
Managing the Continuous Corn Yield Penalty
Crop Physiology Laboratory
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Trends of Continuous Corn Acres

- According to the USDA
  - IL harvested 11.8 million corn and 9.48 million soybean acres in 2014
- IL producers are increasing the amount of land planted in corn, resulting in more continuous corn acres

Identifying Factors Controlling the Continuous Corn Yield Penalty

Laura F. Gentry, Matias L. Ruffo, and Fred E. Below*

ABSTRACT

It is widely accepted that yields decline when corn (*Zea mays* L.) is grown continuously vs. in rotation with soybean [*Glycine max* (L.) Merr.], although causes for the yield reduction are unclear. The primary objective of this study was to elucidate the source(s) of the continuous corn yield penalty (CCYP). The experiment was conducted from 2005 to 2010 in east-central Illinois beginning with third-year continuous corn (CC) or a soybean–corn (SC) rotation at six N fertilizer rates. Averaged across all years, yield at the agronomic optimum N rate for CC was 8.84 Mg ha^{-1} and for SC was 10.20 Mg ha^{-1}, resulting in a CCYP of 1.36 Mg ha^{-1}; values ranged yearly from 0.47 to 2.23 Mg ha^{-1}. Using a regression model, three significant and independent predictors explained >99% of the variability in the CCYP: unfertilized CC yield (0NCCYD), years in CC (CCYRS), and the difference between CC and SC delta yields (maximum yield – unfertilized yield) (DELTADIFF). The strongest predictor, 0NCCYD, reflects net soil N mineralization and demonstrates that it decreases in CC systems. The CCYRS was strongly and positively correlated with CCYP, indicating that the CCYP increased through Year 7. We believe that CCYRS measures the effects of accumulated corn residue in CC systems. Finally, we consider DELTADIFF to be a measure of the interaction between yearly weather patterns and crop rotation, which results in more negative yield responses for CC than SC under hot or dry conditions. This study concluded that the primary causative agents of the CCYP are N availability, corn residue accumulation, and weather.

- Agronomy Journal
- Vol. 105(2): 2013
- Gentry, Ruffo, and Below

Follow-Up Study: Stover Removal & Intensification

- Does stover removal increase yield in CC?
- How does stover removal in CC affect fertility requirements?
- Do higher plant populations in CC
  - increase yields?
  - increase root biomass?

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Follow-Up Study: Results

- Does stover removal increase yield in CC? Yes…high-pop, high-input
- Does stover removal in CC affect crop nutrient availability? Yes.
- Do higher plant populations in CC
  - –increase yields? No.
  - –increase root biomass? No.

Current Focus: Better fertility and agronomic practices to reduce the CCYP

- Management
  - Standard vs High Tech
- Planting Population
  - 32,000 vs 45,000 plants acre^{-1}
- Hybrid Selection
  - 8 commercially-available hybrids with distinctly different genetic makeups

11th year Continuous Corn

vs

Corn-Soybean Rotation

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Standard vs. High Tech

Phosphorus	No P, S, or Zn based on soil test 100 lbs P_2O_5 as MicroEssentials SZ (12-40-0-10S-1Zn)
Potassium	No K or B based on soil test 75 lbs K_2O as Aspire (0-0-58-0.5B)
Nitrogen	180 lbs N pre-plant as urea 60 lbs extra N sidedress as stabilized urea
Fungicide	No Fungicide vs. Strobilurin (@ Vt/R1)

Evaluated over 8 hybrids and contrasting populations

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Tissue Analysis

- V6 growth stage
- High tech management had 2x greater nutrient accumulation across rotations
- Derived from an increase in biomass

V6 Nutrient Uptake

	Standard		High Tech	
Nutrient	CC	CS	CC	CS
	lbs acre^{-1}			
Biomass	390	352	655	630
N	18.0	16.4	29.8	28.5
P_2O_5	3.8	3.4	6.8	6.5
K_2O	13.4	6.7	19.9	11.6
S	1.0	1.0	1.9	1.9
Zn (oz)	6.5	6.6	10.1	11.4

Standard vs. High Tech

Rotation and Management Effect on Final Grain Yields

	Rotation		
	CC	CS	
	bu acre^{-1}		Δ Rotation
Standard	167	205	+38
High Tech	217	237	+20
Δ Mgmt	+50	+32	

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Enhanced Fertility and Leaf Protection

- High Tech significantly improved grain yield across rotations
  - –41 bu acre^{-1}
- Nearly 60% greater fertility effect in CC
  - –50 vs 32 bu acre^{-1}
- These data clearly suggest that the CCYP can be lessened with management

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Yield Components

Mgmt	Pop	Yield	Kernel #	Kernel Wt
		Continuous Corn		
	pl acre^{-1}	bu acre^{-1}	seed m^{-2}	mg seed^{-1}
Standard	**32,000**	**168**	**4133**	**216**
	45,000	**166**	**4436**	**200**
High Tech	**32,000**	**218**	**4681**	**248**
	45,000	**216**	**5088**	**226**
		Corn-Soybean Rotation		
Standard	**32,000**	**207**	**4707**	**236**
	45,000	**201**	**4581**	**237**
High Tech	**32,000**	**238**	**4906**	**257**
	45,000	**235**	**4891**	**257**

Management Effect on Yield Components

- High Tech increased both kernel # and kernel weight

CS Advantage over CC:

- Standard - both higher kernel # and heavier kernel weight in CS
- High Tech - rotation differences in only kernel weight (heavier) as kernel numbers were similar

Yield Component Compensation: Density

- 11th year CC
  - Increased kernel # from higher planting densities offset by a lower kernel weight
- 1st year CS
  - Higher planting populations led to decreased kernel # with similar kernel weight

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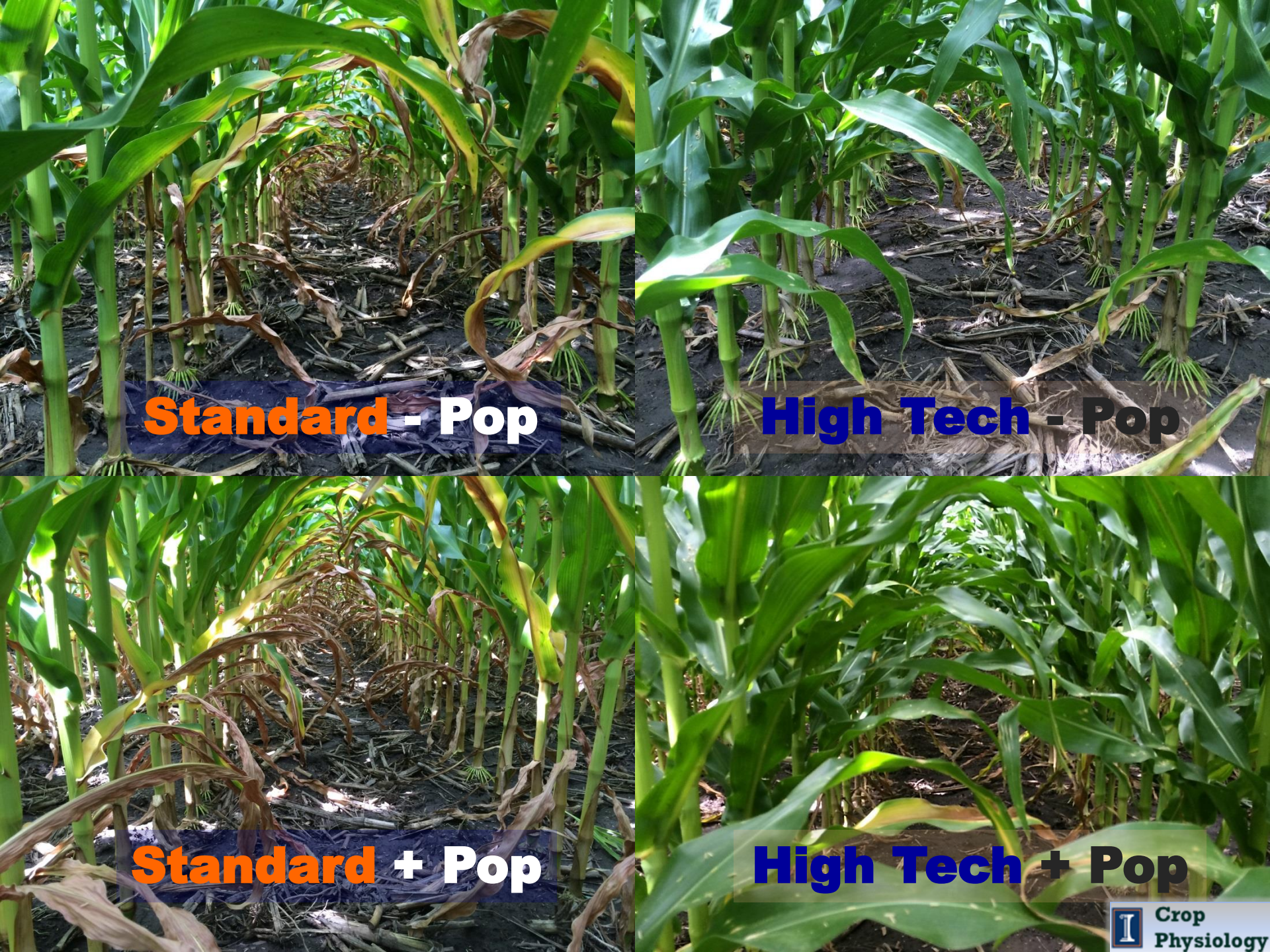
Standard - Pop
High Tech - Pop
Standard + Pop
High Tech + Pop
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Effect of Population on Yield

Management	Population	Yield
		Continuous Corn
	plants acre^{-1}	bu acre^{-1}
Standard	**32,000**	**168**
	45,000	**166**
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	45,000	**216**
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Planting Population Effect on Yield

- **Highest yields - CS rotation with High Tech management and 32,000 plants acre^{-1}**
- **Increased planting densities decreased yield by 3.6 bu acre^{-1}**
- **Surprisingly, CC did not magnify this response**

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Tolerant Hybrids

- In previous years of this study, hybrid selection significantly impacted the CCYP
- Hybrids that can tolerate CC are more competitive for resources in stressful environments

Penalty Associated With Hybrid Selection

	Standard		High Tech	
Year	CC	CS	CC	CS
	Δ bu acre^{-1}			
2011	-1	-0	-6	-4
2012	-47	-11	-15	-19
2013	-11	-2	-16	-5
Average	-20	-4	-12	-9

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Current Study: Tolerant Hybrids

- **Individual hybrids responded differently to management**
- **Select hybrids, nearly overcome the CCYP with High Tech management**
- **Penalty reductions of 60 to 80% with High Tech for 4 hybrids: 2 (58%), 6 (76%), 7 (72%), and 8 (77%)**

2014 Continuous Corn Yield Penalty

	Standard	High Tech
Hybrid	Δ bu acre^{-1}	
1	46	29
2	31	13
3	36	40
4	43	20
5	45	31
6	28	7
7	44	12
8	30	7
Average	38	20

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Key Takeaways

In a year that optimized yields for the CS rotation, we needed the right combination of management and hybrid to help CC overcome the CCYP

Key Takeaways

Consistently highest yields:

- **CS rotation**
- **High Tech management**
- **32,000 plants acre^{-1}**

Key Takeaways

The CCYP can be controlled by:

- **Better fertility and leaf protection (+50 bu acre^{-1})**
- **With High Tech, select hybrids reduced the CCYP by 60-80%**

SPECIAL THANKS!

- **Fluid Fertilizer Foundation**
- **Ward Laboratories**
- **The Mosaic Company**
- **Monsanto**

For more information:
Crop Physiology Laboratory at the University of Illinois:

http://cropphysiology.cropsci.illinois.edu

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