Proceedings of the 29th Annual Central Plains Irrigation Conference, Burlington, Colorado, Feb. 21-22, 2017
Available from CPIA, 760 N. Thompson, Colby, Kansas

IMPACTS OF RESIDUE MANAGEMENT IN IRRIGATED PRODUCTION

J Schneekloth — Water Resources Spec — Joel.Schneekloth@Colostate.Edu
D.C. Nielsen — Res. Agron. — David.Nielsen@Ars.Usda.Gov
F. Calderon — Res. Soil Sci. — Francisco.Calderon@Ars.Usda.Gov

Colorado State University
USDA-ARS
Akron, Colorado
(970) 345-2259

ABSTRACT

Irrigated corn production was compared in two tillage management practices (no-till and conventional) and two residue management practices (when residue was not removed or was harvested). Corn yields were suppressed in both 2014 and 2015. In 2014, zinc deficiencies were prevalent and most severe in no-till management and severe hail damage in 2015. Impacts to water infiltration were significant in both 2014 and 2015 due to residue and tillage management. Infiltration was not significant in 2016 but followed similar trends of 2104 and 2015. In 2014, first year in no-till, residue was the significant factor in influencing infiltration, time to runoff and steady state infiltration. In 2015, residue management impacted total infiltration and time to runoff but tillage management was significant in steady state infiltration. No-till had significantly greater infiltration rates after 30 minutes of water application. Residue management had more significant impact to total infiltration than tillage management on average while steady state infiltration tends to increase with tillage management.

INTRODUCTION

With recent droughts, forage prices have escalated and have attracted the use of corn stover as a feed source. Also, continued research could expand the use of corn stover for cellulosic ethanol production. Continual removal of corn residue can have significant impacts on soil properties as well as the potential productivity without the additional input of nutrients to offset those removed in the residue. One of the potential greatest impacts is water. Residue can reduce evaporation from the soil surface as well as increase snow retention in the field. As water supplies become limited, the impact of residue management can signficantly impact the proftablity of production. Previous work has show that the reduction in evaporation from residue can impact yields positvely in limited water situations.

With low corn prices, economics of reduced input costs (tillage) and increased income (residue sales) can have an impact on decision making. However, consideration for the long term implications must be considered.

GENERAL STUDY METHODS

The study was conducted under a linear sprinkler system at the USDA-ARS Central Great Plains Research Center at Akron, CO beginning in 2014. Corn was previously grown on this site with conventional tillage management. The predominant soil type is Weld Silt loam with a water holding capacity of 2.0 inches foot^{-1}. Average yearly precipitation is 16.8 inches with an average of 11 inches of growing season precipitation.

A corn hybrid with a relative maturity of 104 days (DeKalb 54-18: 2014 and 2015; Dekalb 54-38: 2016) was planted on May 15, 2014, May 3, 2015 and May 16, 2016. The seeding rate was 34,500 seeds acre^{-1} for all treatments. Plots were planted with a 4 row JD 1700 MaxEmerge planter with Accra-Plant Zone Till row cleaners. Irrigation was scheduled on a water balance approach with estimates of evapotranspiration based on CoAgMet estimates.

Treatments included no-till and conventional tillage (tandem disk) and where residue was harvested or remained in the field for a total of 4 treatments. Treatments were replicated 4 times in a randomized complete block design. Within each treatment, sub plots of nitrogen rates of recommended, +/- 50 lbs acre^{-1} were applied to look at nitrogen response with tillage and residue management. Residue in 2014 was harvested in early April, November of 2014 and April 2016. Tillage occurred following residue harvest.

Fertilizer was applied according to soil test results and expected yields. An application of 15 gallon acre^{-1} of 10-34-0 was applied at planting with 0, 50 and 100 lbs N additional for the fertility study. Additional N was applied through the sprinkler system during the growing season prior to tassel emergence. Water was monitored bi-weekly to a depth of 6 feet for irrigation scheduling.

Soil infiltration rates were measured using the Cornell Infiltrometer in late August to early September. Measurements were taken on when first runoff occurred as well as runoff amounts and water applications over a 30 minute period with readings every 1 minute for 6 minutes and then every 3 minutes for the next 24 minutes. Steady state infiltration was estimated with the average of the final 3 infiltration readings. Total infiltration was the difference between water applied in the 30 minute time period and runoff measured.

RESULTS AND DISCUSSION

Residue Cover

Residue was removed from 2 treatments in April 2014, November 2014 for the 2015 cropping season and April 2016 for the 2016 cropping season. Tillage plots were tilled immediately after residue removal. Tillage was done with a tandem disc. Plots with the residue removed were tilled 2 times while the plots with the residue remaining were tilled 3 times. Residue cover for the T/NR was approximately 13% while the NT/R plots had 89% cover. Both NT/NR and T/R plots had approximately 55% residue cover. Residue covers in 2015 were similar to 2014. Both NT and the T/R plots were within conservation compliance which mandates a minimum of 30% cover.

Infiltration

One of the benefits of residue and reduced tillage has been the resulting increase in infiltration shown by previous research. Increasing tillage destroys macro and micro pore structure which reduced infiltration of water. Maintaining or increasing infiltration is important for irrigation sprinkler package design to reduce runoff potential without increasing system pressure to increase the wetted diameter and reduce the maximum application rate. In the fall of 2014, 2015 and 2016, a Cornell Infiltrometer was used to measure infiltration patterns of the treatments.

Differences were observed in the pattern of measured infiltration by residue management. Where residue was not removed, infiltration was greater than that of when residue was removed no matter what tillage system was utilized (Figure 1). Positive impacts when residue remained in the field were observed for the 3 major factors of infiltration. Total infiltration in 30 minutes increased in 2015 and 2016 compared to 2014 and was still the greatest when residue was not removed. Total infiltration was less than 2 inches in 30 minutes for all treatments in 2014 and 2015 but greater than 2 inches in 2016 for all treatments except for NT/NR.

When looking at what the main impact to total infiltration of tillage or residue management (Figure 2), residue was the significant impact. When comparing NT vs T (average of residue and no residue), total infiltration was similar for each tillage management each of the three years. However, residue management (average of NT and T), residue removal significantly impacted total infiltration. In each of the three years, leaving residue in the field resulted in greater total infiltration as compared to residue harvest. On average, residue removal reduced total infiltration by approximately 0.5 inches in a 30 minute infiltration test. With similarities of infiltration to tillage within a residue management strategy, soil surface conditions appear to have the greatest impact on infiltration for the first 30 minutes.

Steady state infiltration (Figure 3) shows that NT/R had the greatest infiltration rates at 30 minutes compared to all other treatments. The increase in steady state infiltration averaged 0.75 in hr^{-1} greater than all other treatments. All other treatments were equal in steady state infiltration rates. The impact of tillage or residue removal (Figure 4) shows that the impact of tillage and residue removal are equal in steady state infiltration. However, the greatest impact was on NT when residue remained in the field and had less of an impact on T where residue remained or NT when residue was removed. Improvements in steady state infiltration could potentially show improvements in soil structure. Samples collected in 2016 show that NT/R had significantly greater earthworm populations compared to all other treatments.

Total and steady state infiltration increased each of the three years for all treatments (Figures 1 and 3). This shows the impact of yearly variability on these factors. In 2016, both total and steady state infiltration increased dramatically from 2015. Reasons for this increase were potentially precipitation intensity differences early in the year. Precipitation during the May-July time period was above average, however, no single precipitation event had an intensity of more than 0.25 in hr^{-1}. These low intensity precipitation events and no irrigation during that time period did not compact or deteriorate soil surface conditions. The average steady state infiltration was highest for NT/R compared to other treatments. Impacts of main treatments of tillage and residue (Figure 4) show NT having greater steady state infiltration compared to T and leaving residue in the field having a similar impact. This would show that residue management and NT having a greater impact on steady state infiltration. This would be indicative of potential soil structural changes below the soil surface.

Time to first runoff was greatest for NT/R followed by T/R. Both treatments where residue was removed had faster times to runoff. Steady state infiltration was the average of the last 4 infiltration readings. Time to first runoff was lower in 2016 compared to either 2014 or 2015 for all treatments. It is uncertain as to the factors that influenced this change in 2016.

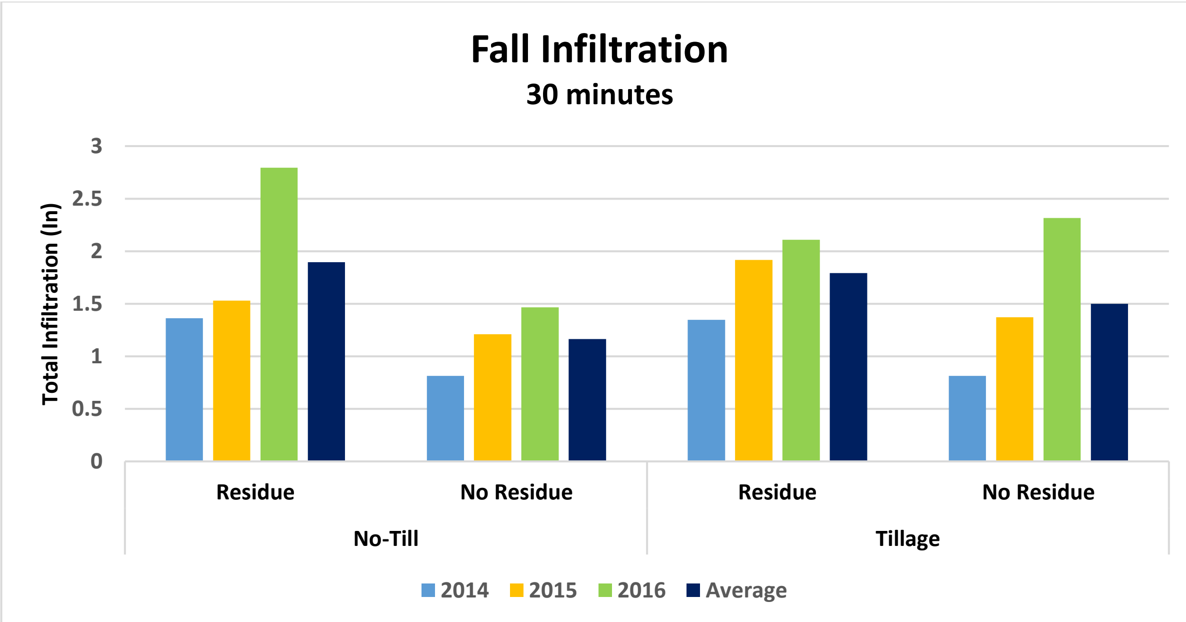

Figure 1. Measured infiltration over 30 minutes for tillage and residue management.

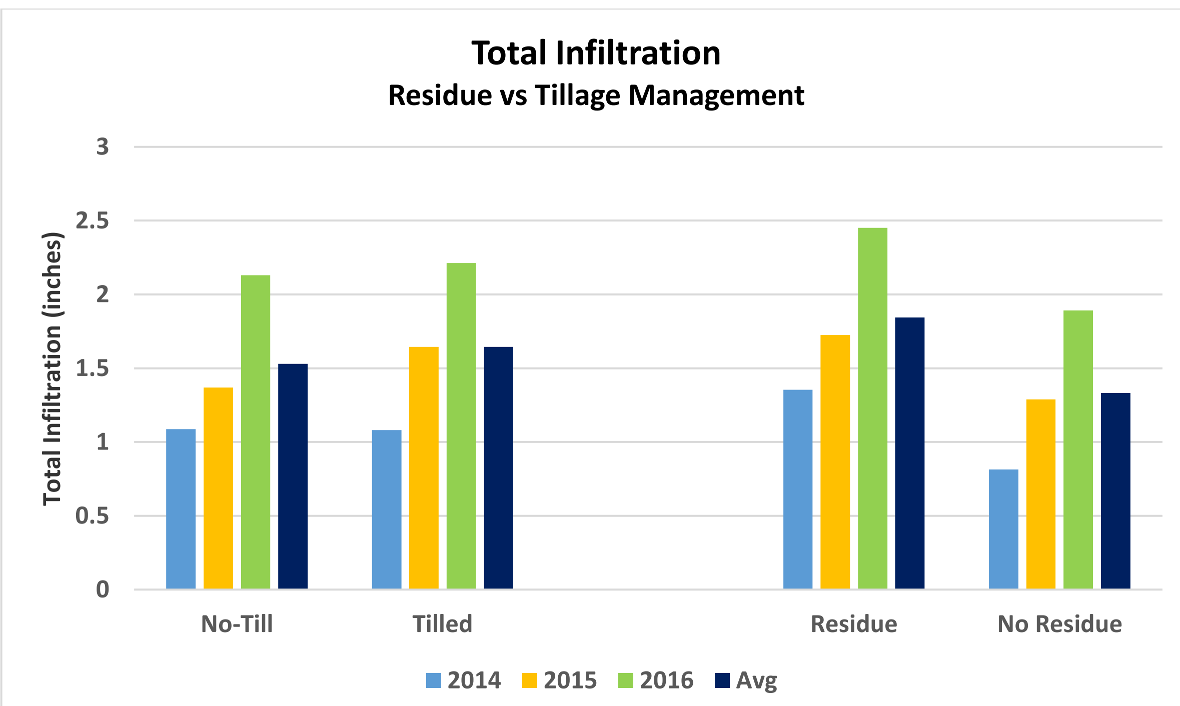

Figure 2. Impact of tillage and residue management on measured total infiltration.

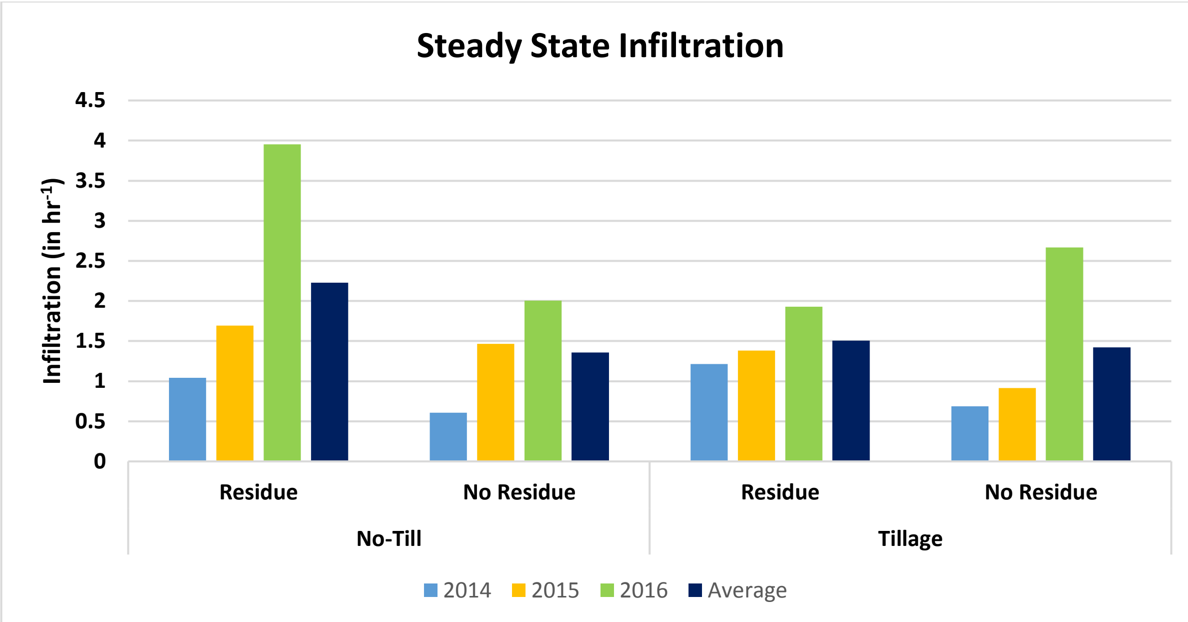

Figure 3. Steady state infiltration averaged over the last 4 measurements.

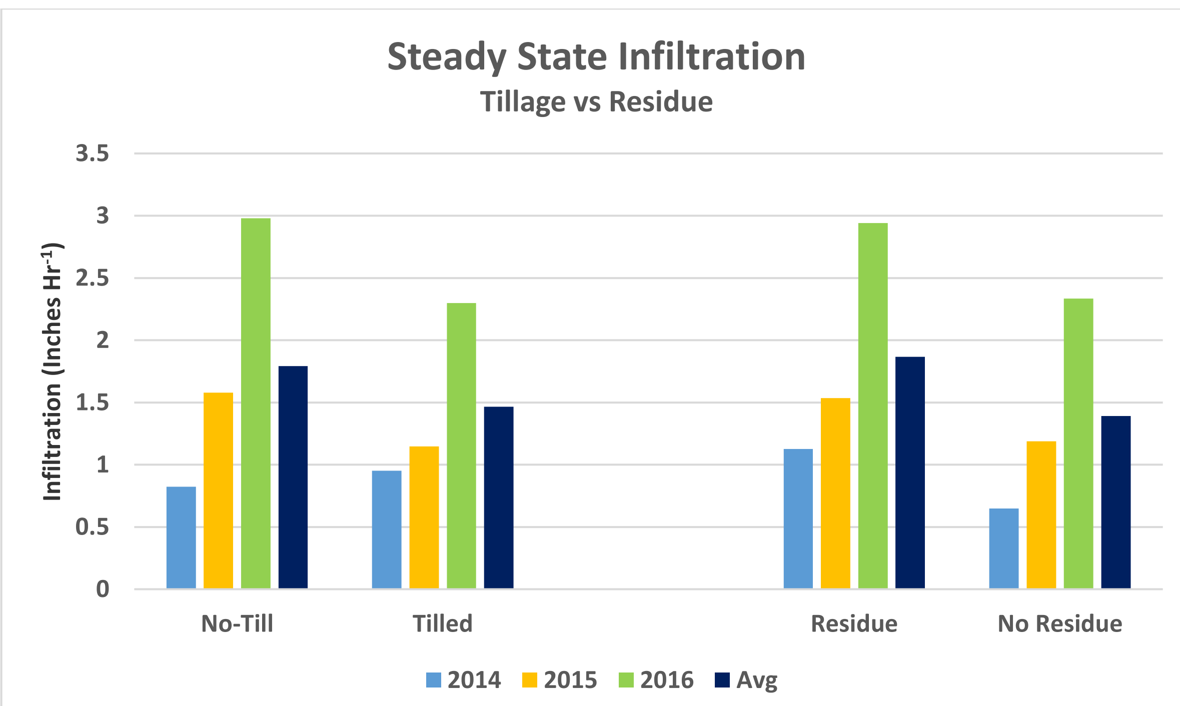

Figure 4. Impact of tillage and residue management on steady state infiltration.

Agronomics and Grain Yield

Plant stands were measured at V5 with multiple 30 ft measurements within the plots. Final plant stands ranged from 33,800 to 31,100 plants acre^{-1}. The stand counts for NT/NR, T/R and T/NR were equal with stands from 32,900 to 33,800 plants acre^{-1} and less than 3% difference. NT/R had a significantly lower plant stand and was 7% less than the average of the other tillage/residue treatments.

Grain yields in 2014 (Table 1) were impacted by zinc deficiencies which impacted the NT/R treatments more significantly than the other treatments. In 2015, grain yields (Table 1) were significantly reduced for all treatments by a significant hail storm that occurred on August 1 with estimates of 75 to 80% leaf area loss for all treatments. Grain yields averaged from 84 bu acre^{-1} to 99 bu acre^{-1} for NT/R to T/R. Grain yields for NT/R were significantly lower than all other treatments.

At the time of the hail event, the NT/R was slightly behind the other treatments in growth stage. NT/R was slightly past silking while the other treatments were closer to silks brown. Estimates of yield loss with similar hail damage show 60% for silks brown and 65% for silked. Similar hail damage at an earlier growth stage for NT/R would have brought yields closer to that of all other treatments if the hail had not occurred. Yield estimates for NT/R adjusted for hail damage would have averaged 240 bu acre^{-1} with no statistical difference between treatments.

Increases in nitrogen generally increased yields in 2015. Yield increases for the NT treatments average 2.0 bu acre^{-1} for each additional 50 lbs N applied. These increases would not be economical at today's prices for nitrogen and grain. In 2014, yields decreased for both NT treatments and T/NR. With further discussion with a fertility specialist, this type of response is not uncommon when a zinc or iron deficiency is seen that additional nitrogen reduces grain yield. However, the T/R yields increased with additional nitrogen. This may be due to the decomposition of the residue by tillage and release of the micro nutrients back to the system as compared to the NT where decomposition is slowed by lack of contact of residue to soil.

Grain yields in 2016 where greater for NT than T by 6 to 9 bu ac^{-1}. This increase could be attributed to less evaporative losses by tillage. Residue management did not impact grain yields as compared to tillage management.

Table 1. Grain yields for 2014 and 2015 by tillage and residue management. Average of nitrogen applications.

	Grain Yield, Bu ac^{-1}			
	NT/R	NT/NR	T/R	T/NR
2014	168	191	189	196
2015	242	230	241	255
2016	183	180	174	174
Average	198	200	201	208

Evapotranspiration

Reducing evaporative losses is one of the potential benefits of residue. In both 2015 and 2016, early season evapotranspiration was significantly reduced by no-till with residue. The average reduction from mid-June to late July was 0.95 inches. ET was not significantly different in all other treatments during the mid to late vegetative growth stages. Work on measuring evaporative losses has shown that surface cover needs to be near 100% to effectively reduce evaporative losses. Any tillage results in a reduction of residue surface coverage which eliminates the potential for evaporative losses.

CONCLUSIONS

Changes in infiltration by residue management are significant in a short duration application of either irrigation or precipitation. Leaving residue in the field significantly increased total infiltration in 30 minutes compared to where residue was harvested irrespective of tillage in all years. Tillage had no impact on total infiltration in 30 minutes of water application. Leaving residue in the field was the significant factor for total infiltration. Changes in steady state infiltration occurred due to tillage and residue management for three years. However, no-till and leaving residue in the field had the greatest impact on steady state infiltration as compared to all other treatments.

Residue management can have a significant impact on water dynamics in irrigation management. Removal such as either baling the corn stalks for bedding or forage or harvesting for silage will change the infiltration patterns for the next year of crop production. When moisture or irrigation availability is limited, increasing moisture capture is important to maximize crop production and water availability. When moisture or irrigation is not limited, removal of residue had little impact on grain yields (2014 and 2015). However, more irrigation was required to for best management practices.