.



1) 4% yield increase with added fertilizer.

2) No advantage to the mini-moldboard or high plant population.

**16 site-years in central & northern IL;
silt loam & silty clay loam (2003-2007)**

Tillage	Fertilizer (lb/ac)	Plant pop.	Yield (bu/ac)
Disk-chisel (8")	Normal	32,000	193
Mini-moldboard (13")	Normal	32,000	195
Mini-moldboard (13")	+ 100-80-120	32,000	200
Mini-moldboard (13")	+ 100-80-120	40,000	201

Corn Residue (Stover)

- Can interfere with planting and seed-to-soil contact.
- Soil temp. often limits early-season growth in MN.
 - Corn stover insulates soil, which prohibits warming.
- Has an autotoxic effect on corn seedlings.
- A source of inoculum for corn diseases.
- Temporarily ties up (immobilizes) soil nitrogen.



**Plant that was
2 leaf stages
behind early in
the season
Is late to silk**



Lamberton, MN (32,000 plants/acre)

Emergence pattern	Avg. of all plants	Early plants	Late plants
— Yield (% of control) —			
Uniform	100%	---	---
1 leaf-stage delay on every other plant	94%	107%	80%
2 leaf-stage delay on every other plant	83%	118%	49%
Every other plant missing	73%	---	---



Use Row Cleaners to Clear the Rows

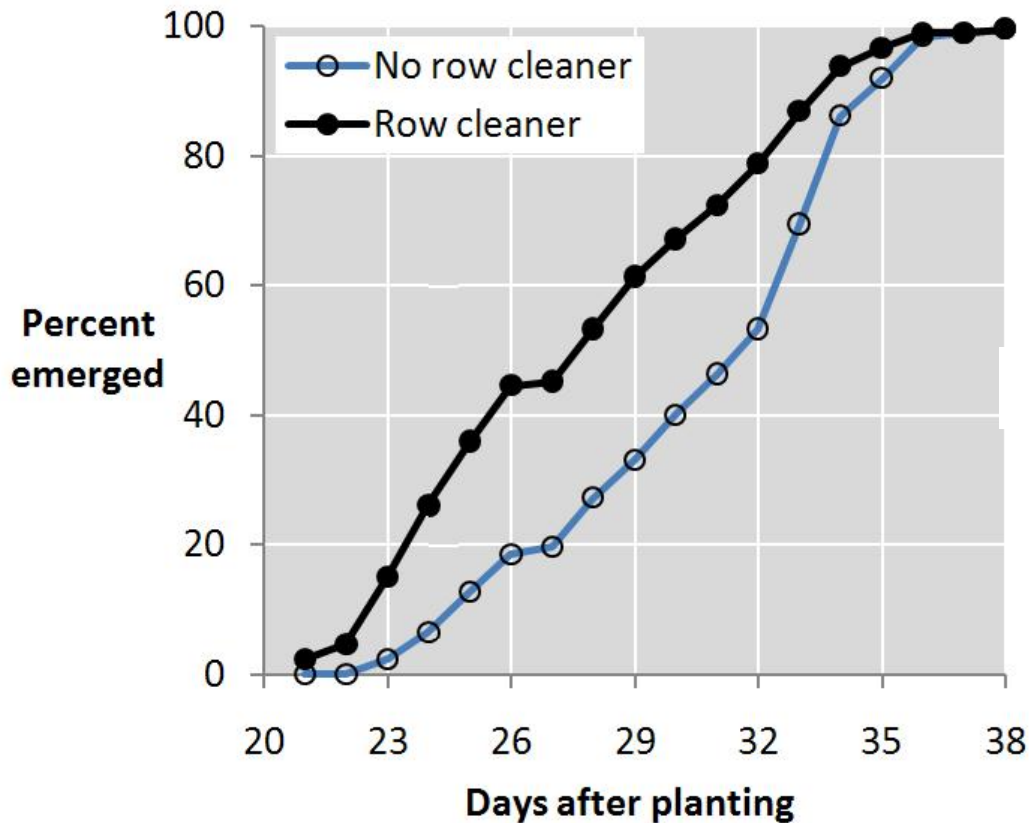
- Move residue and clods off the row for good seed-to-soil contact. This will also:
 - Increase soil temperature in the seed zone.
 - Reduce the potential for N deficient seedlings.
- Set row cleaners properly, and don't run them too deep.



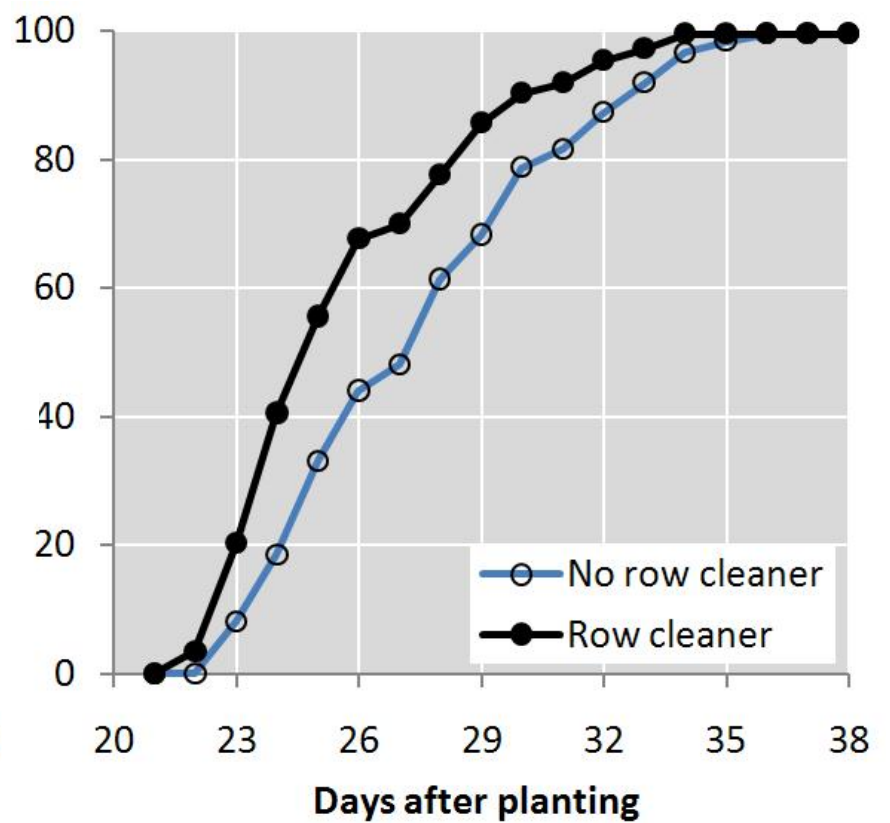
Waseca, MN (1997)

Nicollet-Clarion Clay Loam

No-till corn following corn



No-till corn following soy



2 site-years in central Illinois (silty clay loam; 200 lb N/ac)

Cropping system	Yield (bu/ac)
Corn after soybean	200
Corn after soy (corn residue added)	188 (-6%)
Corn after corn (residue removed)	176 (-12%)
Corn after corn	167 (-17%)



3 site-years in northern IL - silty clay loam

Previous year's hybrid maturity	Previous year's harvest/fall tillage time	UAN on stalks before tillage (50 lb N/ac)?	Yield (bu/ac)
Early	Early	No	212
		Yes	210
Early	Late	No	213
		Yes	212
Late	Early	No	210
		Yes	208
Late	Late	No	211
		Yes	210

Size residue and evenly distribute it with a stalk chopper or chopping corn head

- Speed up decomposition.
- Reduce problems during spring tillage and planting.



Corn-on-Corn Residue Management Study

- Waseca and Lamberton, MN
- Nicollet-Clarion-Webster clay loam
- Stalk chopping vs. not prior to fall disk-ripping
- Fertilizer treatments, on top of adequate P, K, pH, and 170 lb N/acre:
 - 30 lb N/acre as UAN (none, fall, spring)
 - 15 lb S/acre (none, fall, spring)
 - 30 lb N + 15 lb S/acre (none, fall, spring)
- Stalk chopping and fertilizer treatments did not affect emergence or plant population.



Corn after Corn, Waseca, MN – 2011

Additional nitrogen treatment	Plant height at V8 (inches)	NDVI at V8	CV of NDVI at V8
None	45	0.78	6.4
30 lb N/ac in fall	46	0.80	5.9
30 lb N/ac in spring	45	0.79	6.5
Significance	NS	NS	NS



Corn after Corn, Waseca, MN – 2011

Sulfur treatment	Plant height at V8 (inches)	NDVI at V8	CV of NDVI at V8
No sulfur	44 b	0.77 b	7.0 a
15 lb S/ac in fall	46 a	0.80 a	5.8 b
15 lb S/ac in spring	46 a	0.80 a	5.9 b



Manage corn stover by removing it?

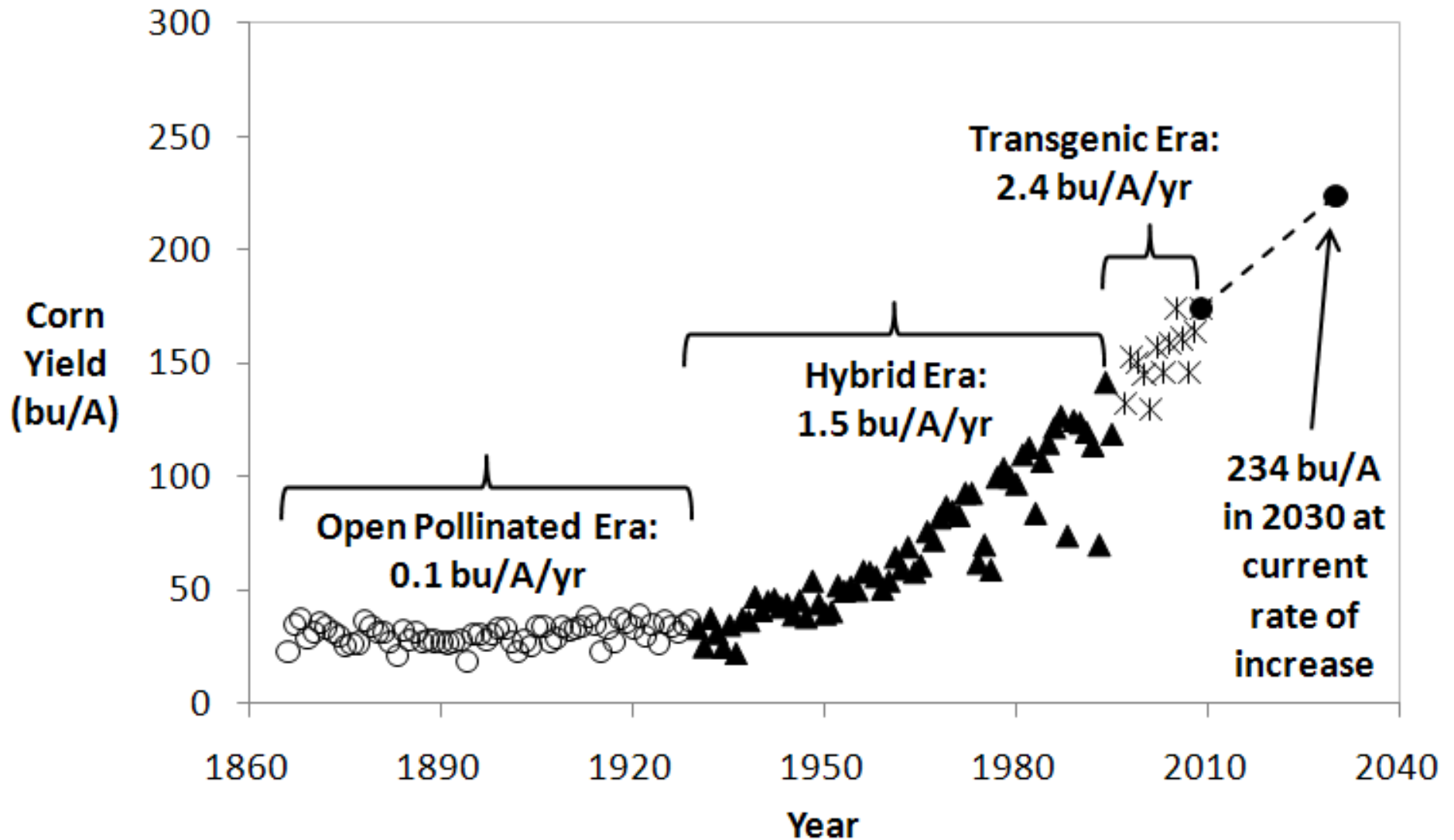


Corn Stover Yield is Equal to Grain Yield (Regardless of Yield Level & Hybrid)

Grain Yield bu/acre (15%)	Stover Yield tons/acre (15%)
150	4.2
200	5.6
250	7.0



Minnesota Average Corn Yield



Data from USDA-NASS



Agronomic Considerations for Corn Stover Harvest

- Sustainable stover harvest rates:
 - Maintain soil organic carbon & protect against erosion
- Nutrient removal
- Soil compaction
- Effect on subsequent crop yields
- Modification of cropping systems for:
 - Improved efficiency
 - Potential to sustainably harvest more stover



Soil Organic Carbon

- Key indicator of soil quality.
- Carbon portion of soil organic matter (about 50%).
- Soil organic matter = decaying plant & animal residues, soil organisms, & substances released by soil organisms.
- Promotes aggregation of soil particles, which:
 - Improves water infiltration & soil water holding capacity.
 - Decreases potential for soil erosion.
 - Increases rooting ability of plants.
 - Allows soil to be tilled easier.

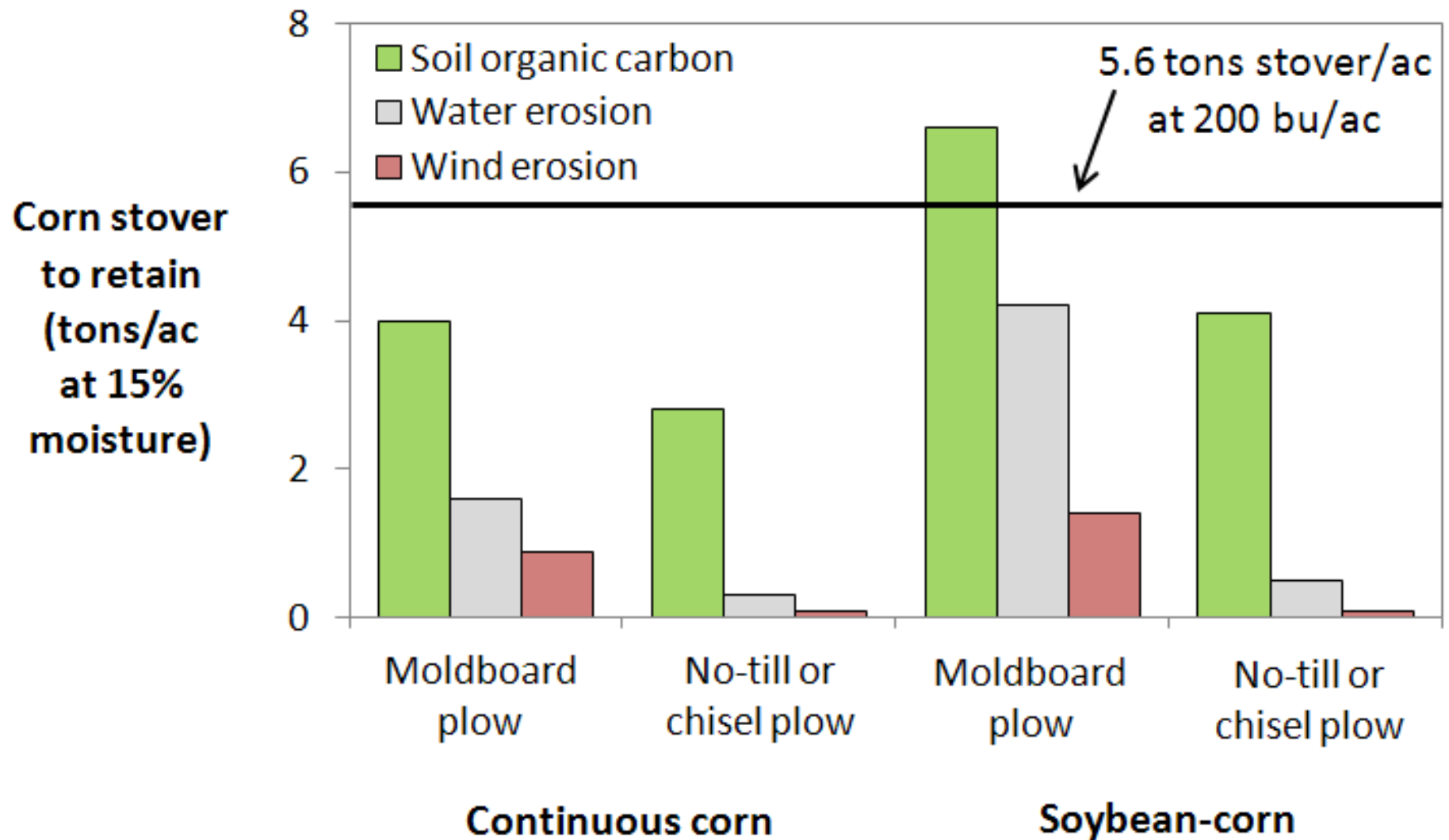


Corn Stover on the Soil Surface Protects Against Wind & Water Erosion

- Covers the soil
- Intercepts raindrops to protect against soil detachment
- Creates miniature dams to reduce runoff



Amount of Corn Stover Needed to Maintain Soil Organic Carbon & Protect Against Erosion



Sustainable Corn Stover Harvest Rates

Rotation	Tillage	Corn stover yield at 200 bu/ac (tons/ac - 15%)	Corn stover needed to maintain SOC (tons/ac - 15%)	Sustainable corn stover harvest rate
Continuous corn	No-till or chisel plow	5.6	2.8	50%
	Moldboard plow	5.6	4.0	29%
Soybean-corn	No-till or chisel plow	5.6	4.1	27%
	Moldboard plow	5.6	6.6	-18%

Typical tillage in MN is in between here.

Typical tillage in MN is a little more aggressive than this.

Sustainable Corn Stover Harvest Rates

- Continuous corn:
 - About 40% harvest with current disk-rip tillage systems.
 - Up to 50% harvest with less intensive tillage systems.
- Soybean-corn rotation:
 - 27% harvest or less (about 15% of stover is cobs).
- Alternative: harvest a larger quantity of stover, but...
 - Only every other year in continuous corn.
 - Only every 4th year in a soybean-corn rotation.
 - Leave enough stover to protect against erosion.



Nutrient Removal & Replacement Costs with 40% Stover Harvest in 200 bu/acre Corn

40% stover removal in 200 bu/ac corn (dry tons/ac)	Nutrient removal in corn stover (lb/dry ton)*	Nutrients removed with 40% stover removal (lb/ac)	Nutrient price**	Nutrient replacement cost (\$/ac)
1.9	14.8 lb N	28 lb N	\$0.46/lb N	\$12.88
1.9	5.9 lb P ₂ O ₅	11 lb P ₂ O ₅	\$0.66/lb P ₂ O ₅	\$7.26
1.9	25.4 lb K ₂ O	48 lb K ₂ O	\$0.50/lb K ₂ O	\$24.00
				\$44.14

\$31.26

*From Sawyer & Mallarino (2007).

**Nutrient prices for May 2-5, 2011 from DTN.

**Nutrient sources were anhydrous ammonia, DAP, and potash. Cost of N in DAP was removed.

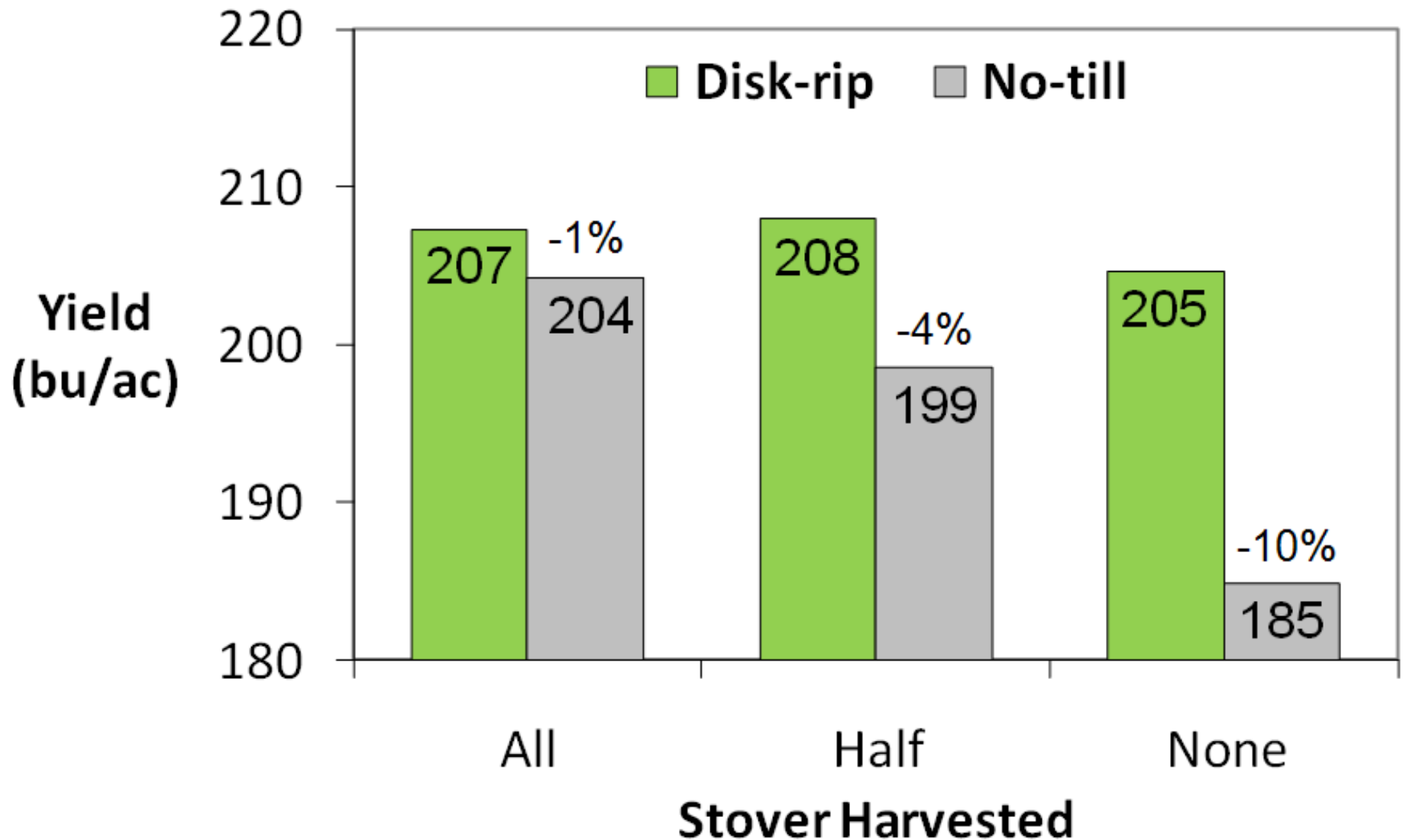


Stover Removal in Continuous Corn

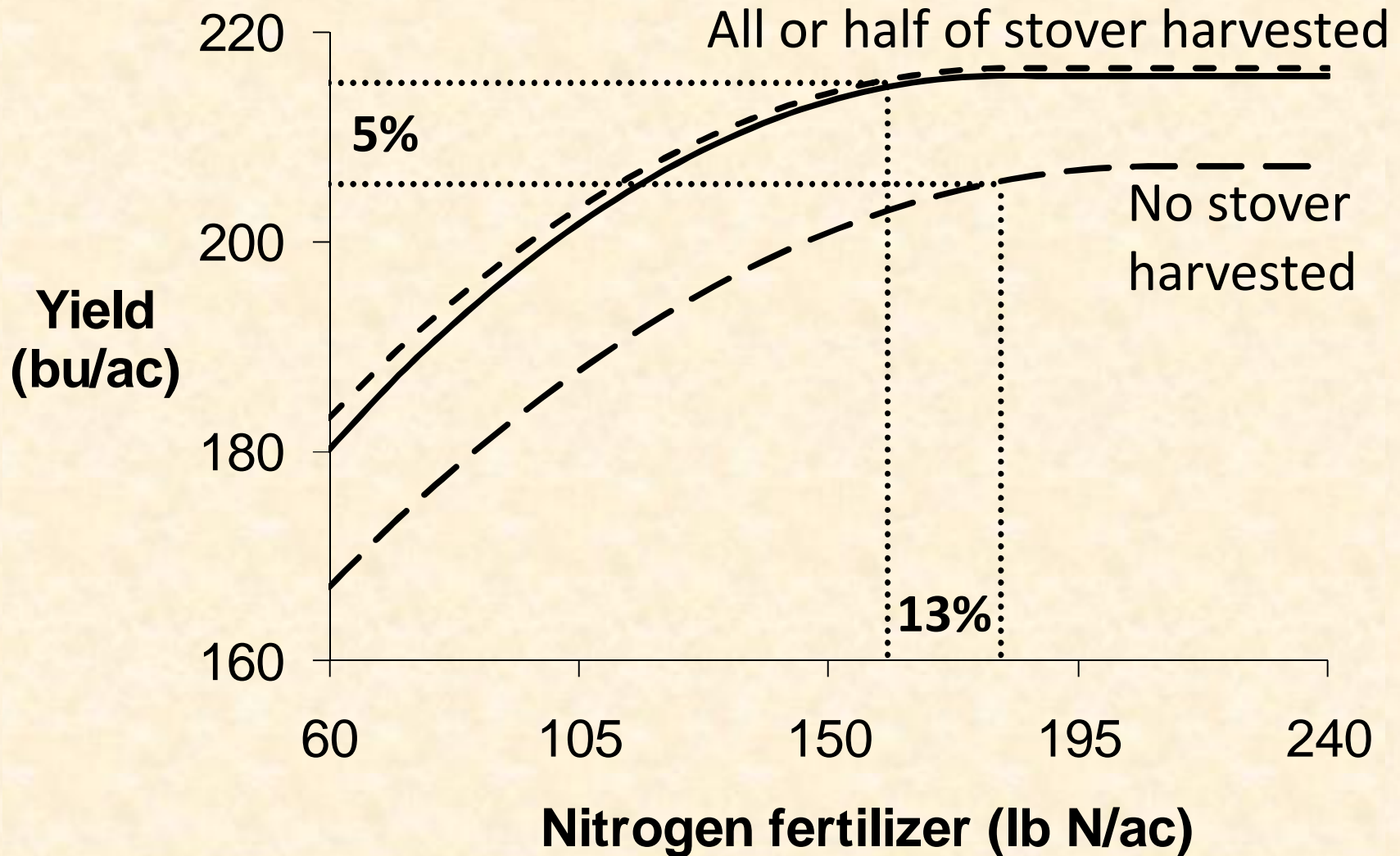
- **Under dryland production in eastern Nebraska:**
 - Each 1,050 lb/acre of stover removed (at 15% moisture) reduced grain yield by 4 bu/acre.
- **Full removal on drought-prone clay soils in Ohio:**
 - Decreased corn grain yield 12%.



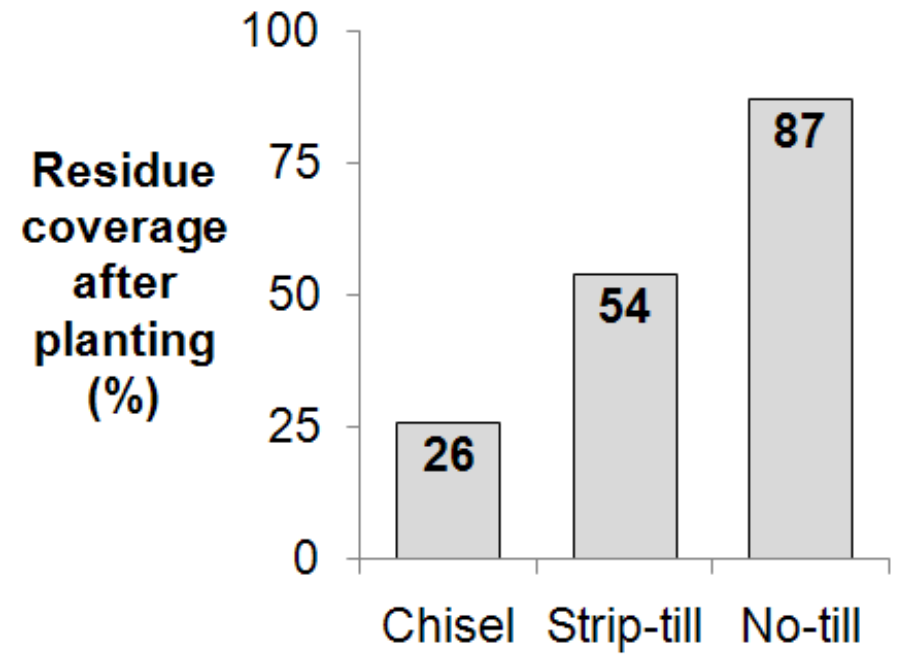
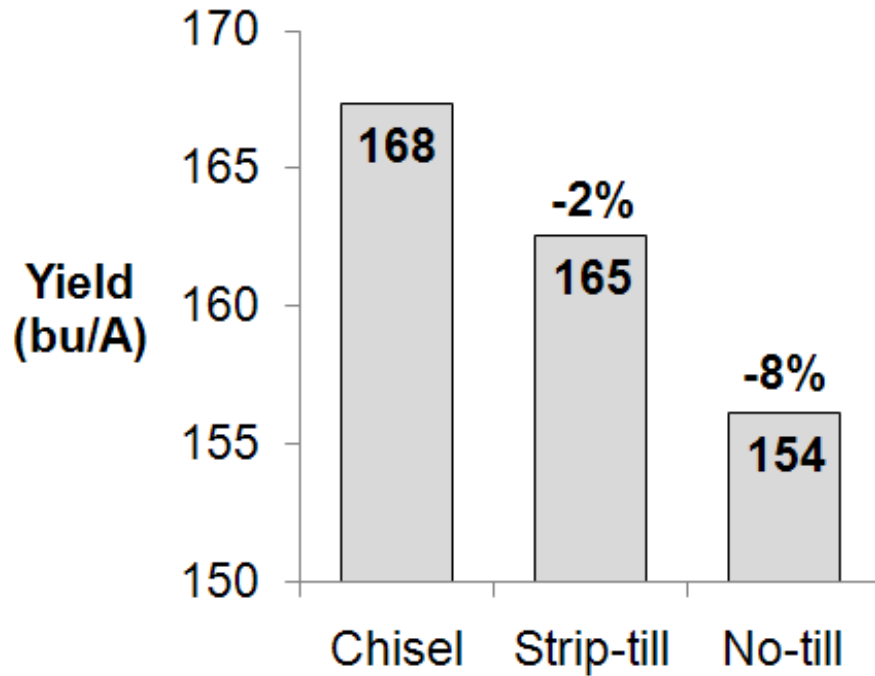
Less Tillage was Needed for Continuous Corn in Illinois When Stover Was Harvested



Stover Harvest Increased Grain Yield & Decreased the N Requirement in Illinois



Continuous Corn (Rochester, 1997-2000) Port Byron Silt Loam



**No Stover Removed
Disk-Rip**



**No Stover Removed
Strip-Till**



**No Stover Removed
No-Till**



**Stover Removed
Disk-Rip**



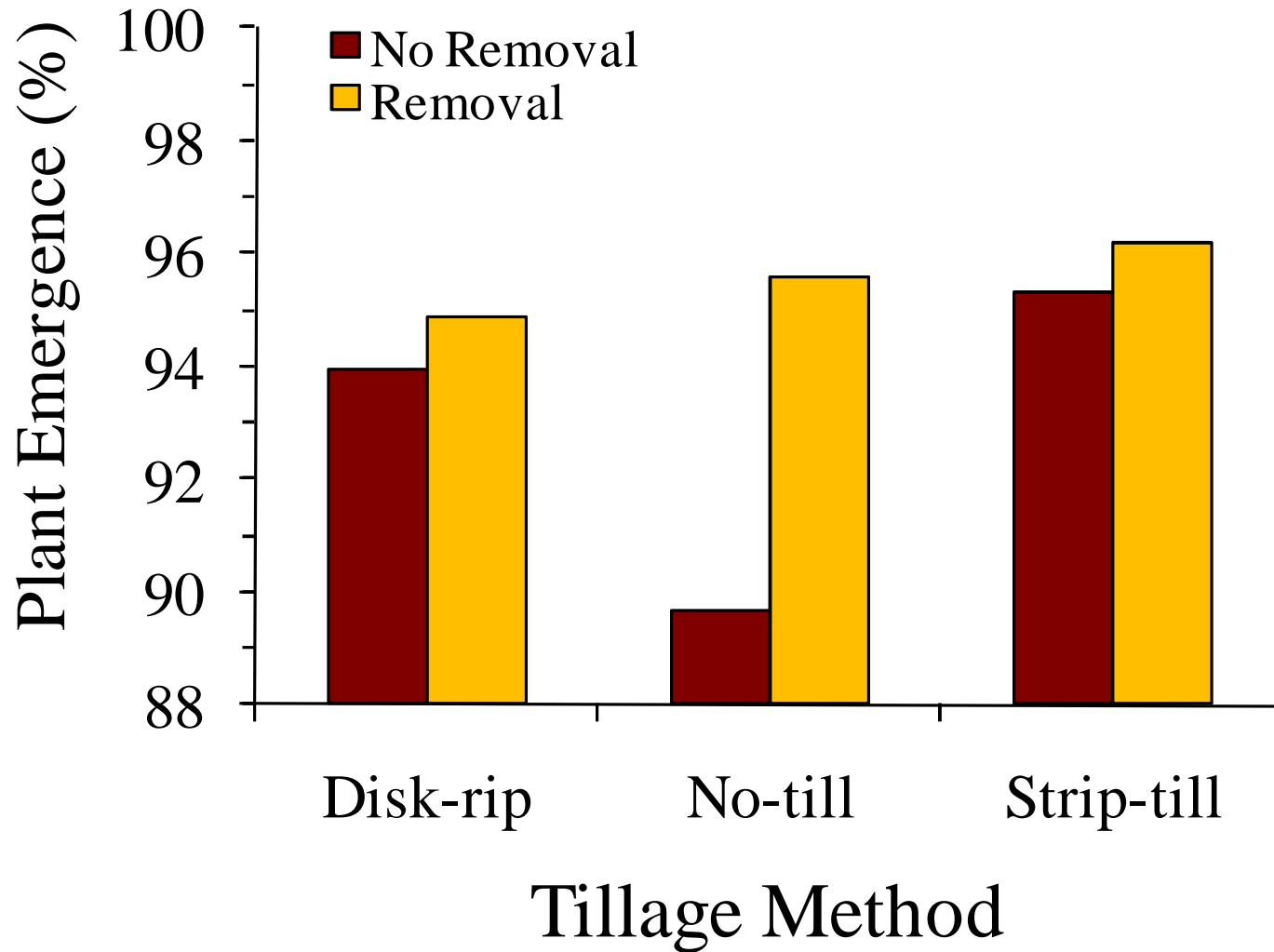
**Stover Removed
Strip-Till**



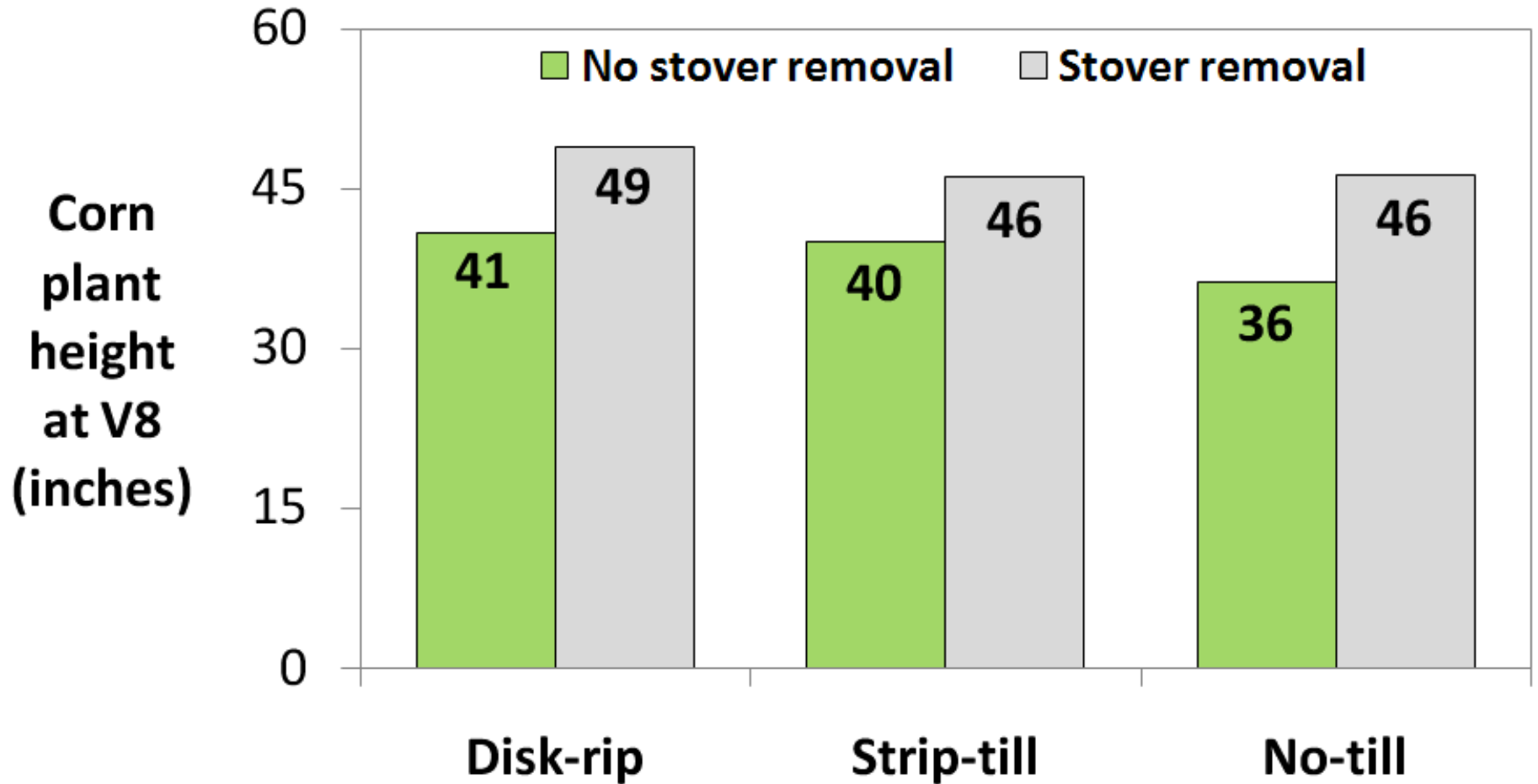
**Stover Removed
No-Till**



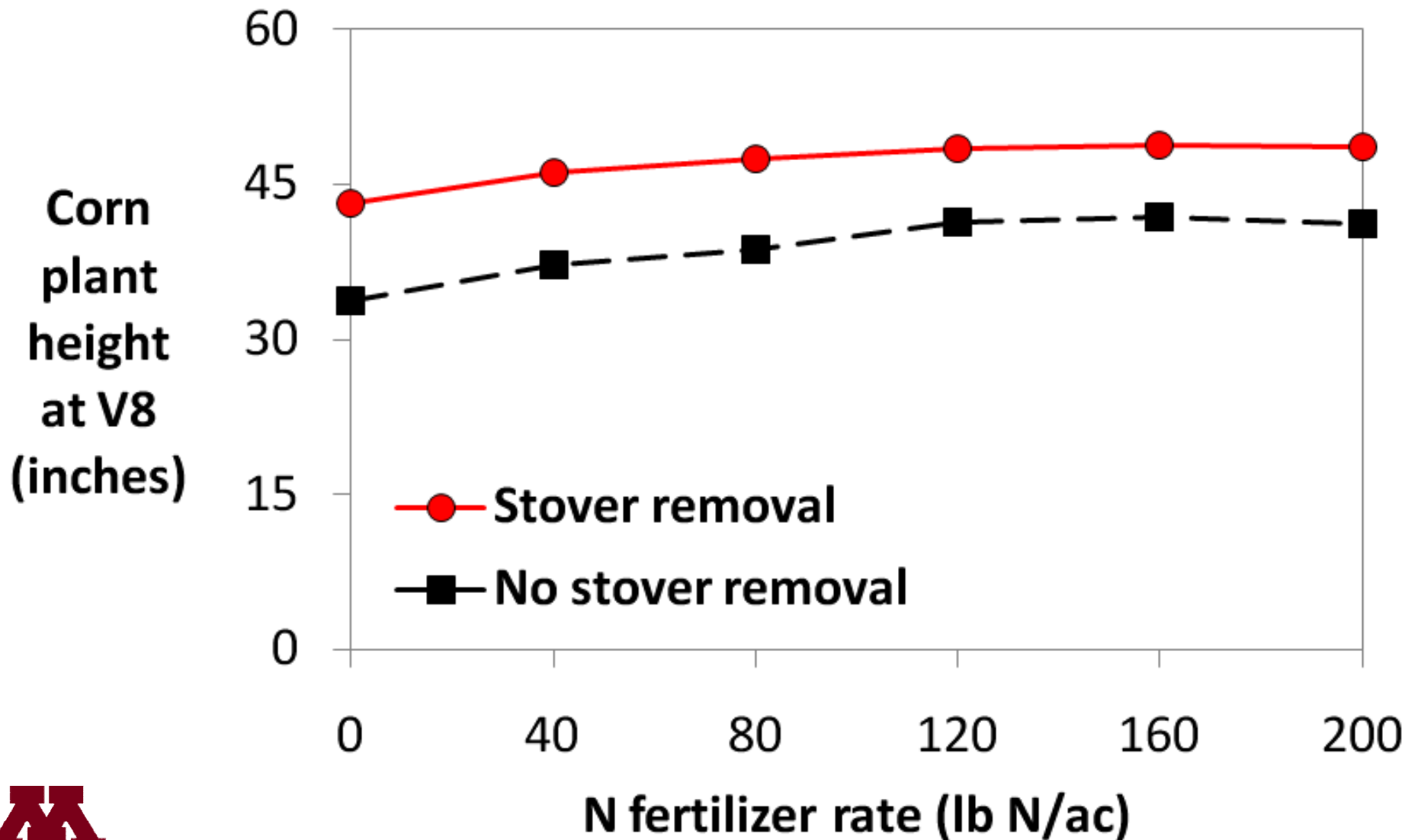
Continuous Corn (Lamberton & Waseca, MN - 2009-2010)



Continuous Corn, Waseca, MN - 2009-2010 (averaged across N rates)

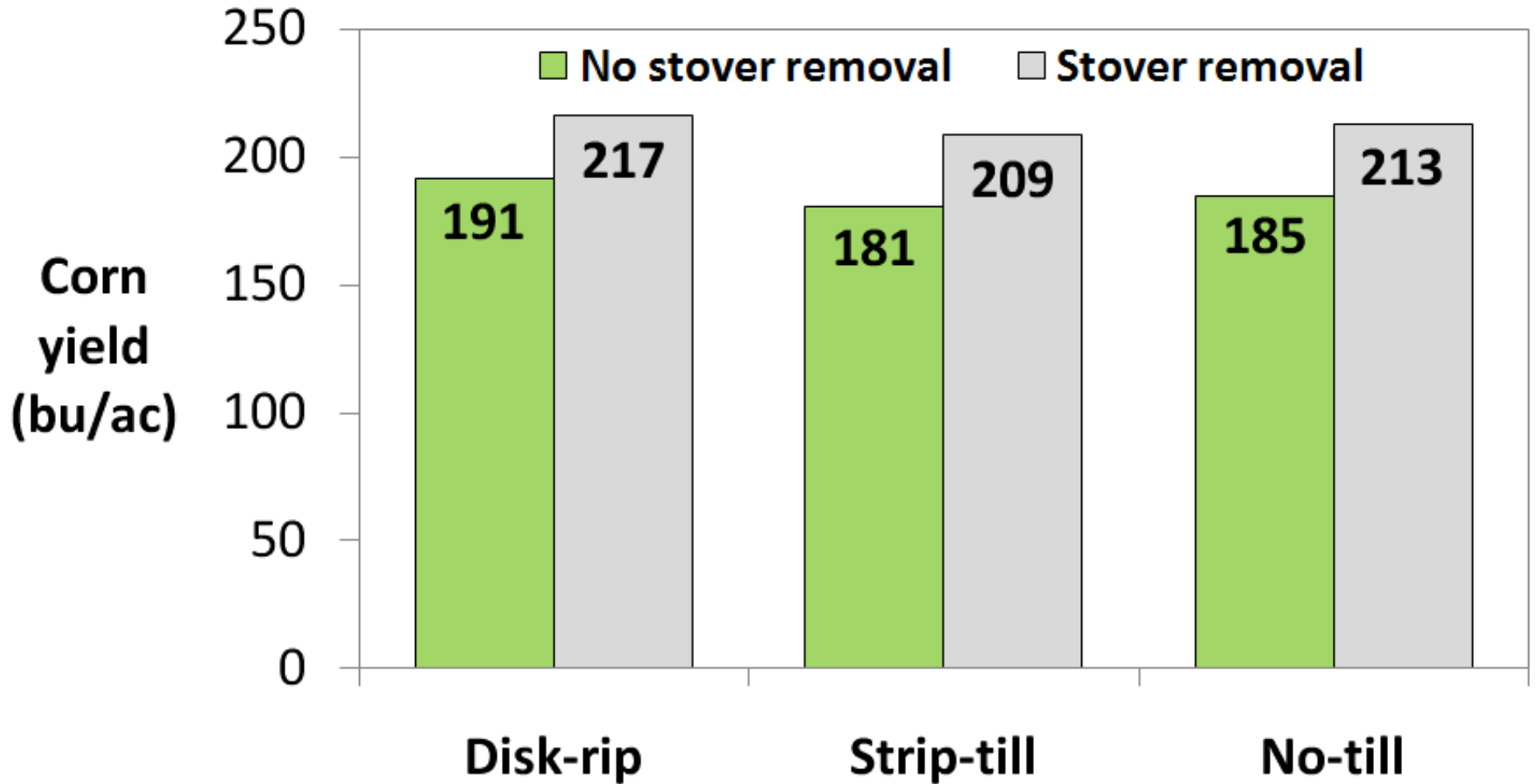


Continuous Corn, Waseca, MN - 2009-2010 (averaged across tillage systems)

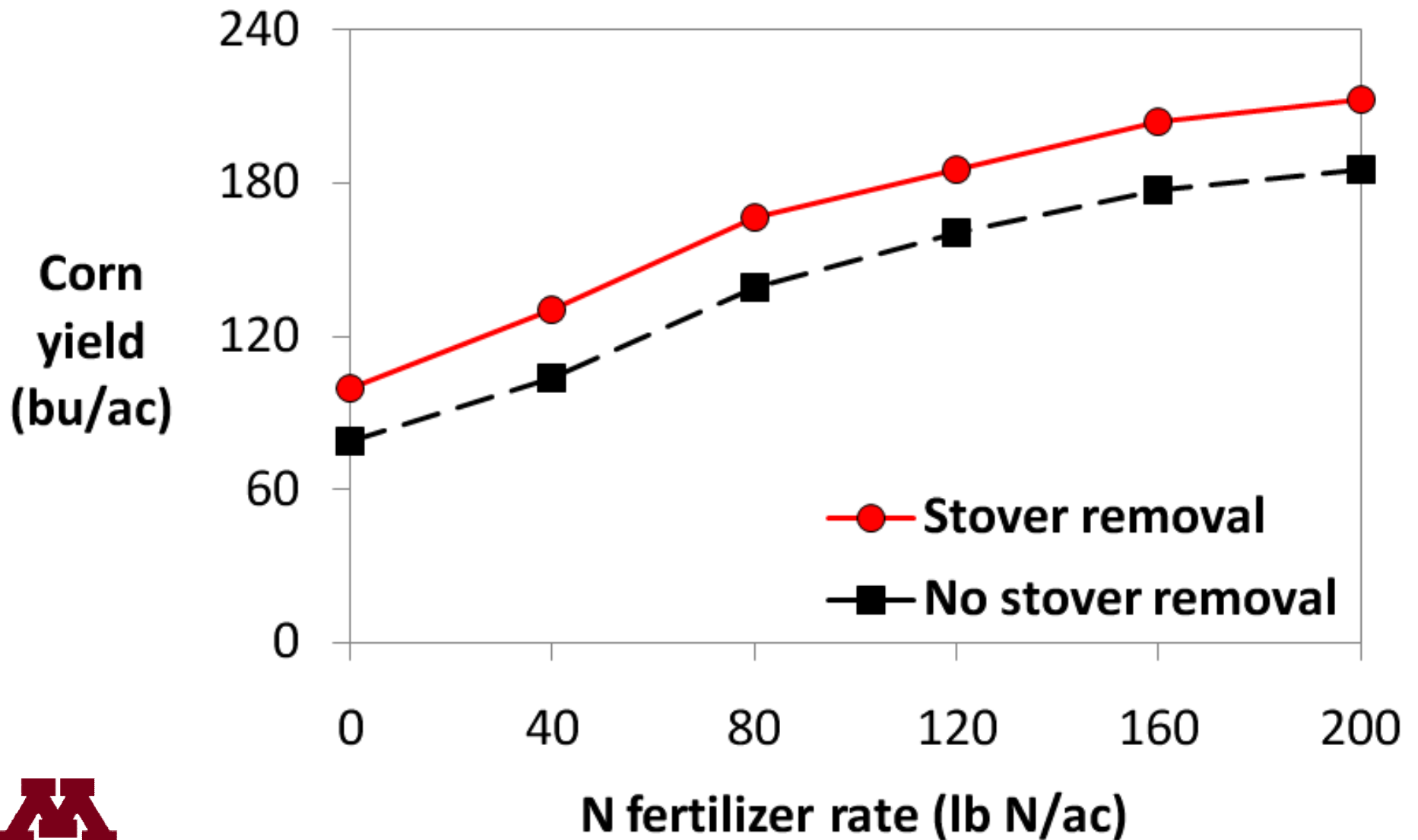


Continuous Corn, Waseca, MN - 2009-2010

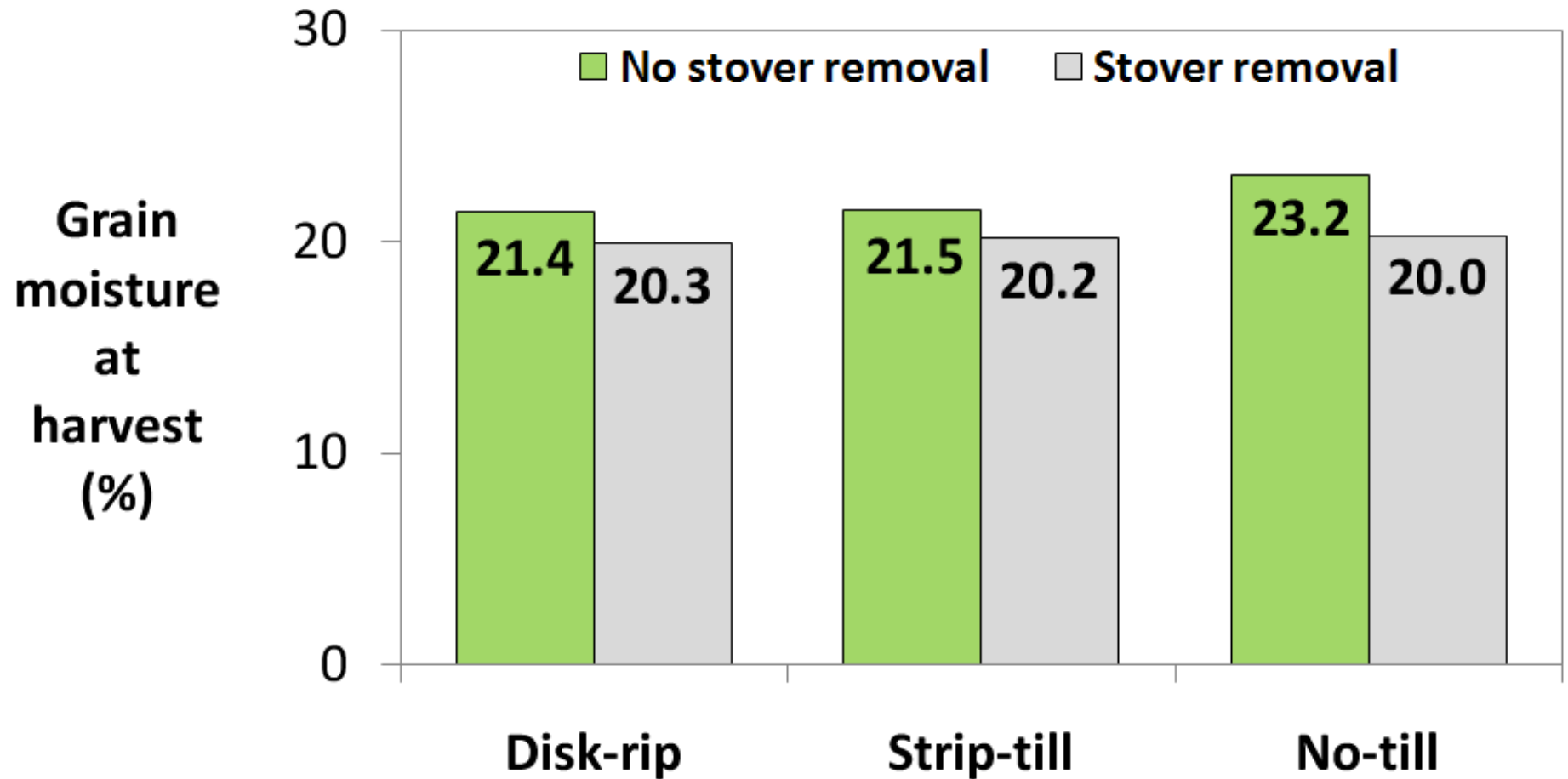
200 lb N/ac



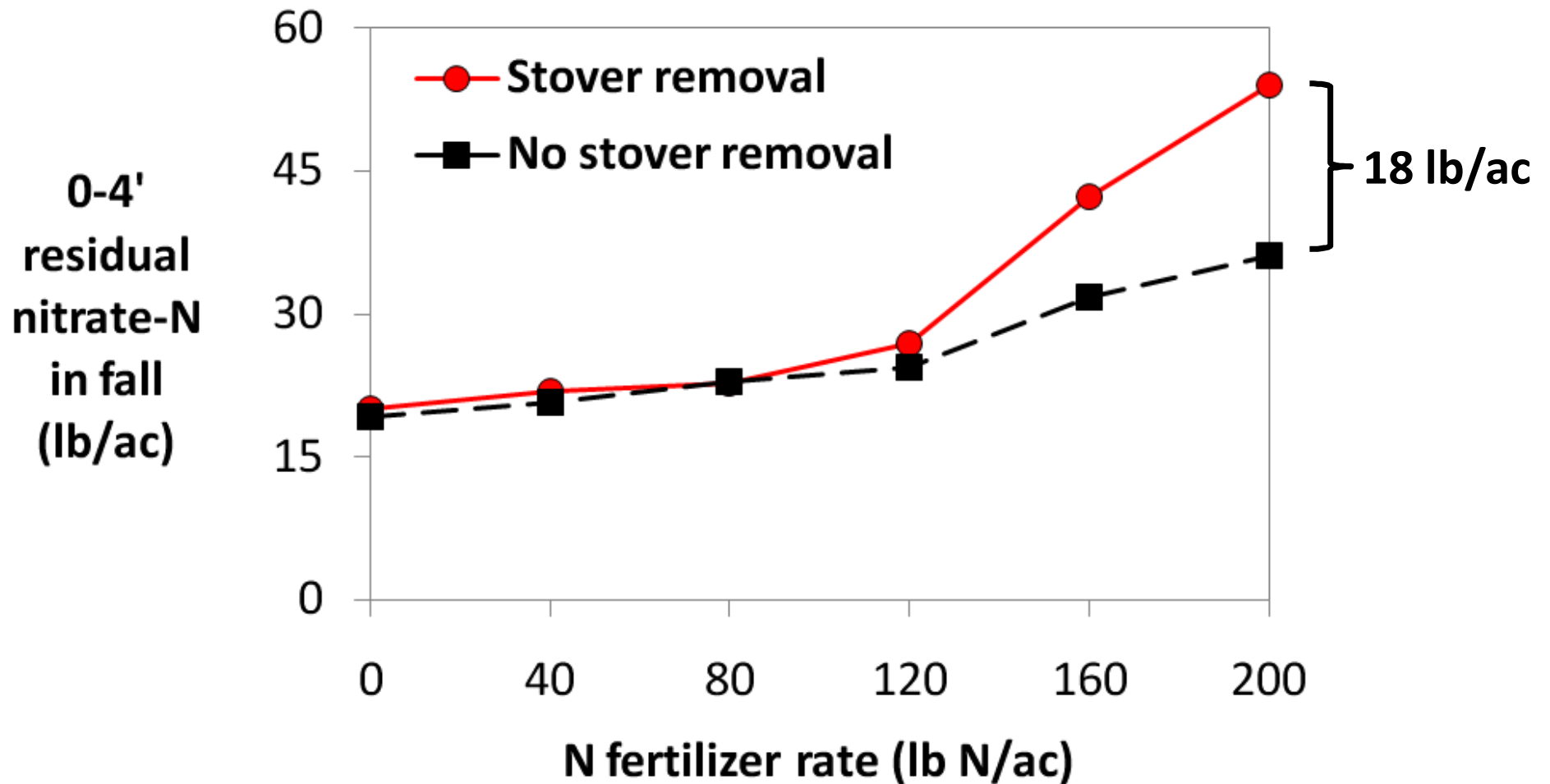
Continuous Corn, Waseca, MN - 2009-2010 (averaged across tillage systems)



Continuous Corn, Waseca, MN - 2009-2010 (averaged across N rates)



Continuous Corn, Waseca, MN - 2009-2010 (averaged across tillage systems)



Take Home Points - Corn after Corn

- The northern Corn Belt appears better suited to corn than soybean when compared to other regions.
- Consider a corn-corn-soybean rotation as an alternative to continuous corn.
- High-input production “packages” do not guarantee high yields for corn after corn, and they can be costly.



Take Home Points - Tillage

- Within reason, corn yield on heavy soils (clay loam or silty clay loam) when corn follows corn is generally greater with more aggressive tillage.
- Conservation tillage can work very well for corn on medium to light soils, when corn follows soybean or alfalfa, or when corn stover is harvested.
- Yield reductions for corn after corn are due in part to corn residue, especially if it is not cleared out of the seed row.
- Corn stover harvest can increase yield of the following corn crop on productive soils.



Take Home Points - Corn Stover Harvest

- Some stover harvest appears sustainable on productive soils in the Upper Midwest.
- Avoid stover harvest in drought-prone fields & regions.
- Stover harvest is best suited to continuous corn fields.
- Reduce tillage following stover harvest.
- Stover harvest may allow N fertilizer rates to be reduced some in the first few years of stover harvest.



Take Home Points - Corn Stover Harvest

- Consider alternative practices to offset potential soil organic carbon losses with stover harvest, or to allow more stover to be harvested:
 - Manure or by-products (ash, biochar)
 - Perennial crops in the rotation (alfalfa)





Thanks!



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