IMPACTS OF RESIDUE MANAGEMENT IN IRRIGATED PRODUCTION

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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. In 2014, and 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.

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) was planted on May 15, 2014 and May 3, 2015. 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 and again in November of 2014. 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 and again in November 2014 for the 2015 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 and 2015, 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 from 2014 and was still the greatest when residue was not removed. Total infiltration was less than 2 inches in 30 minutes for all treatments.

Time to first runoff was greatest for NT/R (Figure 2) followed by T/R. Both treatments where residue was removed had faster times to runoff. Steady state infiltration (Figure 3) was the average of the last 4 infiltration readings. Steady state infiltration was greatest in NT/R followed by NT/NR, T/R and T/NR respectively. Large increases in steady state infiltration were observed by both NT treatments compared to 2014 while both tilled treatments had little increase. No-till plots are potentially having structural changes that are impacting steady state infiltration. In 2014, steady state infiltration was observed in all 4 treatments. In 2015, T/R had not reached steady state infiltration as observed in Figure 4. Decreases were still occurring to infiltration rates in T/R even at 1800 seconds. The infiltration rate at that point was approaching T/NR rates of approximately 0.8 inches per hour. If this was truly steady state infiltration, infiltration rates were approximately 50% of the NT treatments. This was a dramatic drop in steady state infiltration for T/R from 2014 where all other treatments either remained steady or increased slightly. Tillage management would have dramatic impacts on long lasting precipitation events on stored soil moisture.

Changes in steady state infiltration from 2014 to 2015 could potentially indicate the impact of no-till management on infiltration past 30 minutes. Increases in steady state infiltration have an impact on soil moisture during long precipitation events. Data shows a potential of increasing infiltration by approximately 0.8 inches per hour over tillage.

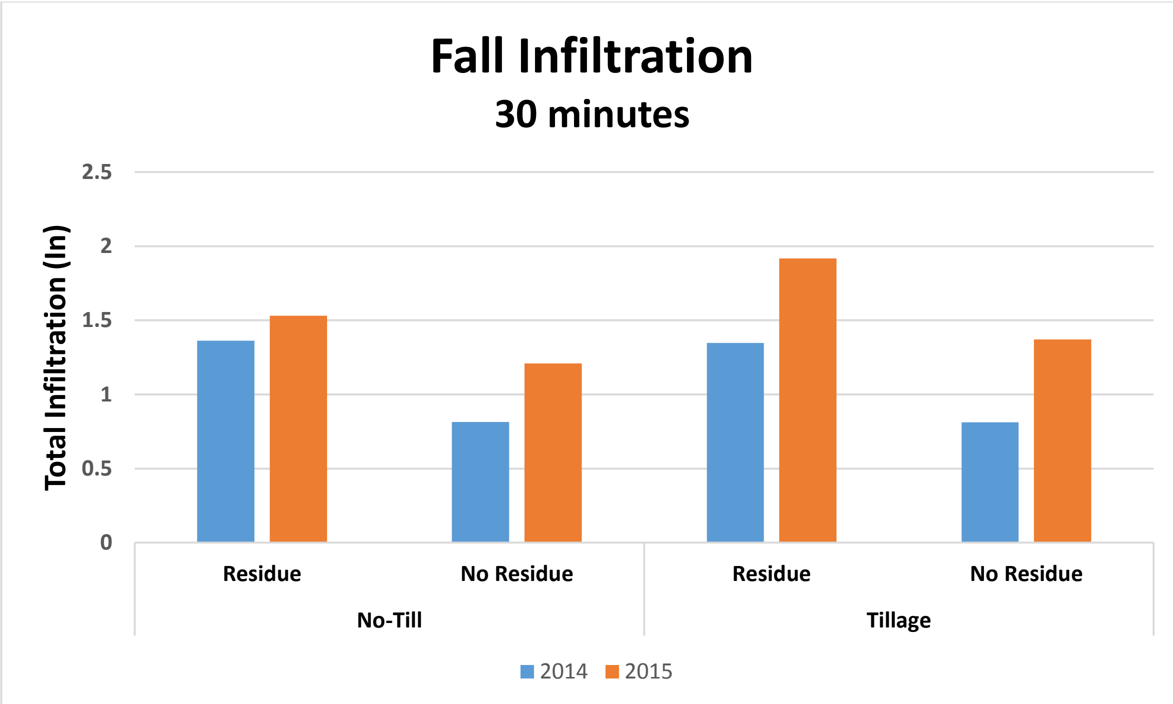

Figure 1. Measured infiltration over 30 minutes for tillage and residue management.

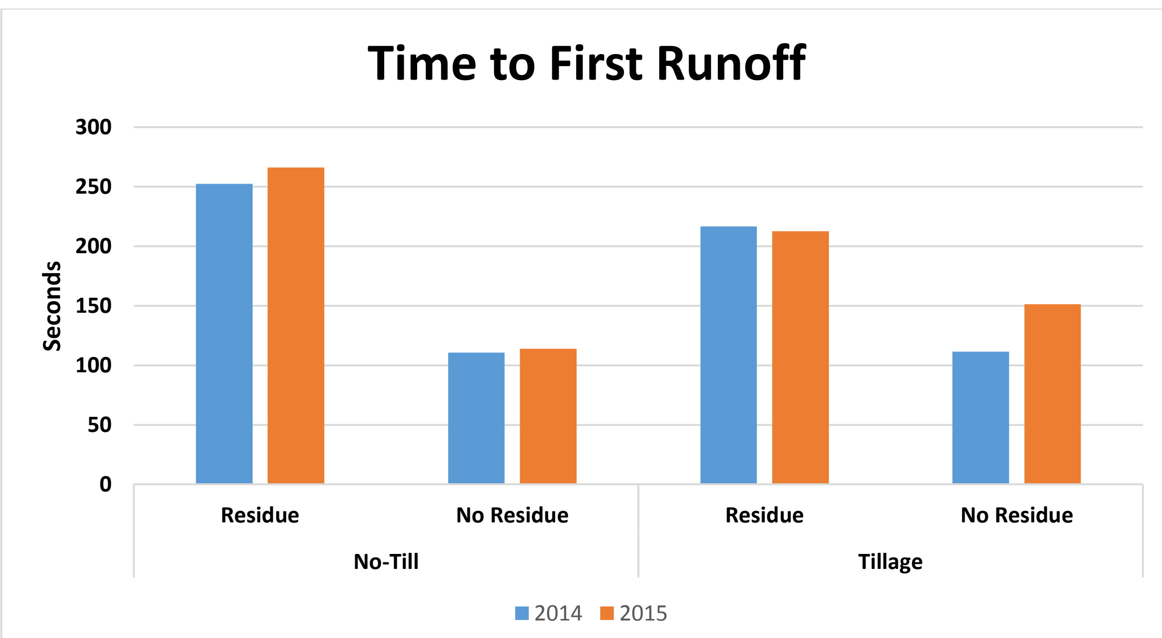

Figure 2. Time to first observed runoff for tillage and residue management.

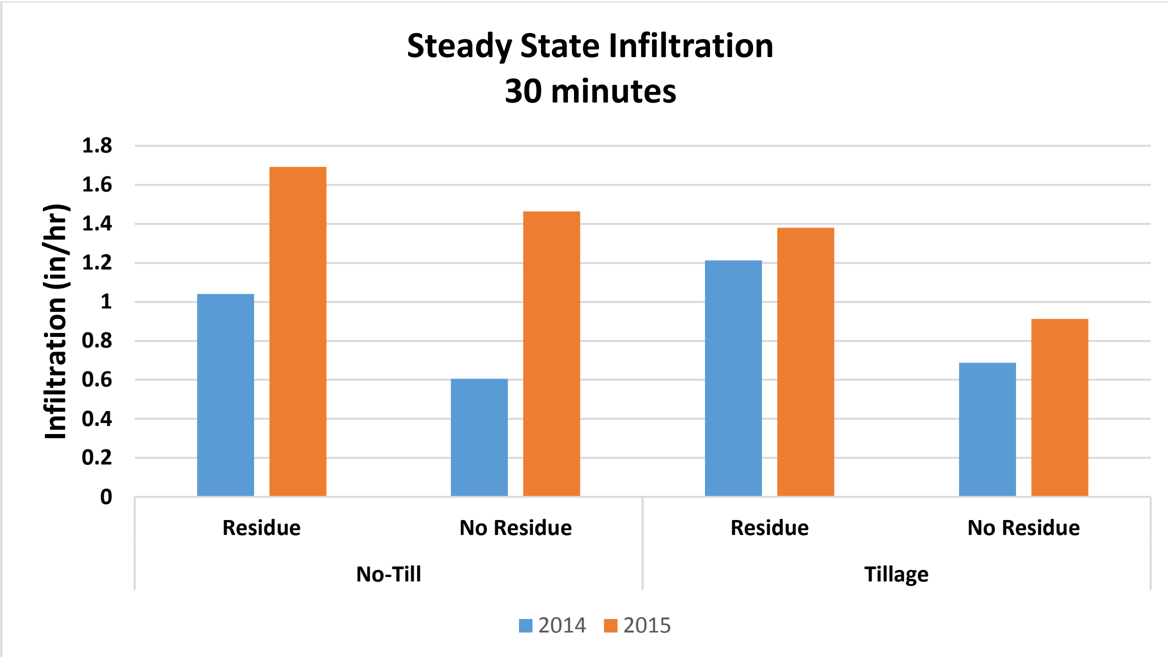

Figure 3. Steady state infiltration averaged over the last 4 measurements.

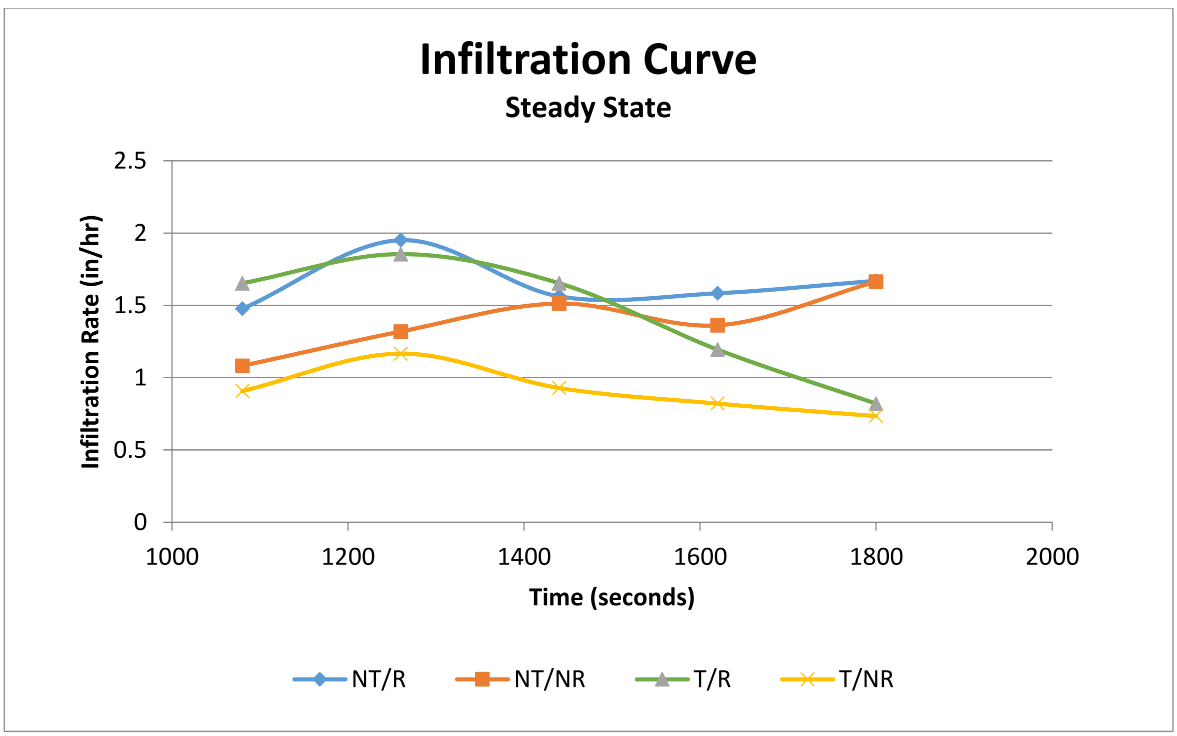

Figure 4. Infiltration measurements for the last 15 minutes.

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 silked 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.

Economics

Economics are an important aspect of crop production. Any changes that may increase soil health must have an equal or greater economic impact on the overall farm economics. Economics of production were calculated with any additional costs above that incurred by NT management with no residue removed. Planting, seeding, herbicide and fertilizer management were similar for each of the practices. Only costs associated with tillage, residue harvesting and additional irrigation were calculated. Costs were estimated by utilizing Custom Rates for Colorado Farm and Ranches in 2013.

Total gross revenue in 2014 (Table 2) from grain only was greatest for T/R which was approximately \$7, \$28 and \$53 acre^{-1} greater than T/NR, NT/NR and NT/R respectively. After associated costs of tillage for preparation for planting were accounted for, net revenues for grain production in the T/R and T/NR without residue harvest were \$1 to \$8 acre greater than NT/R. The costs associated with tillage and increased irrigation reduced the difference to NT/R by approximately \$50 per acre.

Income associated with harvesting of the residue was \$90 acre^{-1} with residue yields of 2 tons acre^{-1} and a price of \$45 ton^{-1}. Costs associated with residue harvest accounted for \$97 acre^{-1} so the net return for harvesting of residue was approximately -\$7 acre^{-1}. Nutrient removal (Nebraska estimate) from residue is estimated at \$28.90 ton^{-1} for a net removal of \$57.80 acre^{-1}.

Table 1. Grain yields for 2014 and 2015 by tillage, residue management and nitrogen applications. Includes 2015 hail adjusted yields.

Tillage	Residue Mgt.	Grain Yield, Bushel Acre^{-1}			
		Nitrogen Rates			Average
		-50	Rec	+50	
2014					
No-Till	Residue	174.7	162.1	168.0	168.2
No-Till	No Residue	192.1	195.0	186.2	191.1
Tillage	Residue	187.3	188.5	192.7	189.5
Tillage	No Residue	202.6	191.4	194.3	196.1
2015					
No-Till	Residue	81.2	84.7	86.2	84.0
No-Till	No Residue	87.6	92.2	94.2	91.3
Tillage	Residue	99.5	96.4	102.5	99.5
Tillage	No Residue	98.3	102.3	93	97.9
2015 Hail Adjusted					
No-Till	Residue	232.0	242.0	246.3	240.1
No-Till	No Residue	219.0	230.5	235.5	228.3
Tillage	Residue	248.8	241.0	256.3	248.7
Tillage	No Residue	245.8	255.8	232.5	244.7

In 2015, hail damage reduced the grain yields more significantly in NT/R as compared to the other treatments. Economics of NT/R were less than that of NT/NR and T/R by \$23 and \$7 acre^{-1} respectively but equal to T/NR. Residue harvest did not significantly increase total returns in 2015 because of the costs associated with residue harvest were equal to the potential income. If yields were adjusted for hail damage, NT/R was significantly better economically than all other treatments by \$41 to \$60 acre^{-1}. With reduced corn prices, lower yields with significantly reduced expenses are justifiable economically.

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 2014, year 1 of tillage conversion, steady state infiltration was significantly better when residue remained in the field no matter the tillage management. However, potential changes in soil structure due to reduced tillage in 2015 showed that tillage significantly reduces the steady state infiltration beyond 30 minutes of water application. Long time period precipitation or irrigation events can have potentially significantly greater runoff potential when tillage occurred as compared to no-till management.

Economics of these tillage and residue management practices is greatly dependent upon the prices of residue. When values are low as with 2015 at harvest, the costs associated with harvesting of residue was equal to the value of that reside. However, potential changes in soil infiltration are not factored into the value of the residue in decreased evaporation or potential changes in infiltration.

Table 2. Economics of tillage and residue management for 2014 and 2015 with adjusted grain yields in 2015. Values are dollars per acre.

			Income			
Tillage	**Residue Mgt.**	**Total Expenses**	**Grain**	**Residue**	**Total**	**Net Revenue**
2014						
No-Till	Residue	$ -	$ 588.84	$ -	$ 588.84	$ 588.84
No-Till	No Residue	$ 97.00	$ 668.78	$ 150.00	$ 818.78	$ 721.78
Tillage	Residue	$ 51.00	$ 663.21	$ -	$ 663.21	$ 612.21
Tillage	No Residue	$ 142.00	$ 686.46	$ 150.00	$ 836.46	$ 694.46
2015						
No-Till	Residue	$ -	$ 294.00	$ -	$ 294.00	$ 294.00
No-Till	No Residue	$ 91.00	$ 318.50	$ 90.00	$ 408.50	$ 317.50
Tillage	Residue	$ 45.00	$ 346.50	$ -	$ 346.50	$ 301.50
Tillage	No Residue	$ 136.00	$ 339.50	$ 90.00	$ 429.50	$ 293.50
2015 Hail Adjusted						
No-Till	Residue	$ -	$ 857.50	$ -	$ 857.50	$ 857.50
No-Till	No Residue	$ 91.00	$ 798.00	$ 90.00	$ 888.00	$ 797.00
Tillage	Residue	$ 45.00	$ 861.00	$ -	$ 861.00	$ 816.00
Tillage	No Residue	$ 136.00	$ 854.00	$ 90.00	$ 944.00	$ 808.00