

Agricultural Management Options for Climate Variability and Change: Conservation Tillage¹

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This series of EDIS publications provides information about different agricultural management options available to improve resource-use efficiency and adapt to climate variability and change. To see the complete series of publications, visit http://edis.ifas.ufl.edu/topic_series_agricultural_management_options.

Introduction

Adapting to climate variability and change can be achieved through a broad range of management alternatives and technological advances. While decision making in agriculture involves many aspects beyond climate, including economics, social factors, and policy considerations, climate-related risks are a primary source of yield and income variability. Existing strategies can help producers minimize the risks associated with climate variability and change as well as improve resource-use efficiency. This series of EDIS publications gives information on these existing technologies, and this publication focuses on the use of conservation tillage in crop production systems.

What is conservation tillage?

The USDA-NRCS (United States Department of Agriculture, Natural Resources Conservation Service) defines conservation tillage as a system that leaves enough crop residues from cover crops and/or cash crops on the soil surface after planting to provide at least 30% soil cover.

Research has identified 30% soil cover as the minimal amount of residue needed to avoid significant soil loss, but greater residue amounts are preferred. The use of cover crops is critical to producing this additional plant residue. In addition to maximizing surface residues, conservation tillage can increase below-ground disruption to eliminate compacted soil layers by maintaining plant roots and soil macropores. While conservation tillage can resolve the occurrence of a shallow plow-compacted layer in some systems, subsoil tillage may be required in some soils to manage compaction from vehicle traffic or from naturally occurring compacted layers. Together with cover crops, conservation tillage has the potential to reduce erosion, increase rainfall infiltration, reduce subsurface compaction, and maximize soil organic carbon (SOC) accumulation, which positively affects many soil physical and chemical properties.

Conservation tillage includes the following practices:

- **No-tillage or direct seeding:** In this system, the only soil disturbance is from the coulters or disk openers of direct seeding equipment.
- **Strip tillage:** A narrow seed bed is tilled prior to planting, exposing some soil. This can result in the beneficial warming and drying of a seed bed.

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- **Ridge tillage:** Soil is mostly undisturbed, and planting is done on established ridges. Some residues on the ridge tops are removed at planting by equipment sweeps or shoes to prepare the seed bed.



Figure 1. Erosion resulting from concentrated flow in a cornfield. Credits: Lynn Betts



Figure 2. Cotton under conservation tillage; soil is completely covered by corn crop residues, protecting against soil erosion and non-beneficial evaporation. Credits: David Nance

How does conservation tillage reduce climate-related risks?

The main way that conservation tillage can reduce risks related to climate variability (particularly droughts and dry spells) is by increasing the water available to plants. Conservation tillage alters the soil water balance at the surface, which accounts for much of the reduction in potential risk from climate change and variability. Compared to areas where conventional tillage is used, agricultural areas where conservation tillage is used will show the following changes in the water balance:

- Reduced erosion and runoff
- Increased water infiltration
- More plant-available water
- Reduced soil water evaporation
- Reduced diurnal temperature fluctuations

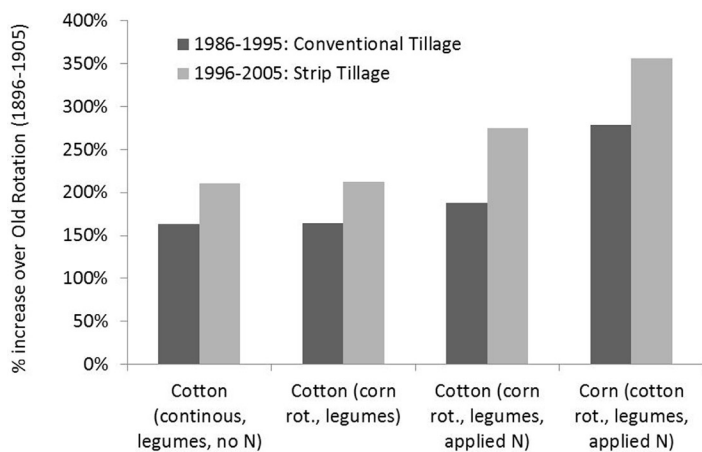
Conservation tillage has greater impacts on erosion rates than on runoff and infiltration (Leys et al. 2010). The decline in soil quality that accompanies erosion can reduce the productivity of agricultural land (Montgomery 2007). Erosion can reduce the water-holding capacity and other important properties of soils, making agriculture on eroded soils more susceptible to climate-related risks. Conservation tillage can slow the runoff of excess rainfall and increase infiltration by maintaining residue cover at the soil surface. Residue cover can also decrease daily soil temperature fluctuations, soil water evaporation, and soil crusting that can limit rainfall infiltration. Increased plant-available water, resulting from improved soil organic carbon near the surface, increases the efficiency of rainfall and/or irrigation events, conserves water resources, and reduces irrigation energy costs.

What are the agronomic benefits?

- Reduced soil compaction by avoiding plow pan
- Lower rates of soil loss
- Increased root growth
- Enhanced nutrient/water uptake and improved nutrient cycling
- Reduced yield variability, resulting from rainfall infiltration increases



Figure 3. Cover crop rolling and strip tillage in preparation for planting; note the substantial plant residues maintained on the soil surface. Custom roller/strip-till unit by Myron Johnson of Headland, AL. Credits: Brian Kahn



Three selected cotton treatments and one corn treatment

Figure 4. Percent increase in cotton and corn yields (for the 10 years from 1986-1995, and the 10 years from 1996-2005, compared to the first 10 years of the “Old Rotation,” from 1896-1905) of four treatments under conservation (strip tillage) and conventional tillage. Note the significantly greater yield increases for conservation tillage treatments. Credits: Data from Mitchell, Delaney, and Balkcom 2008; Figure by Dan Dourte.

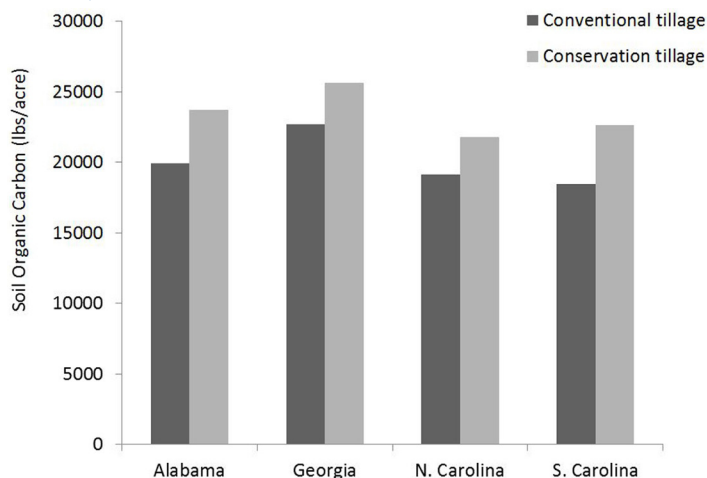


Figure 5. Soil organic carbon in agricultural areas under conventional and no tillage (conservation tillage) in four Southeastern states. There was an average of 20 sampling locations per state following an average of 10 years of tillage treatments. Credits: Data from Franzluebbers 2010.

What are the impacts on production costs?

- Table 1 highlights the benefits and costs associated with switching from conventional tillage cotton to strip tillage cotton under non-irrigated conditions.
- Production costs are site-specific and depend on current cropping methods and system characteristics.
- The costs and benefits in this table do not include potential yield changes or environmental benefits such as decreased soil erosion.

Table 1. Impacts on cotton production costs for a transition from conventional to conservation tillage.

Benefits (Decreased Annual Production Costs Per Acre)	Costs (Increased Annual Production Costs Per Acre)
Reduced machinery costs Fuel and Lube (-\$6) Repairs and Maintenance (-\$3) Reduced labor (-\$3) Reduced interest on operating capital (-\$1) Reduced fixed costs (-\$12) Total decrease in production costs (benefits) = \$25	Increased seeding rate (+\$8) Increased chemical use (+\$5) Total increase in production costs (costs) = \$13
Net Benefits = \$12 per acre	
Note: Impacts are based on South Georgia Crop Enterprise partial budgets (Smith, Smith, and Shurley 2011) for cotton. Fixed costs include machinery depreciation, taxes, insurance, and housing, as well as general overhead and management costs. A reduction in fixed costs assumes less machinery is maintained on-farm for conservation tillage compared to conventional tillage.	

What is the investment cost?

The two most popular conversion options are modifying existing equipment or purchasing new equipment specifically designed for conservation tillage. Modifications to planters and grain drills can be made to ensure sufficient down-pressure for cutting through residue and opening soil. Planter modifications can also be made to add clearing wheels or sweeps to remove some residue from the seed zone. Where subsoiling is required, splitter points can replace standard ripper points to reduce upheaval at the soil surface. Plastic shields on subsoiler shanks can reduce buildup of soil that can drag residues. The costs for potential modifications to subsoilers and planters are listed in Table 2.

Table 2. Investment costs for converting traditional equipment for applications in conservation tillage.

In-Row Subsoilers		Planters	
Splitter points	\$31/row	Down-pressure springs	\$39/row
Polyshields (cover and shin)	\$69/row	Seed firmers	\$31/row
Toolbar Extension	Variable	Spoke closing wheels	\$110 – \$238/row
		V-slice inserts	\$26/row

An example of per-acre investment costs to transition from conventional to conservation tillage: new subsoiler + planter = \$43,700; 10% at purchase, 5 yr. note at 8% = \$9850.45/yr ÷ 425 acres = \$23.18/acre.

What are the impacts on greenhouse gas emissions?

Conservation tillage can directly reduce carbon emissions of a farming system by reducing fuel use. The reduction in fuel consumption for tillage depends on the amount of subsoil tillage required and/or the reduction in the number of trips across the field needed to prepare the land for planting. Also, crop residues maintained on the soil surface can enhance soil carbon storage. Improved carbon sequestration under conservation tillage depends on the climate, management history, and soils of the system (Baker et al. 2007; Manley et al. 2005). However, soil carbon improvements in the Southeast United States have been shown to be generally consistent; an extensive review of conservation tillage impacts on soil organic carbon in the Southeast showed that a change from conventional to conservation tillage would sequester an additional 400 ± 35 lbs C/acre annually (Franzluebbers 2010).

What are the barriers and incentives for implementation?

Barriers

- Costs of new or modified equipment
- Trying something different

Incentives

- Decreased erosion, increased infiltration
- Increased plant-available water
- Government cost-share programs for equipment modifications and purchases (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip>)

Additional Resources

National Soil Dynamics Library: <http://www.ars.usda.gov/msa/auburn/nsdl>

Managing Cover Crops Profitably, 3rd edition: <http://www.sare.org/publications/covercrops/covercrops.pdf>

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