Alleviating the Continuous Corn Yield Penalty with Crop Management

Crop Physiology

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Introduction:

- There is wide acknowledgement that grain yields of continuously grown corn (*Zea mays* L.) are generally less than when corn is rotated with soybean [*Glycine max* (L.) Merr.]; although continuously grown corn is still produced in the Midwestern U.S.
- The primary agents of yield reduction in continuous corn are soil nitrogen availability, residue accumulation or years in continuous corn, and the weather.
- Potential candidates to increase corn yields and reduce the causative factors of the continuous corn yield penalty (CCYP) are enhanced fertility and agronomic management, planting population and hybrid selection.

Research approach:

- The two-year field experiment was conducted at Champaign, Illinois on a Drummer Flanagan silty clay loam during 2014 and 2015 on 11th year continuous corn and 1st year corn in a corn-soybean rotation.
- The agronomic factors evaluated were:

1) **Management System:**

Standard

- One week prior to planting, nitrogen was applied at 202 kg N ha^{-1} as urea ammonium nitrate (UAN; 28-0-0).
- Soil test values for P and K were in the optimal range and no additional fertility was applied.
- No fungicide was applied.

High Input

- A base rate of 202 kg N ha^{-1} as UAN was applied preplant with an additional sidedress of 67 kg N ha^{-1} as urea (46-0-0) at V5 (269 kg N ha^{-1} total).
- Phosphorus was banded preplant at 112 kg P_2O_5 ha^{-1} as Mosaic's MicroEssentials® SZ™ (12-40-0-10S-1Zn).
- Preplant potassium was broadcast at 84 kg K_2O ha^{-1} as Mosaic's Aspire® (0-0-58-0.5B).
- Plots received a foliar fungicide application of BASF's Headline AMP® at VT/R1.

2) **Hybrid**: 8 different commercially-available hybrids that had distinctly different genetic makeups were grown each year.

3) **Population**: Plots were planted to achieve a final stand of 79,100 plants ha^{-1} (32,000 plants ac^{-1}; to simulate a standard producer practice) vs. 111,200 plants ha^{-1} (45,000 plants ac^{-1}; as an intensive practice).

- Final grain yield was harvested by a plot combine. All dry weights are expressed on a dry basis (0% moisture).

Figure 1. Late-season differences between 11th year continuously grown corn (left) and 1st year corn in a corn-soybean rotation (right).

Figure 2. Early-season differences between standard (left) and high input (right) management systems.

Question: ***Can the continuous corn yield penalty be reduced with hybrid selection and agronomic management?***

Objective: ***Identify elite commercial germplasm and agronomic practices to lessen inherent yield losses of continuously grown corn.***

Results and Discussion:

- **The greatest corn yields were consistently achieved in the corn-soybean rotation with intensive management (i.e., added fertility, sidedressed nitrogen, and a foliar fungicide application) (Table 1).**
- **Visual differences in plant appearance between continuous corn and rotated corn were readily apparent (Figure 1), and across treatments grain yield of continuous corn was reduced by 13% and 22% in 2014 and 2015, respectively (Table 1).**
- **With standard management, continuous corn yielded significantly less grain than corn following soybean (-2.0 Mg ha^{-1} in 2014 and -3.0 Mg ha^{-1} in 2015).**
- **High input management, demonstrated in Figure 2, significantly improved grain yield across rotations by 2.3 Mg ha^{-1} (Table 1), through increased kernel number and heavier kernel weight (data not shown).**

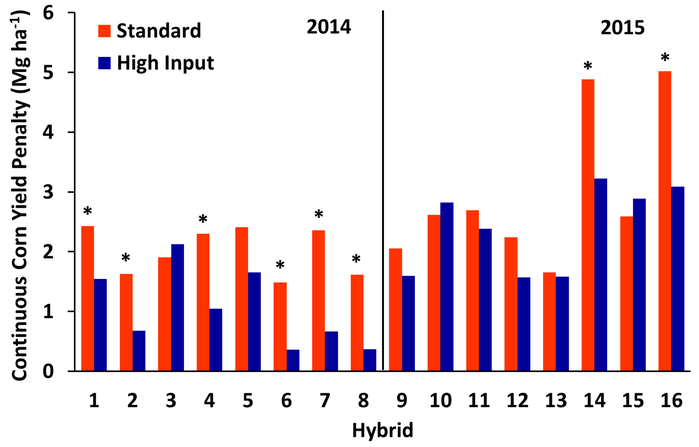

Figure 3. The yield penalty associated with continuous corn under two levels of management (Standard vs. High Input) at Champaign, IL during 2014 (hybrids 1-8) and 2015 (hybrids 9-16). Values represent the average of 79,100 and 111,200 plants ha^{-1}. All values are expressed on a dry weight (0% moisture) basis.
* Significantly different at $P \leq 0.05$ in the CCYP due to crop management for each hybrid.

Table 1. Effect of rotation, management, and planting density on final grain yield at Champaign, IL during 2014 and 2015. Values represent the average of 8 hybrids and are expressed on a dry weight (0% moisture) basis. The continuous corn yield penalty (CCYP) is the yield difference between 1st year corn in a corn-soybean rotation and 11th year continuously grown corn.

		Rotation		
Management	**Population**	**Continuous Corn**	**Corn-Soybean**	**CCYP**
2014	plants ha^{-1}		Mg ha^{-1}	
Standard	79,100	8.9 b	11.0 b	2.1 a
Standard	111,200	8.8 b	10.7 c	1.9 a
High Input	79,100	11.6 a	12.7 a	1.1 b
High Input	111,200	11.5 a	12.5 a	1.0 b
	Mean	10.2 B	11.7 A	1.5
2015	plants ha^{-1}		Mg ha^{-1}	
Standard	79,100	8.8 b	11.6 b	2.9 ab
Standard	111,200	7.9 c	11.0 c	3.1 a
High Input	79,100	10.9 a	13.4 a	2.5 ab
High Input	111,200	10.9 a	13.1 a	2.3 b
	Mean	9.6 B	12.3 A	2.7

$^{\text{Ŧ}}$ Mean separation tests were conducted using an LSD calculation with the Tukey adjustment. Lower case letters compare treatments within a rotation for each year, upper case letters compare the main effect of rotation within a year. Similar letters are not significantly different at $P \leq 0.05$.

- **There was a 40% greater yield response to high input management in continuously grown corn compared to the corn-soybean rotation, suggesting intensified management as a method to mitigate the continuous corn yield penalty (2.7 compared to 1.9 Mg ha^{-1} across years; Table 1).**
- **With select hybrids, intensive management reduced the continuous corn yield penalty by 40 to 80% (Hybrids 1, 2, 4, 5, 6, 7, 8, 14, and 16; Figure 3).**
- **Continuous corn did not magnify the stress of increased planting density in 2014, and the high density only resulted in a modest reduction in yield with an average of -0.2 Mg ha^{-1} across cropping systems. However, in 2015 with standard management, the increased stand significantly reduced continuous corn yields (Table 1).**

Conclusions:

1. Can high input management reduce the yield penalty associated with continuous corn?

- ✓ **Yes, intensified management increased yields regardless of cropping system or planting population. The continuous corn yield penalty was significantly reduced with high input management.**

2. Does hybrid selection play a role in mitigation of the CCYP?

- ✓ **Yes, select hybrids in combination with enhanced management (i.e., additional fertility and a foliar fungicide application) reduced the continuous corn yield penalty by 40 to 80%.**