TILLAGE-BASED WATER CONSERVATION ON FARMS IN THE SOUTHEASTERN UNITED STATES

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Abstract. Conservation tillage, particularly no-till, has a significant role to play toward achieving agricultural water conservation goals envisaged in Georgia's Comprehensive Statewide Water Management Planning Act of 2004. We base this on scientific evidence from across the country and our own research showing that conservation tillage allows substantially more of rain and/or irrigation water to infiltrate/percolate into the soil compared to conventional tillage methods, thus reducing much runoff waste.

In one study spanning May 1, 1997 to May 5, 1998 near Watkinsville, GA, we found an extra 6.93 inches of rain water infiltrated into the soil profile in a no-till cotton/rye system compared to conventional tillage. This represents 14% of the average annual rainfall and is equivalent to more than 188 billion gallons of water from one million acres of cropland, which is about a third of Georgia's harvested cropland. Annual irrigation use in Georgia fluctuates between 100 and 300 billion gallons. Additionally, conservation tillage reduces sediment that alters critical habitat and stream flow, and reduces non-point source contaminants that require additional assimilative capacity in those streams.

While the current agricultural water conservation plan rightly targets potential waste in irrigated agriculture through retrofitting irrigation system components, conservation tillage offers water conservation both in irrigated and non-irrigated agriculture. For this potential to materialize, aggressive leadership that provides both political will and appropriate resources is needed across all government agencies and non-government organizations (NGOs) involved in natural resource policy formulation, research, education, extension, and outreach.

INTRODUCTION

Georgia has close to 50,000 farms occupying about 10,750,000 acres of which close to 3,250,000 acres are harvested cropland (Georgia Statistics System, 2006). About 5,400 of these farms occupying about 1,550,000 acres are irrigated. Corn, cotton and peanuts account for about 1,150,000 acres of the irrigated lands (NESPAL, 2006). Average irrigation water use is estimated at about 1,100 million gallon per day (MGD). Based on data reported in the Georgia Statistics System (2006), irrigation water use appears to be strongly correlated to irrigated area according to the following quadratic relationship (Eq.1, adjusted $R^2 = 0.893$, $P<0.001$, df=155);

$$Y = 5.00\times10^{-2} + 5.03\times10^{-4} X + 4.5\times10^{-9} X^2 \quad \text{(Eq.1)}$$

where Y is average irrigation water use in MGD and X is irrigation area in acres. Harrison and Hook (2005) estimate annual irrigation water use to fluctuate between 100 and 300 billion gallons. Of total 6.5 billion gallons per day (BGD) withdrawal, 3.3 BGD is for thermoelectric power, 1.2 BGD for public supply, and about 1 BGD for industrial (Conserve Water Georgia, 2006).

With this amount of water use at stake, population growth and competition for water among economic sectors and regional states have raised the level of (at times acrimonious) debate over equitable distribution of this precious resource among stakeholders in Georgia and neighboring states. Georgia's population grew by 26.4% between 1990 and 2000, and is expected to reach 12 million in the next 25 years – an additional 3 million from current level (Carl Vinson Institute of Government, 2006). The drought during 1998-2002 has reaffirmed the cyclic nature of drought in the region. These facts are forcing planning agencies to move away from the traditional 'laissez-faire', due to the perception of plentiful available water, and reactive (response to crisis) approach to water resource planning, into one of proactive and long-term-based approach where the holistic look at water availability, use, reuse, conservation, and quality has become imperative.

Georgia is in the process of formulating a statewide water management plan following The Comprehensive Statewide Water Management Planning Act of 2004. There are four major water management objectives under consideration (Georgia Department of Natural Resources, 2006): minimizing withdrawals of water by increasing conservation, reuse, and efficiency; maximizing returns to river basins; meeting in stream and off stream needs for water; and protecting water quality. Agriculture is grouped with the sectors under consideration in the first objective of minimizing withdrawals. The draft plan recognizes some general approaches that have worked across the nation with regard to agricultural water conservation. These include: metering, on-site auditing, use of reclaim water, use of assessment of new technology, and best management practices (BMP) to reduce evaporative water loss. These BMPS consist of such things as irrigation scheduling, low drift nozzle retrofit, micro irrigation, drip irrigation, timers, automatic shut off valves, and mulches and/or cover crops.

It is the mulch and/or cover crop side of agricultural water conservation that this paper addresses. Research has clearly demonstrated in many areas across the United States that conservation tillage enhances infiltration in irrigated and non-irrigated croplands. This enhanced infiltration allows water that would otherwise be lost to be stored in the soil and aquifer below. Potentially this water can reduce needs for supplemental irrigation, as well as continually recharging aquifers. A Texan who has been farming for 41 years cut his water usage in half following conversion to conservation tillage (10 years) (NRCS, 2006). We believe the visibility of conservation tillage as a best management practice in the water management plan ought to be much greater than it currently is.

CONSERVATION TILLAGE

Soil tillage (inversion) using farm equipment such as moldboard plow, and disk plow and harrow has traditionally been considered a part, often a prerequisite, of crop farming across the world. At the same time humans have learned the hard way that excessive soil tillage destroys organic matter and soil structure leading to negative impact on soil physical, chemical and biological quality needed to sustain food and fiber production – a challenge to meeting the globally rising per capita consumption. In response, alternative tillage practices have been developed and are being adopted globally. One such alternative is conservation tillage, an umbrella term that encompasses four interlinked management practices: minimum or no soil disturbance, permanent residue cover on 30% or more of the surface, direct sowing, and sound crop rotation. No-till is one such practice where zero-tillage is adopted. During the previous two decades no-till has expanded to some 148 million acres of land worldwide (Pieri et al., 2002). In 2004 40.7% of the USA (112.6 million acres) of all cropland was planted in conservation tillage with no-till comprising 22.6% of total cropland (CTIC, 2005). These data suggest that the system is getting significant acceptance at the level where it matters most – the farmer/producer.

A recent survey of farmers in Latin America reveals primary reasons for adoption of no-till as being, labor saving, time saving, erosion control, higher income, and higher yields, in that order (Pier et al., 2002). A number of significant economic and environmental benefits associated with no-till have been used to promote adoption of no-till in the USA (Uri, 1999). A recent survey questionnaire (Shurley, 2006) found that of the 2004 Georgia cotton crop about 47% was in conventional tillage, 43% in strip tillage (tillage of only a 10 to 14 inches wide seed-bed area), 3% in no-till and 7% reduced-till. Producers rated labor savings (cost, time) as a primary reason for their decision to use strip-till and no-till, followed by availability of glyphoste resistant technology, reduced erosion, machinery savings (cost, time), conserving soil moisture, other cost savings, improved soil quality, crop protection from wind/sand, government incentives or cost-share, and higher yields, in that order. It is clear from these assessments that the value of conservation tillage in directly conserving water resources at farm, local, regional or national level has not yet been fully grasped or appreciated. Research across states and regions indicates, however, that no-till and other conservation tillage technology can lead to significant savings in water use and/or loss in crop production.

Endale et al. (2002) compared drainage from May 1, 1997 to May 5, 1998 from a no-till and conventional-till cotton/rye system near Watkinsville, GA. A total of 69.65 inches rain fell during the period. From this 69.65 inches, 52.44 inches was collected through drainage at the 3-ft depth. Approximately 30.2% of the 52.44 inch rainfall was measured as drainage in no-till compared to 16.9% in conventional tillage. An extra 6.93 inches of the rainfall infiltrated into the drainage zone in the no-till. The 67-yr average annual rainfall in Watkinsville is 49.12 inches. Therefore, additional rain water, equivalent to 14% of the mean annual rainfall, infiltrated into the soil in the no-till. In Georgia in 2000, a dry year, typical irrigation amounts were 13-14 inches for corn, 8-12 inches for cotton and peanut, and 6 inches for soybean (Harrison and Hook, 2005). One inch of water on one acre of farmland is equivalent to 27,156 gallons. Hence 6.19 inch is equivalent to 188,300 gallons per acre. This translates to: 1,883,000,000 gallons from 10,000 acres; 18,830,000,000 from 100,000 acres; 188,300,000,000 gallons from 1,000,000 acres (1.88, 18.8, and 188 billion); and so on. As indicated above, Georgia has about three and a quarter million acres of harvested cropland of which about half is irrigated. It is not difficult to see the potential for water saving in Georgia agriculture if conservation tillage such as no-till is adopted in large scale. Georgia's estimated annual irrigation water use is between 100 and 300 billion gallons as indicated above. The per capita water use in

Georgia has fluctuated from about 168 gallons per year during normal weather years to about 155 gallons per year during drier years – close to the national average (Carl Vinson Institute of Government, 2006). Assuming a population of 9 million, this translates to 1.4 to 1.5 billion gallons per year. We can see how water conservation in conservation tillage such as no-till can translate into meeting the per capita need of the population too. Of course part of the extra drainage indicted above for no-till will be used by plants immediately or in subsequent periods but part of it will percolate to the groundwater to be released slowly at later times. Without the extra infiltration the water turns to runoff.

Similar data differentiating surface and subsurface hydrology of conventional tillage and conservation tillage plot and/or fields are reported elsewhere. Langdale et al. (1992) showed that a 6.5-acre Piedmont cropland lost 16% of the annual rainfall to runoff when cultivated conventionally. Runoff was reduced to less than 2% soon after conversion to no-till. Twenty-four years into the continuous no-till cultivation, the field continued to lose <2% of the annual rainfall (Endale et al., 2000) to runoff. As reported in Hendrickson et al. (1963), over a 20-year period (1940-59) a research plot near Watkinsville-GA of 7% slope and a slope length of 70-feet, on which conventionally tilled cotton has been grown each year, lost annually an average of 20 tons of soil per acre and 21% of the rainfall. Reeves et al. (2005) and Truman et al. (2005) cite several studies across southeastern U.S. that show that infiltration could be up to 50% higher in conservation tillage crops compared to conventionally tilled ones.

CONCLUSIONS

Conservation tillage practices, particularly no-till, have a significant role to play toward achieving agricultural water conservation goals envisaged in Georgia's Comprehensive Statewide Water Management Planning Act of 2004. While the current agricultural water conservation plan rightly targets potential waste in irrigated agriculture through retrofitting irrigation system components, conservation tillage offers water conservation both in irrigated and non-irrigated agriculture. For this potential to materialize, aggressive leadership that provides both political will and appropriate resources is needed across all government agencies and NGOs involved in natural resource policy formulation, research, education, extension, and outreach. The farming community has to be fully engaged in this commitment, so that it recognizes that the potential for water conservation through conservation tillage is as important as the savings in labor, energy and machinery costs that motivate large-scale adoption of conservation tillage in certain regions. For those that have yet to adopt the technology, we have to learn and understand why, so that we can embark on the necessary educational efforts to convince and empower them to do so. We can take lessons from approaches used by statewide organizations and agencies who are currently engaged in areas of water resource management: advocacy, educational outreach, funding or financial assistance, research and planning, technical assistance and others. We agree with the statement that "Conservation tillage pays for itself" often stated by proponents. Additionally, reduced losses of sediment and agricultural chemicals from erosion and runoff associated with adoption of conservation tillage provide a number of environmental benefits- including improved water quality in our streams, rivers and lakes with potentially favorable monetary and environmental impacts downstream.

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