CONSERVATION TILLAGE IN GEORGIA: ECONOMICS AND WATER RESOURCES

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Abstract. Conservation tillage systems have proven effective in reducing soil erosion, but additional benefits to agricultural production, water quality and quantity, and on- and off-site impacts of water loss are often ignored. In spite of known benefits, no specific mention has been made of the use of conservation tillage in the development of the current statewide comprehensive water use plan. We estimate that water savings from the use of conservation tillage on cropland currently in conventional tillage could result in potentially enough water to support 2.8 million people annually in Georgia, and that off-site benefits associated with reduced erosion and improved water quality could be as great as $245 million annually. Based upon these potential benefits, conservation tillage needs to be considered in the formulation of the current policy to conserve and protect the state's water supply for the future. Conservation tillage warrants recognition as a cost-effective practice to conserve Georgia's water resources.

INTRODUCTION

During the late 1990's, drought and increased demand for water in both rural and metropolitan areas of Georgia highlighted the importance of water for the vitality of the state's economy. Rapid population growth along with an extended period of drought helped focus attention on the need to better manage this limited resource. In addition, Georgia's neighboring states of Alabama, Florida, and South Carolina were also experiencing similar population growth and increased demand for water. The collective effect resulted in legal disputes among states over water allocation rights such as the "Tri-State Water Wars" between Georgia, Alabama, and Florida (NESPAL, 2005). In response to the water resource challenges facing Georgia in 2001, Governor Roy Barnes and the General Assembly created the 23 member Joint Comprehensive Water Plan Study Committee and the 50 member Water Plan Advisory Committee. These committees have developed the framework for the state water management plan and identified actions the state should take to better manage water resources.

Agriculture has repeatedly been identified as the largest user of water in Georgia. Most of this water use is for irrigation of crops in the southern half of the state. The state's 0.5 million irrigated hectares receive an average of 193 mm of water or 319,418 million gallons annually or 875 million gallons per day (MGD) (Harrison, 2005). Although some of this water returns to the original source through ground water recharge, agriculture is considered a consumptive user of water. Application of improved agricultural technologies such as irrigation monitoring and scheduling, low impact flow systems, drip irrigation, and conservation tillage can help reduce these consumptive losses and should be encouraged as ways producers can contribute to improving water availability. However, much of the debate over mitigating the effects of agriculture on water availability have focused on irrigation related topics such as increasing irrigation efficiency or actual reductions in water use through purchasing of water rights. Little attention has been paid to the role that conservation tillage can play in improving water management. It is the purpose of this paper to delineate the potential for conservation tillage, particularly no-tillage, to increase water availability in the state.

CONSERVATION TILLAGE AS A TOOL FOR WATER CONSERVATION

Conservation tillage, defined as any planting practice or tillage operation that leaves at least 30% of the soil surface covered with crop residues, has long been recognized for it's ability to reduce soil loss from water and wind erosion (Langdale et al., 1992). The crop residues left on the soil surface in conservation tillage systems influence the water cycle through two main effects; increased infiltration and reduced evaporation. Crop residues protect the soil from the impact of raindrops, thus reducing soil crusting, and slow lateral movement of water, allowing it to infiltrate into the soil.

In a comparison of conventional tillage versus no tillage for Coastal Plain and Tennessee Valley region soils in Alabama, Truman et al. (2002) showed lowest runoff (highest infiltration) for no-till systems compared to conventional tillage. At rainfall intensities of 50 mm h^{-1}, runoff was reduced by greater than 57% with no tillage compared to conventional tillage in loamy sand soils like those of the Georgia Coastal Plains, and by greater than 31% in soils similar to those of the Georgia Piedmont. Similar results were demonstrated for a Georgia Piedmont soil where after one hour of simulated rainfall, infiltration rates were 47% greater for soil in no-till sorghum compared to conventional till soybean or sorghum planted into fallow (Bruce et al., 1992). Langdale et al (1992) showed that changing from a conventional tillage system to a conservation tillage system on the Georgia Piedmont could reduce rainfall losses to runoff from 16% to less than 2% during the summer growing season. The amount of residues on the soil surface can directly influence the amount of runoff and sediment loss. Using conservation tillage systems that retain 70% cover or more can reduce water losses by 50% or greater compared to conventional tillage (Hill and Mannering, 2004) (Table 1).

In 2004, farmers in Georgia planted 1.4 M hectares of field crops with about one-third or 0.5 M hectare being irrigated (Harrison, 2005). Of the irrigated land, cotton, peanuts, and corn comprised 52-, 28-, and 17%, respectively with soybean, small grains, and tobacco receiving the remaining percentages. For all crops planted in the state, conservation tillage was used on 41% of cotton, 36% of corn, 54% of soybean, 29% of small grains, 29% of sorghum, and 21% of remaining crops, which include peanut (CTIC 2004).

Table 1. Effects of Residue Cover on Runoff and Sediment Loss (from Hill and Mannering, 1995).

Residue Cover	Runoff	Runoff Velocity	Sediment in Runoff	Soil Loss
%	% of rain	ft min^{-1}	% of runoff	t ha^{-1}
0	45	26	3.7	30.7
41	40	14	1.1	7.9
71	26	12	0.8	3.5
93	0.5	7	0.6	0.7

Of the 3800 MGD used in Georgia, nearly 45% is used for agricultural production with 74% of this being applied to the major row crops grown in the state (Georgia DNR, 2005; Harris, 2005). No data is available for amounts of irrigated land with conservation tillage but assuming the percentages for all land are representative of the irrigated area, it is apparent that a significant portion of the irrigated area in the state could benefit from the use of conservation tillage.

Additional benefit from conservation tillage for water conservation could be achieved if this practice was used on the remaining 0.9 M hectares of field crops in the state. Mean annual rainfall is approximately 1270 mm statewide, but can vary by as much as 40% of the mean due to intense summer rain storms, and tropical disturbances between June and November (New Georgia Encyclopedia, 2005). Reducing runoff by 50% or greater with the use of conservation tillage practices statewide could reduce runoff from intense storms by 724 mm to 1013 mm annually. Assuming 50% of the annual rainfall statewide occurs during the growing season, and the intensity of 20% of the rainfall events are greater than or equal to 25.4 mm hr^{-1}, using conservation tillage on Georgia's 924,000 ha of cropland currently in conventional tillage would result in a total of 170.5 B gallons of water annually for infiltration instead of runoff. The water savings would not only translate into greater yields and potential for further improvements in soil physical properties due to the increase in soil carbon at the soil surface, but also increased ground water recharge.

According to the U.S. Census Bureau, Georgia's population has more than doubled since 1960. There were 8.2 million people living in the state in 2000, and statewide, the average water use per person is 168 gallons per day (Georgia DNR, 2005). This translates to 503 B gallons of water annually. A potential savings of 170.5 B gallons of water annually with conservation tillage translates to enough water to supply 2.8 M people or one third of the population. In addition, other benefits from the reduction of runoff would be the reduction in off-site impacts of sediment and impacts on water quality discussed below.

Additional economic benefits from conservation tillage can be estimated from reducing soil loss. Soil erosion results in soil degradation which limits infiltration and water storage and also causes a loss in soil productivity. Off-site impacts include eutrophication of watercourses and lakes, destruction of wildlife habitat, siltation of dams, reservoirs, rivers, and property damage by flooding (COST, 2004; ASAE, 2002; Robertson and Colletti, 1994). Currently agricultural cropland in the U.S. loses an estimated 4 x 10^9 tons of soil and 130 x 10^9 tons of water each year. This translates into an on-site economic loss of more than $27 billion, of which $20 billion is for replacement of nutrients and $7 billion for lost water and soil depth (Pimentel et al., 1995). The Natural Resources Conservation Service estimates that average erosion losses in the U.S. can be reduced from 27 t ha^{-1} y^{-1} with conventional tillage to 7 t ha^{-1} yr^{-1} with conservation tillage, a savings of 20 t ha^{-1} y^{-1} of soil. If soil erosion was reduced by 20 tons ha^{-1} yr^{-1}, at an estimated savings of $6.32 per ton of eroded soil, the value of conservation tillage associated with erosion reduction alone would be worth $177 ha^{-1} y^{-1}. The current benefit to water resources in Georgia from use of conservation tillage to control erosion is thus estimated at $83 million per year. The potential economic benefit from reduced erosion on Georgia's water resources as a result of conservation tillage adoption on all 1.4 M hectares of field crops could be as high as $245 million per year.

Nationally, the results of several studies indicate that the annual benefits from improving water quality could total tens of billions of dollars. Off site benefits of soil conservation programs aimed at reducing soil erosion have been estimated to be $340 million from the 1983 soil conservation program (Ribaudo, 1986) and $3.5 - $4.5 billion in surface-water quality benefits from the retirement of 40-45 million acres of highly erodible cropland through the Conservation Reserve Program (Ribaudo, 1989). Recreational water use benefits have been estimated at $300-$966 million for fisheries (Russell and Vaughan, 1982), $611 million for improved recreational use (Feather and Hellerstein, 1997; Feather et al., 1999) and about $29 billion for surface-water pollution control (Carson and Mitchell, 1993; Crutchfield et al., 1997). Water quality benefits from erosion control on cropland alone could total over $4 billion per year (Hrubovcak, et al., 1995).

Georgia farmers that have used a continuous conservation tillage system for several years frequently report that the quality of their soil has improved due to higher soil organic matter, reduced crusting, improved soil tilth, less soil erosion, and decreased runoff, all of which can result in improved production, crop quality, and water quality (Dean et al., 2003). Conservation tillage can result in significant reductions in erosion and water loss while improving the soil for agricultural production (Christensen, 1985).

In May 2004, the state of Georgia authorized the EPD to prepare a statewide comprehensive water plan by the year 2007 to address water conservation and long-term water needs. A wide range of water issues was to be addressed, including water allocation to farmers, industry and local government. In addition, legislation was enacted that mandated monitoring (metered) of all farm uses of water by the year 2009. There are several programs and policies in effect for Georgia addressing the amount and types of irrigation that farmers use in order to conserve water resources (NESPAL, 2004; USDA-NRCS, 2004). None of these promote the use of conservation tillage directly as a practice to reduce water use. Other Federal programs such as EQIP (USDA-NRCS, 2004) and state legislation recently enacted to preserve and protect greenspace through public and private land acquisition address the importance of land conservation practices to protect air and water resources (GLCPP, 2004).

The state's goal for improving water use through the implementation of a comprehensive water use plan is to protect the health, safety, and welfare of the public. Georgia farmers have been asked to contribute to achieving this goal through conservation of on-farm water use. A greater contribution to this goal could be obtained if the policies implemented by the State recognized the role that conservation tillage can play in reducing water use and on- and off-site impacts from water-eroded soil. The benefits to the state would reach beyond the need for water to include improved water quality through reduced nonpoint source pollution in runoff from land into streams and lakes.

CONCLUSIONS

In spite of the available knowledge and the programs to promote conservation tillage in the state, no specific mention has been made of the use of conservation tillage in the development of the current statewide comprehensive water use plan. Based upon the known benefits of conservation tillage to agricultural production, soil and water quality and quantity, and on- and off-site impacts of water loss due to erosion from conventional tillage systems in Georgia and nationwide, conservation tillage needs to be considered in the formulation of the current policy to conserve and protect the state's water supply for the future.

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