Environmental Influences on Conservation Tillage Adoption in the Central U.S.

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Abstract

Conservation tillage provides many benefits to soil including reduced soil erosion, increased soil fertility, increased soil moisture and improved soil physical properties. However conservation tillage is not widely adopted by producers, possibly due to precipitation, temperature, soil properties or other environmental factors that could negatively affect crop yields. A literature review of long-term tillage trials was conducted to compare crop yields from conventional and conservation tillage systems across a variety of environmental conditions. A statistical analysis was conducted to determine the relationship between yield trends and environmental conditions following adoption of conservation tillage. In the first phase of this analysis we evaluated the significance of changes in yields for several crops following adoption of conservation tillage. Yields did change significantly after conservation tillage adoption in corn, cotton, soybean, sorghum, sunflower and other small grains. In the second phase, we further investigated the relationship of these changes in yields to management and environmental conditions. We found that N fertilizer rate, climatic conditions and time since adoption all had significant relationships with yield trends following adoption of conservation tillage practices. Based on this study, crop yields can change with reduction in tillage intensity due to environmental factors. These changes can both enhance production and in some cases reduce production. Consequently managers may consider the affects of reducing tillage intensity on yields before adopting a conservation practice along with a variety of associated benefits such as improved soil tilth, carbon sequestration or reduced fuel use.

Introduction

Benefits of Reducing Tillage Intensity

- improves soil tilth
- reduces soil erosion by up to 90%
- increases organic matter
- conserves soil moisture
- requires less fuel and time
- potential to offset emissions of GHG through carbon sequestration
- reduces run-off of soil and agricultural chemicals into surface water

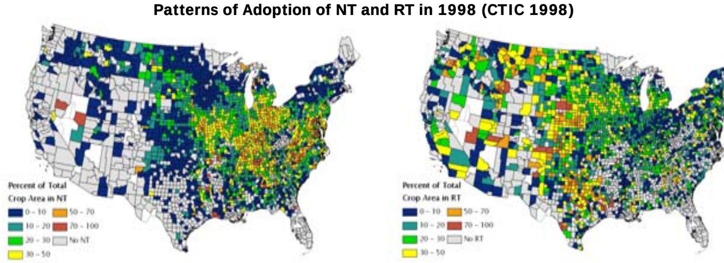
Conservation Tillage Adoption Rates

Only 22.6% cropland acres in no-till in 2004

almost 40% in intensive tillage in 2004

Some studies have found that climate, soil factors, weed infestation and disease may reduce yields in reduced- and no-till systems, and influence adoption rates (Linden et al. 2000, Iragavarapu and Randall 1995, Hill 2001)

Patterns of Adoption of NT and RT in 1998 (CTIC 1998)

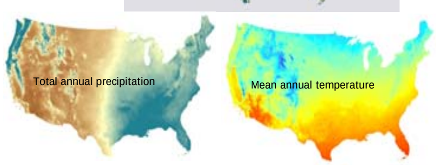


Objective: Determine environmental influences on conservation tillage adoption based on the assumption that the decision process is mostly directly affected by environmental and management interactions that change crop yields.

Methods

Comprehensive literature review of tillage experiments

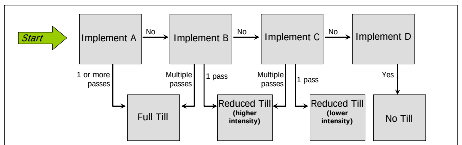
- any cropping system or experimental treatment
- ~ 90 study sites in U.S. and Canada
- > 2000 data points



Classification of tillage system:

Tillage intensity is estimated from mixing efficiency, which is the fraction of materials mixed uniformly by an implement, and depth of tillage. Tillage system is defined by implement group and number of passes.

Implement Group A
Moldboard plow, disk plow, disk chisel, twisted point chisel plow, offset disk-heavy duty, subsoil chisel plow, bedder disk-hipper
Implement Group B
Chisel plow, single disk, tandem disk, offset disk-light duty, one-way disk (disk tiller), heavy-duty cultivator, ridge-till, roto-tiller
Implement Group C
Sweep chisel, paraplow, sweep plow, stubble-mulch plow, light cultivators (row, field), rod weeder, light harrows, packers, harrows
Implement Group D
Planters, drills, fertilizer applicators



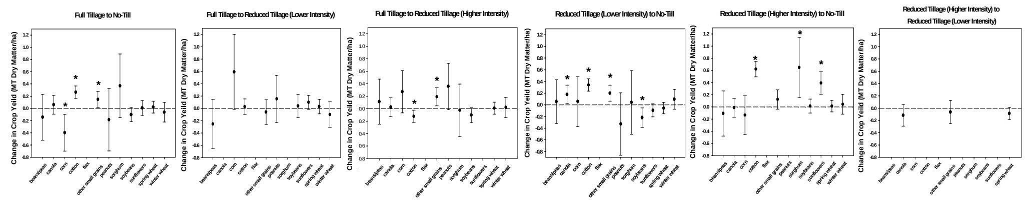
Statistical Analysis

Used linear mixed effect modeling approach (Pinheiro and Bates 2000) to analyze crop yield differences from the 90 tillage experiments.
Two stages were used in the analysis:

- **Stage 1:** Determine if yields differed following a reduction in tillage intensity for several crops (beans/peas, canola, corn, cotton, flax, other small grains (oats and barley), peanuts, sorghum, soybeans, sunflowers, spring wheat, and winter wheat).
- **Stage 2:** Determine if environmental and management effects significantly influenced the trends in yields for those crops that showed significant changes in yields following a reduction in tillage intensity (i.e., Stage 1). All tillage comparisons were controlled so that only the tillage practice differed between experimental paired plots. Variables were considered significant at an alpha level of 0.05.

Results

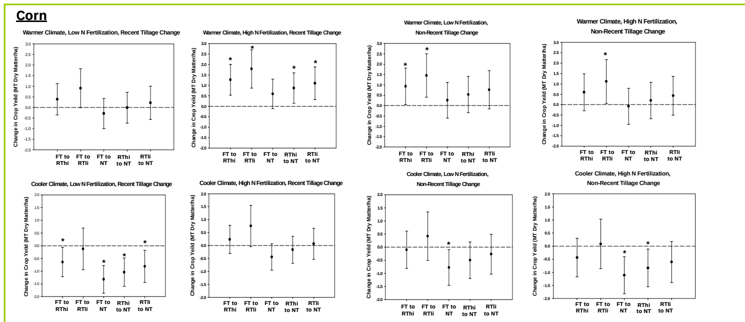
Stage 1: Predicted change in yield as a function of tillage change (Errors bars are a 95% Confidence Interval). Asterisks (*) designate confidence intervals that do not include no change (i.e., 0 MT Dry Matter/ha)



Corn, cotton, sunflowers, soybeans, sorghum and other small grains had confidence intervals for a subset of the tillage changes, suggesting that yields are influenced by tillage and possibly environmental conditions. In Stage 2, these influences were further investigated by evaluating yield differences due to climate, soil texture, hydric conditions, irrigation management, fertilization practice, years since the tillage change, residue management (i.e., removed or retained in the field), use of organic amendments and liming

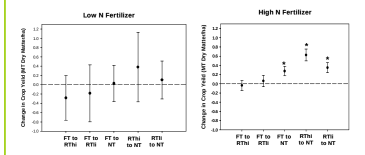
Stage 2: Predicted change in yield as a function of environmental conditions and tillage practice (Errors Bars are a 95% Confidence Interval). Asterisks (*) designate confidence intervals that do not include no change (i.e., 0 MT Dry Matter/ha)

Corn



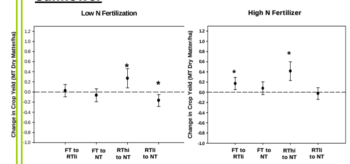
Note: Management and environmental conditions approximated as follows, warm climate = MAT of 20 C, cool climate = MAT of 5 C, low N fertilization rate = 25 kg/ha and high N fertilizer rate = 250 kg/ha, recent change = 2 yrs and non-recent change = 20 yrs. Acronyms: FT = Full tillage, RThi = Reduced Tillage (High Intensity, RTli = Reduced Tillage (Low Intensity), NT = No-Till

Cotton



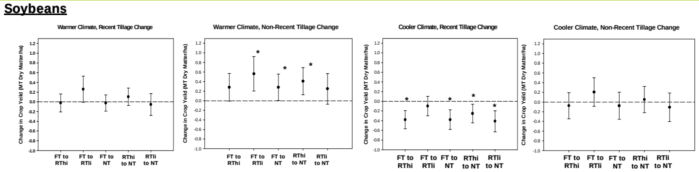
Note: Management and environmental conditions approximated as follows, low N fertilization rate = 0 kg/ha and high N fertilizer rate = 100 kg/ha. Acronyms: FT = Full tillage, RThi = Reduced Tillage (High Intensity, RTli = Reduced Tillage (Low Intensity), NT = No-Till

Sunflower



Note: Management and environmental conditions approximated as follows, low N fertilization rate = 35 kg/ha and high N fertilizer rate = 100 kg/ha. Acronyms: FT = Full tillage, RThi = Reduced Tillage (High Intensity, RTli = Reduced Tillage (Low Intensity), NT = No-Till

Soybeans



Note: Management and environmental conditions approximated as follows, warm climate = MAT of 15 C, cool climate = MAT of 15 C, recent change = 2 years and non-recent change = 20 years. Acronyms: FT = Full tillage, RThi = Reduced Tillage (High Intensity, RTli = Reduced Tillage (Low Intensity), NT = No-Till

Conclusions

- In general, climate, fertilizer and time since adoption of conservation tillage have an influence on crop yields.
- If yields change following adoption, the production tends to increase for crops grown in warmer climates, and decrease in cooler climates.
- A crop production system with high N fertilizer rates will tend to have higher yields with conservation tillage adoption, or remain unchanged.
- A crop production system with low N fertilizer rates will tend to have lower yields with adoption of conservation tillage, or remain unchanged.
- Yields tend to increase over time following adoption of conservation tillage or remain similar to the previous tillage management system, with the exception of corn production systems with higher N fertilization levels.

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Acknowledgements

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