Mitigating the Continuous Corn Yield Penalty with Residue and Agronomic Management

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Introduction:

- Accelerated residue degradation and nutrient cycling will be necessary to maximize yield potential in corn (*Zea mays* L.) grown continuously, in addition to other high volume residue situations such as increased planting density and crops that annually produce much greater than average yields.
- Residue accumulation, along with soil nitrogen availability or immobilization, and the weather are the primary agents of the continuous corn yield penalty (CCYP).[1]
- Potential candidates to increase corn yields and reduce the causative factors of the CCYP are mechanical residue management and intensified levels of agronomic inputs.

Reference

1. Gentry, L.F., M.L. Ruffo, and F.E. Below. 2013. Identifying factors controlling the continuous corn yield penalty. Agron. J. 105:295-303.

Research approach:

The field experiment was conducted at Champaign, Illinois on a Drummer Flanagan silty clay loam, planted on April 28th, 2016 over 4 replicated blocks of 13th year continuous corn and 1st year corn in a corn-soybean rotation (Figure 1).

The factors evaluated were:

1) **Residue Management:**

Mechanical residue treatments were implemented during the previous harvest by using a combine head equipped with:

- Standard Stalk Rollers (residue not sized; Figure 2A),

vs.

- Calmer's BT Choppers® (residue sized 3-4 cm in length; Figure 2B).

2) **Agronomic Input Level:**

Standard

- One week prior to planting, nitrogen was applied at 202 kg N ha^{-1} as UAN.
- Soil test values for P and K were in the optimal range and no additional fertility was applied.
- 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).
- 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) and potassium was broadcast at 84 kg K_2O ha^{-1} as Mosaic's Aspire® (0-0-58-0.5B).
- Planted to achieve a final stand of 111,200 plants ha^{-1} (45,000 plants ac^{-1}; as an intensive practice).
- Plots received a foliar fungicide application of BASF's Headline AMP® at plant growth stage VT/R1.

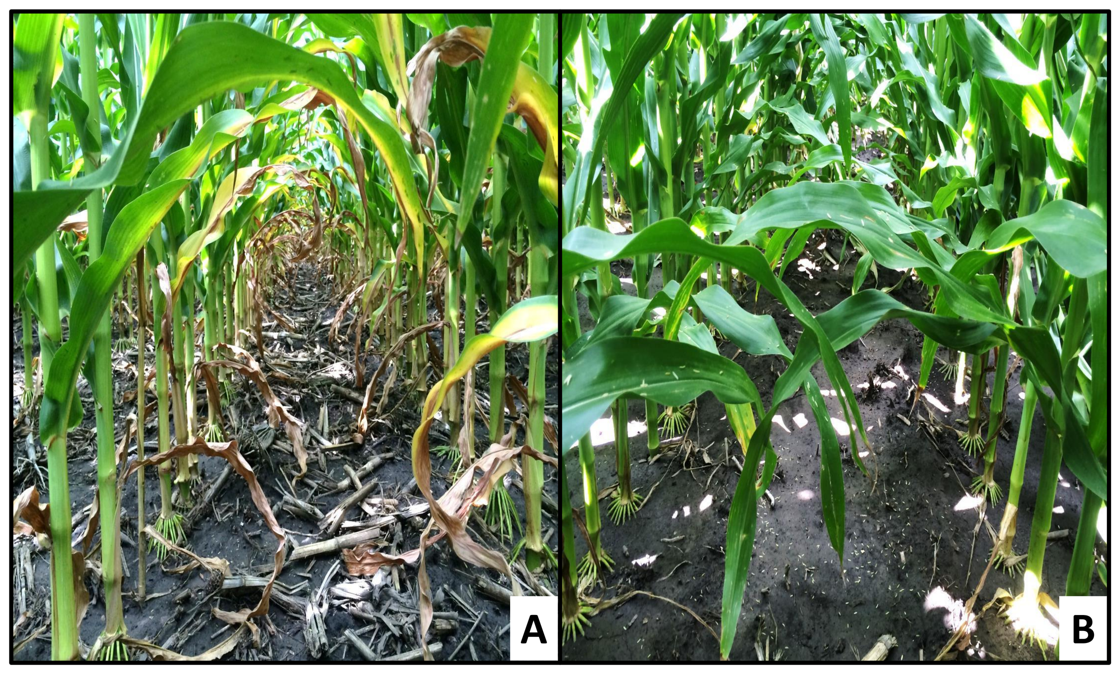

Figure 1. Late-season differences between 13th year continuously grown corn (A) and 1st year corn in a corn-soybean rotation (B).

Question: *Can the continuous corn yield penalty be lessened with residue and agronomic management?*

Objective: *Identify residue management techniques and agronomic practices that reduce yield losses from high crop-residue environments.*

Results and Discussion:

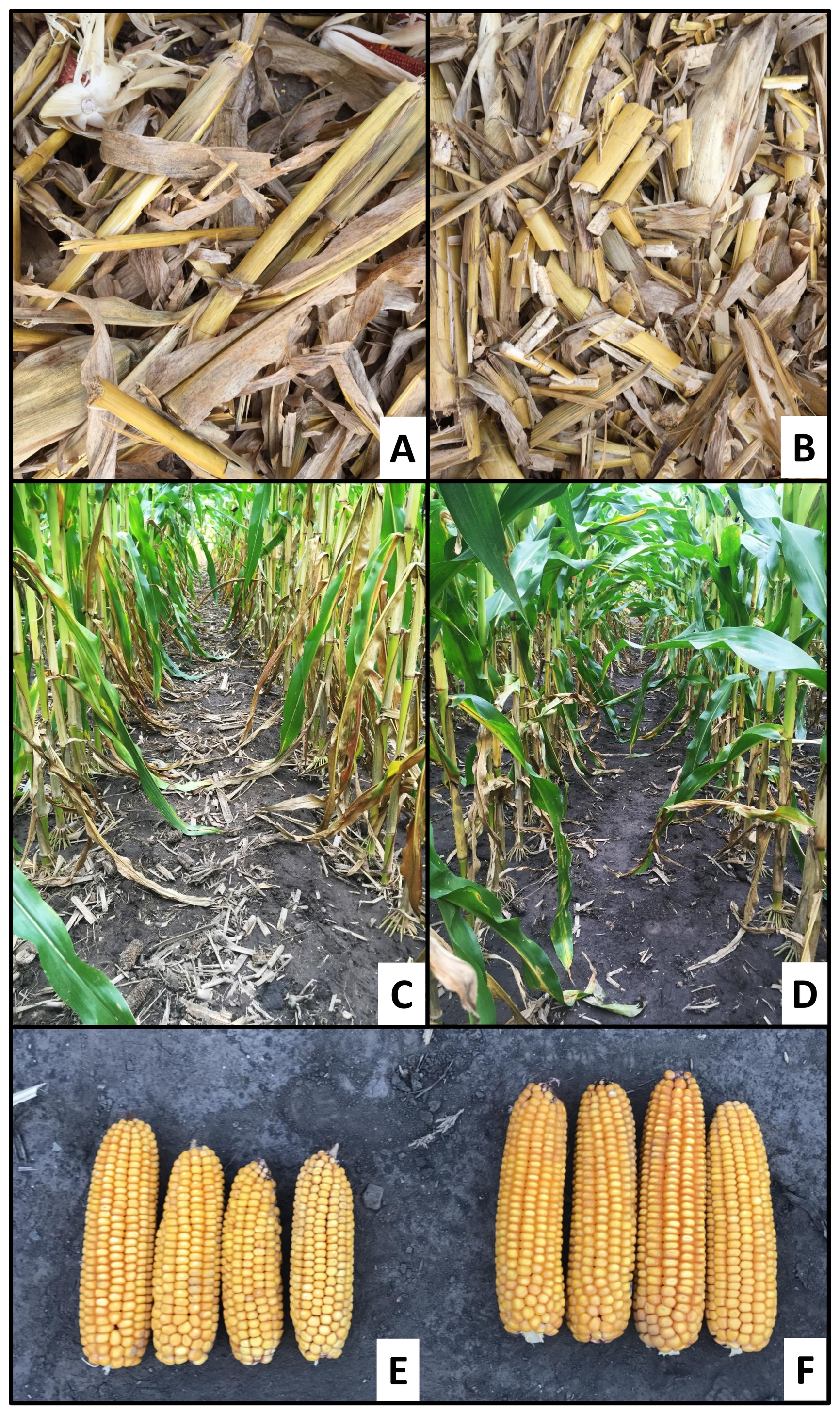

Figure 2. Mechanical residue management effects in continuous corn the previous fall (A and B), at the R3 growth stage the following growing season (C and D), and on ears at the R6 growth stage (E and F) due to Standard stalk rollers (A, C, and E) and Calmer's BT choppers (B, D, and F) .

Table 1. Grain yield changes due to rotation, residue management, and agronomic input level at Champaign, IL in 2016. Values represent the average of 2 hybrids and are expressed on a dry weight (0% moisture) basis.

Input Level	Continuous Corn Standard Residue	Continuous Corn Chopped Residue	Corn-Soybean Standard Residue
		Mg ha^{-1}	
High Input	13.6 a†	13.9 a	14.2 a
Standard	11.3 b	11.8 b	12.3 b
Mean	12.4 C	12.9 B	13.2 A

† Mean separation tests were conducted using an LSD calculation with the Tukey adjustment. Lowercase letters compare agronomic management within a rotation by harvest treatment combination. Upper case letters compare the main effect of rotation and mechanical management. Similar letters are not significantly different at $P \le 0.10$.

- **Mechanical residue treatments showed visual differences in residue after harvest (Figure 2A and 2B), in-season on the soil surface (Figure 2C and 2D), and at the R6 growth stage on ears (Figure 2E and 2F).**
- **High Input management increased early season plant growth (Figure 3). Compared to Standard management, the High Input system led to 2.4 times greater aboveground (598 kg ha^{-1} vs. 248 kg ha^{-1} ; $P \le 0.001$) and 2.2 times greater belowground biomass accumulation (126 kg ha^{-1} vs. 59 kg ha^{-1} ; $P \le 0.001$) at the V6 growth stage (Figure 4).**
- **Corn in rotation with soybean consistently out yielded continuous corn (Table 1). Chopping residue increased continuous corn yields by 0.5 Mg ha^{-1} compared to standard residue, and reduced the CCYP (0.8 Mg ha^{-1} with the standard stalk rollers vs. 0.3 Mg ha^{-1} with sized residue) (Table 1).**
- **The CCYP was highest with standard residue and standard agronomic management (1.0 Mg ha^{-1}), and lowest with chopped residue and High Input management (0.3 Mg ha^{-1}) (Table 1). On average, residue management decreased the CCYP by 0.5 Mg ha^{-1}, while High Input management decreased the penalty by 0.4 Mg ha^{-1}.**
- **Grain yield was improved by High Input management across rotations by 2.1 Mg ha^{-1} ($P \le 0.001$)(Table 1). The CCYP was lessened by 56% with the High Input level (penalty of 0.4 Mg ha^{-1}) vs. the Standard Input level (penalty of 0.7 Mg ha^{-1}), suggesting enhanced agronomic management as a method to alleviate the CCYP.**
- **Both kernel number ($P \le 0.001$) and kernel weight ($P \le 0.001$) were improved by increased agronomic management (Figure 5). Similar to grain yield, kernel weight was heavier with rotation ($P = 0.032$), however, kernel number remained constant regardless of rotation.**

Figure 3. Early-season differences above- and below-ground between standard (left) and high input (right) agronomic systems.

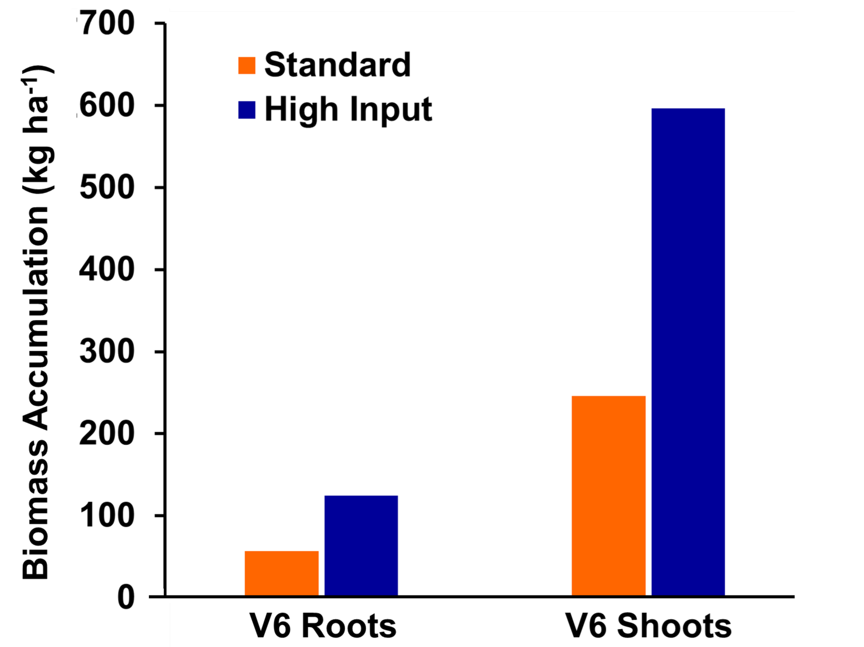

Figure 4. Above- and below-ground biomass accumulation at the V6 growth stage as influenced by agronomic input level. Values represent the average of all other treatments, expressed on a dry weight (0% moisture) basis.

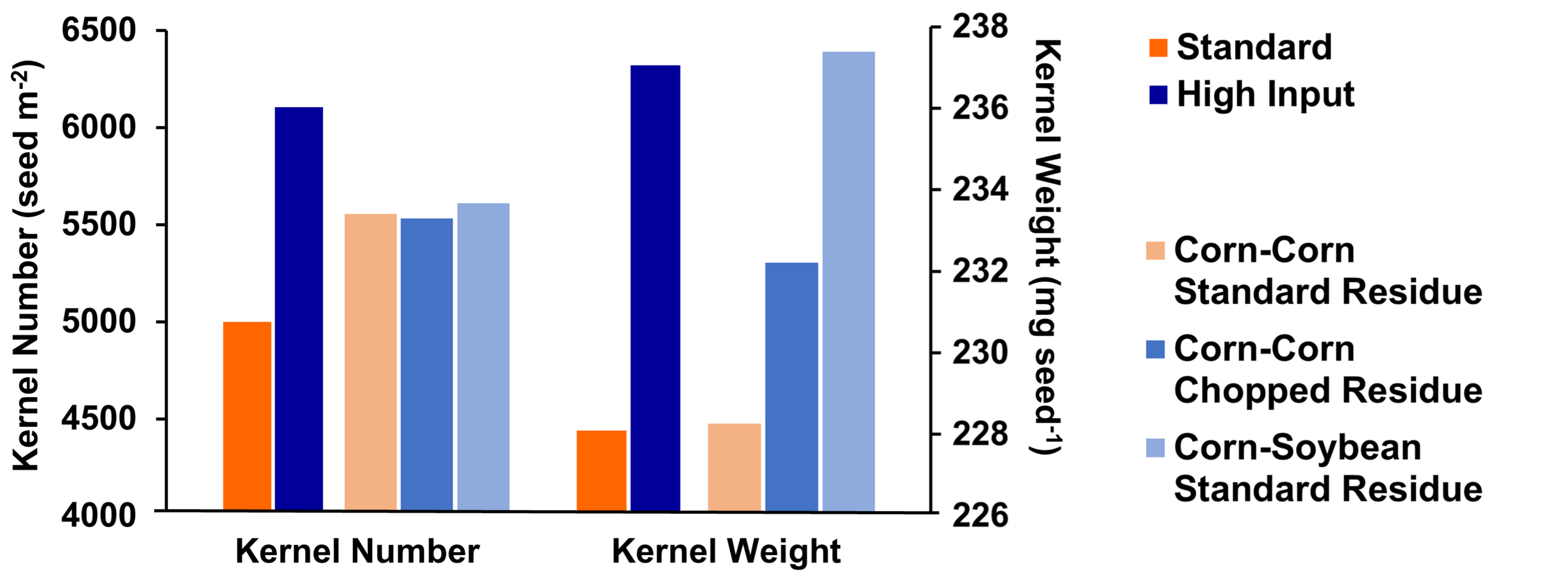

Figure 5. Yield components as influenced by agronomic input level (averaged across hybrid, rotation, and residue management) and crop rotation by residue combinations (averaged across hybrid and input level). Kernel weight values expressed as dry weight (0% moisture).

Conclusions:

1. Does residue management help alleviate the continuous corn yield penalty (CCYP)?
   - ✓ **<u>Yes</u>, mechanically sizing the previous crop residue increased kernel weight and partially decreased the continuous corn yield penalty.**
2. Can a high input system mitigate the yield penalty associated with continuous corn?
   - ✓ **<u>Yes</u>, intensified agronomic management enhanced early season vigor and grain yields regardless of cropping rotation or residue management. The CCYP was significantly reduced with high input management.**