Corn Residue Removal Effects On Subsequent Yield

Brian J. Wienhold
Gary E. Varvel
Virginia L. Jin
Rob B. Mitchell
Kenneth P. Vogel[1]

Summary

Corn residue is used for forage and feed, but residue removal effects on soil properties and yield is a concern. Residue removal effects on corn yields and soil organic carbon is site specific. Removing 50% of the residue from rainfed sites reduced corn yield by 1.9 bu/ac, whereas removing 40% of the residue from irrigated sites increased corn yield by 15.4 bu/ac. However, removing 53% of the residue increased soil erosion by 30%. Agronomic practices such as reduced tillage, cover crops, or manure may offset residue removal impacts. Residue removal should be based on site-specific characteristics and management, but is feasible when sufficient residue is retained to protect soil from erosion and sustain soil biota.

Introduction

Rapid growth of the ethanol industry in Nebraska has created a demand for roughage to be co-fed with distillers grain as a replacement for grain being used as a biofuel feedstock. Crop residue, mainly corn stalks, is being harvested to meet this demand. Crop residue also has been proposed as a future feedstock for cellulosic biofuel production. Crop residue protects the soil from wind and water erosion, contains nutrients that become available for subsequent crops, and sustains soil biota. Removal of crop residue can potentially have a negative effect on these critical functions, and additional field work to remove the residue increases the potential for soil compaction. As the practice of crop residue removal increases, concerns regarding its effect on subsequent crop yields arise. In high production systems crop residue is present in quantities that can hinder establishment of a subsequent crop and under these conditions the potential exists for removing a portion of the crop residue for other uses without negatively effecting soil function. Here we report results from experiments comparing crop yields and soil organic carbon when residue is removed or retained in rainfed and irrigated corn production systems and residue removal effects on runoff as well as sediment loss in an irrigated corn system.

Procedures

Two residue removal studies were conducted at the University of Nebraska Agricultural Research and Development Center (ARDC) near Mead, Neb. The first study was initiated in 1998 under rainfed (nonirrigated) conditions on a site that qualified for the Conservation Reserve Program. Treatments in this study were residue removed (50%) or retained in no-tillage corn receiving 54, 107, or 160 lb N/ac (*Biomass and Bioenergy*, 32:18, 2008). The second study was initiated in 2001 under irrigation on a productive soil. Treatments in this study were disk or no-tillage with 0, 40, or 80% residue removal. All treatments received 180 lb N/ac. Removal rates in both studies are more intensive than what would be expected with grazing but less intensive than harvest for silage. Corn grain and residue production were measured annually in both studies. Soil samples were collected to a depth of 5 feet, in 1 foot increments, when each experiment was initiated and again after 10 years to determine carbon content.

An erosion study was conducted on a cooperator field near York, Neb. in 2009 (*Agronomy Journal,* 102:1448). This field was in continuous corn under irrigation. Beginning in 2006, residue was removed (53%) from four 24-row strips following grain harvest. Residue was retained in four additional 24-row strips. Within each strip, a set of paired plots were placed in a portion of the field having an 8% slope. For each pair of plots, one had cobs removed and one had cobs retained. Each pair of plots was then subjected to simulated rainfall (1.7 inches in 30 minutes) under antecedent soil moisture and again the following day under saturated soil moisture. Runoff and sediment from each plot was measured.

Results

Grain Yield

Under rainfed conditions, annual removal of crop residue resulted in slightly lower 10-year average yields than when residue was retained (Table 1). Averaged across nitrogen treatments, yields were 106.1 bu/ac where residue was retained and 104.2 bu/ac where residue was removed.

In the irrigated study, grain yields were nearly double those of the rainfed study. In the irrigated study, grain yields were greater under disk tillage than under no-tillage. In both tillage treatments, grain yields increased as residue removal increased (Table 1).

In rainfed production systems yield is limited by water availability. Under these conditions a layer of crop residue reduces evaporation losses and increases the amount of water that is available for the crop resulting in greater yields where residue is retained.

In irrigated systems, production is much greater and crop residue can cause problems with soils warming in the spring and establishment of a uniform stand. In these systems, tillage that incorporates the residue into the soil and residue removal when no-tillage is used improves stand establishment and subsequently yield.

Table 1. Corn grain yield (bu/ac) for rainfed and irrigated crop residue removal studies.

Site – Treatment	Yield
Rainfed – Residue Retained – 54 lb N/ac	88.4^{b}
Rainfed – Residue Removed– 54 lb N/ac	81.6^{a}
Rainfed – Residue Retained – 107 lb N/ac	116.0^{c}
Rainfed – Residue Removed– 107 lb N/ac	115.3^{c}
Rainfed – Residue Retained – 160 lb N/ac	113.9^{c}
Rainfed – Residue Removed– 160 lb N/ac	115.8^{c}
Average – Residue Retained	106.1
Average – Residue Removed	104.2
Irrigated – Disk Tillage, 0% removal	201.7^{b}
Irrigated – Disk Tillage, 40% removal	207.5^{c}
Irrigated – Disk Tillage, 80% removal	212.4^{c}
Irrigated – No-Tillage, 0% removal	180.9^{a}
Irrigated – No-Tillage, 40% removal	205.9^{b}
Irrigated – No-Tillage, 80% removal	202.0^{b}

^{a,b,c}Values within a column followed by different letters are significant at ($P < 0.05$).

Table 2. Soil organic carbon content (tons/ac) in the 0- to 1-foot increment for rainfed and irrigated crop residue removal studies.

Site – Treatment	1998	2008
Rainfed	20.6^{a}	24.1^{b}
	2001	2010
Irrigated – Disk Tillage, 0% removal	34.4^{a}	32.2^{b}
Irrigated – Disk Tillage, 40% removal	35.1^{a}	32.5^{b}
Irrigated – Disk Tillage, 80% removal	34.1^{a}	31.4^{b}
Irrigated – No-Tillage, 0% removal	34.7^{a}	33.5^{a}
Irrigated – No-Tillage, 40% removal	33.1^{a}	32.1^{b}
Irrigated – No-Tillage, 80% removal	34.5^{a}	30.9^{b}

^{a,b,c}Values within a column followed by different letters are significant at ($P < 0.05$).

Soil Organic Carbon

In the rainfed study soil organic carbon was similar among treatments in 1998. In 2008 there were no differences among the treatments but averaged across treatments soil organic carbon had increased (Table 2). Increases in soil organic carbon were greatest in the 0 to 1 foot increment but increases were measurable throughout the 0- to 5-foot profile. Use of no-tillage resulted in sequestration of 710 lb/ac/year of organic carbon even with up to 50% removal of crop residue.

In the irrigated study soil organic carbon was similar among treatments in 2001 (Table 2). In 2010, soil organic carbon in the 0- to 1-foot increment was less than in 2001 in all treatments except the no-tillage treatment where no residue was removed. Soil organic carbon in 2001 and 2010 was similar among treatments in the remaining depth increments.

The response to residue removal differed between the sites used in this study. Initial soil organic carbon content at the rainfed site was less than at the irrigated site. Under no-tillage continuous corn, soil organic carbon increased at the rainfed site but remained the same with no residue removal or declined with residue removal at the irrigated site. We speculate that the difference in response between the two sites is related to differences in soil water status at the two sites. Under irrigation, soil water content would be greater and more favorable for soil microbial activity for a greater portion of the year than under rainfed conditions. Greater microbe activity would decompose residue more quickly. Results from related studies support this hypothesis. Preliminary measurements of carbon dioxide emissions show greater losses from irrigated plots than from rainfed plots during the growing season, and in a litter decomposition study we observed more rapid loss of dry matter in residue buried in irrigated plots than in rainfed plots (*Agronomy Journal,* 103:1192).

Runoff and Sediment Loss

Plots where residue was removed had less cover (50%) than plots where residue was retained (77%). Runoff from plots where residue was removed began more quickly (196 seconds) than in residue-retained plots (240 seconds). Residue removal did not affect the amount of runoff from the plots (6% of simulated rainfall). Residue removal resulted in 30% greater loss of sediment (321 lb/ac with residue removal vs. 242 lb/ac with residue retained). Removal of the cob fraction had no effect on runoff or sediment loss. These results demonstrate the importance of crop residue in protecting the soil from raindrop impact. The impact of falling rain is the mechanism that detaches soil particles making them susceptible to loss in runoff.

The results presented in this report complements previous work that has quantified the distribution of corn stover biomass and nutrients as a function of height (*Bioenergy Research*, 3:342, 4:11), the relationship between the cob and other biomass components (*Bioenergy Research,* 1:223), and estimates of residue retention needed to protect the soil against wind and water erosion and to sustain soil biota (*Agronomy Journal,* 99:1665). While the effect of residue removal on crop production and soil properties is site specific, results suggest that a portion of crop residue can be harvested for other uses without negatively impacting subsequent yields. It is essential that sufficient crop residue be retained to protect the soil from wind and water erosion and to sustain soil biota. Implementing management practices such as reduced tillage, cover crops, or applying manure in concert with residue removal may be necessary to reduce the potential for negatively affecting future productivity while meeting current demands for food, forage, and feedstock.

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[1] Brian J. Wienhold, Gary E. Varvel, Virginia L. Jin, Rob B. Mitchell, Kenneth P. Vogel, USDA-ARS, Lincoln, Neb.