
RESIDUE MANAGEMENT AND NITROGEN RESPONSE IN CONTINUOUS CORN

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There has been recent interest in producing ethanol from crop residues to reduce U.S. reliance on imported fossil fuels. In the Midwest, corn residue remaining after grain harvest is one of the most abundant sources of crop residue. If corn residue removal for ethanol production will occur, we believe that it will preferentially occur in fields where corn is grown continuously and not in rotation with soybean, since corn residue is a source of inoculum for many corn diseases. Furthermore, corn residue has a high carbon to nitrogen ratio, thereby favoring N immobilization. It is therefore possible that when corn is grown continuously, removal of corn residue may reduce the economic optimum nitrogen rate.

While removal of corn residue may reduce the amount of nitrogen fertilizer required for a subsequent corn crop and may suppress diseases, we have to consider other roles of crop residue on subsequent crops, and on soils. Residue removal can affect water content, temperature, and strength of soil, thereby affecting corn emergence and growth. Crop residue on the soil surface also reduces water erosion by intercepting raindrops and protecting against soil detachment, and its removal may allow more erosion.

Maintenance of soil organic matter requires a continuous supply of plant residue to the soil. Previous research with continuous corn in Iowa showed that maintenance of soil organic matter levels required 2 tons/acre of corn residue left on the soil surface prior to plowing each fall (Larson et al., 1972). Similarly removal of corn residues for 10-12 consecutive years in Indiana and Iowa reduced soil organic matter levels by 10 to 13% under conventional tillage (Barber, 1979; Larson et al., 1972). More recently, differences in soil physical properties and organic matter in the upper four inches of the soil were identified after only two seasons of residue removal in no-tillage continuous corn in Ohio (Blanco-Canqui et al., 2006). The effects of residue management on corn response to nitrogen fertilizer and soil quality, however, will likely be influenced by tillage due to complex associations between residue and soil near the soil surface. Furthermore, different levels of nitrogen fertilization may influence soil response to residue removal. Such information is vital to decisions about future cropping systems.

While there is some published research on the effects of residue removal on continuous corn yield, there is little published research on how residue removal affects continuous corn response to nitrogen fertilizer or other management practices under different tillage systems. When we have completed this work, we will better know the effects of corn residue removal on the response to nitrogen fertilizer, and on soil quality. With recent instability in the cost of energy and subsequent explorations into alternative energy sources, removal of corn residue for ethanol production is increasingly likely. Understanding corn response to nitrogen fertilizer rate and tillage in fields will be key to our ability to manage corn for maximum economic and environmental outcomes. Illinois producers also need to know how residue removal will affect

soils and yields before they can confidently remove some of it, and before they can know what price they will need for the residue. Our objective with this research is to answer these questions.

Over the first two years of the present study, responses to residue removal, tillage, and N rate were somewhat different in the lower organic matter soil and under the drier conditions at Perry compared to the other three locations (Coulter and Nafziger, 2008). At Perry, the highest-yielding treatment over those two years was in the treatment with no removal of residue followed by no-till. In contrast, this treatment – retaining all residue and no-tilling – produced the lowest yield in the higher-rainfall, higher-OM locations.

Materials and Methods

This study was initiated following corn harvest in the fall of 2005 at four University of Illinois Crop Sciences Research and Education Centers: DeKalb, on an Elpaso silt loam soil; at Monmouth, on a Muscatune sil; at Perry, on a Clarksdale sil; and at Urbana, on a Drummer silt. Main plots were assigned to one of three levels of residue removal—full, partial, and none—with full removal accomplished by chopping stalks and raking them off the plots, and partial removal done by raking without chopping stalks. Partial removal thus approximated the effect of baling off some stalks without chopping them: it removes about 50 to 60% of the residue and leaves in the field portions of mostly lower stalk and fine material. Full removal leaves a considerable amount of fine material, but typically less than 10% of the residue dry weight.

Two tillage systems—chisel plow and none—were assigned to subplots within residue removal main plots, with chiseling done soon after residue removal; at several location wet conditions at harvest required moving residue removal and tillage to the spring. No-till plots were undisturbed in the fall, and were planted using a planter equipped with trash movers. Four N fertilizer rates—60, 120, 180, and 240 lb N per acre—were assigned to sub-subplots, and were applied as 28% urea-ammonium nitrate solution, either just before planting or as a sidedress application. Sub-subplots were 6 or 8 rows (15 or 20 ft.) wide by 50 to 60 ft. long. Treatments have remained in the same place each year in each field.

A plot combine was used to harvest the center two or four rows from each sub-subplot. Yields were adjusted to 15% moisture. In most cases, the quadratic+plateau model was fitted to the data using SAS PROC NLIN. Prices of N and corn prices used to calculate optimum N rates were \$0.60/lb for N and \$6.00/bu for corn.

Results and Discussion

Yield data were combined for analysis over 19 (of 24 total) site-years from 2006 through 2011, with data from the other five sites not averaged due to error (Monmouth in 2006) or to stressful growing conditions that produced atypical responses. The other sites not included in the average were: Perry in 2006 and 2007 (dry years, separated out by Coulter and Nafziger, 2008); DeKalb 2009 (wet and cool, with spring tillage and very late harvest); and Urbana 2010, also spring-tilled and where heavy rainfall early in the growing season greatly lowered yields and rendered the responses to N linear.

Averaged over N rates, corn following full, partial, and no residue removal produced yields of 202, 199, and 203 bu/acre, respectively, with tillage, and 198, 193, and 174 bu/acre, respectively,

under no-till. Thus there was no effect of residue removal on yields when plots were tilled. In contrast, removing (nearly) all of the residue was necessary to prevent loss of yield under no-till.

Nitrogen rate responses were similar for the three residue treatments with tillage, and for the no-till treatment with all residue removed, but no-till with no residue removed both yielded less and responded more to N than did the other treatments (Figure 1). The N response curve for the treatment with partial residue removal and no-till fell between those for tilled treatments and the treatment with no removal and no-till, but was closer to those with tillage (Figure 1).

Optimum N rates based on data from 19 site-years were similar, ranging from 171 to 178 lb N/acre, for the tilled treatments with partial or no residue removal and for the no-till treatment with full residue removal (Table 1). Yields at the optimum N rates were also similar for these three treatments, ranging from 197 to 202 bu/acre. The N rate required to optimize yield (the N rate where the added N cost was just covered by the yield increase) increased as more residue stayed on the soil with no-till; with partial removal, the optimum N rate was 200 lb N/acre and with no removal of residue it was 230 lb N/acre (Table 1). Yields at the optimum N rate also decreased in these treatments, with full, partial, and no residue removal producing 197, 194, and 179 bu/acre, respectively, at optimum N rates.

One difference from results that we had previously noted with data averaged over site-years was the increased N requirement and higher yield in the treatment where all residue was retained followed by tillage. Compared to full residue removal, leaving the residue in the field followed by tillage increased the N requirement by 23 lb N, to 199 lb N/acre, and increased the yield slightly, from 202 to 205 bu/acre. It's possible that this resulted from dry conditions at some sites in 2011, with some value in having residue present for yield, along with more tie-up of N.

This study continues. After harvest in 2010, samples were taken from 0-6 and 6-12" depths in each plot, and analyses are underway for C:N ratios, P, K, pH, and CEC to see if treatments have affected these parameters after five years in the study.

References

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Table 1. Optimum N rate and yield at the optimum N rate for different residue removal levels and tillage, averaged over nineteen site-years. Optimum N rates are calculated at a corn (\$/bu):N (\$/lb) price ratio of 0.1. NT = no-till; CT = chisel-tilled.

Residue-tillage	Opt N	Yield
	lb N/ac	bu/ac
All removed-NT	171	197
All removed-CT	176	202
Part removed-NT	200	194
Part removed-CT	178	199
No removal-NT	230	179
No removal-CT	199	205

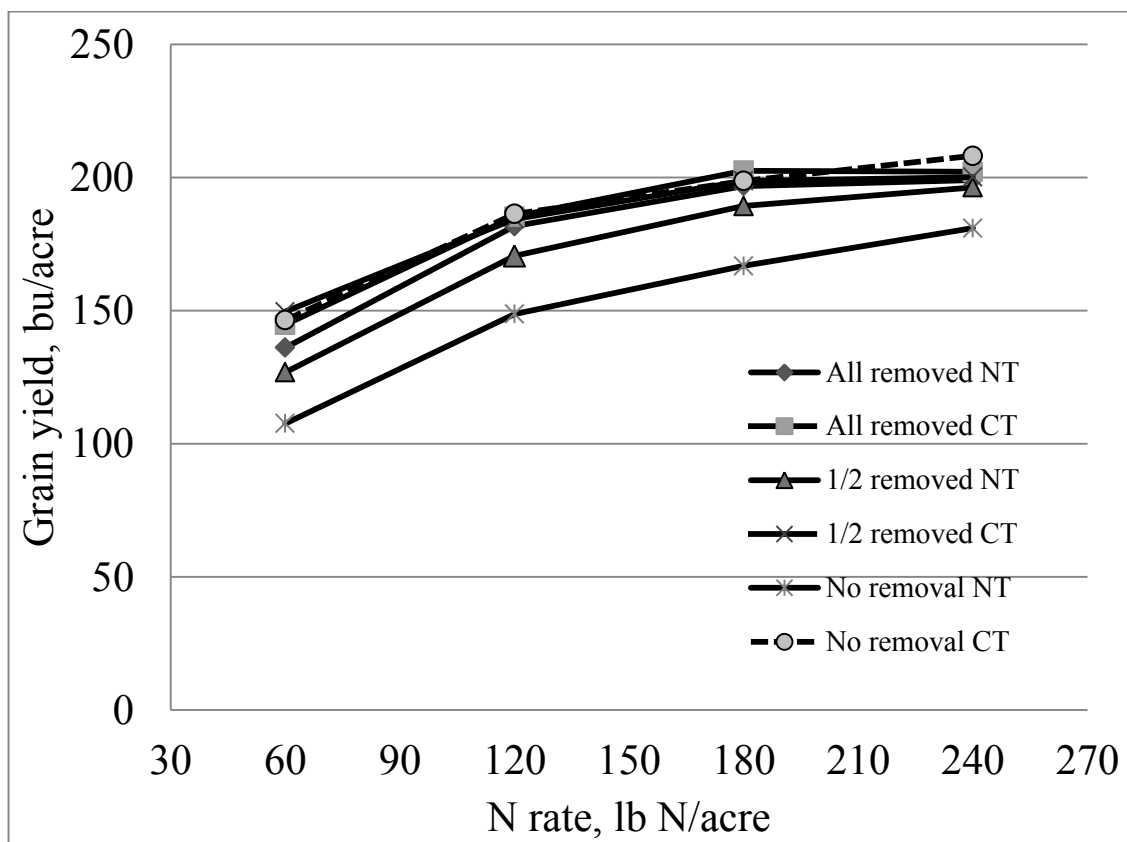


Figure 1. Response of continuous corn yield to residue removal, tillage, and N rate over nineteen Illinois site-years between 2006 and 2011.