BENEFITS OF CONSERVATION TILLAGE ON RAINFALL AND WATER MANAGEMENT

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Abstract. Agriculture represents an important economic sector in Georgia, with a gross farm income of 4.91 and 6.75 billion dollars in 02 and 03, respectively. However, agriculture is facing pressure to improve its efficiency because of global competition and population growth. Water is an integral component in agricultural production and farmers must use this resource as efficiently as possible. Conventional tillage systems, which disrupt the soil surface and bury large amounts of crop residue, typically lose up to 30% of received rainfall in the form of runoff. These tillage systems also decrease irrigation efficiency due to increased evaporation. Conservation tillage systems reduce soil disturbance and maintain crop residue on the soil surface which protects the soil from erosive forces, moderates soil temperature, provides weed control, improves infiltration, and reduces evaporation. Soils under conservation tillage have increased water storage capacity due to additional soil organic matter. Properly managed soils protect surface water (e.g. streams and lakes) because sediment transport through runoff is reduced. Conservation tillage benefits agriculture and helps protect our natural resources.

INTRODUCTION

Georgia is an important agricultural state. In 2003 Georgia lead the nation in broiler production, was second in egg, fourth in cotton and tobacco, and fifth in tomato production. Gross farm income in 02 and 03 was 4.91 and 6.75 billion dollars, respectively (Georgia Agricultural Statistics Service, 2004). Water is an important part of agricultural production. Most recent water use data for the state shows that in 2000 total water use was 6,439 million gallons per day; with irrigation ranking third (17.7%) in water use after thermo-electric power (50.4%) and public/domestic use (21.1%) (USGS, 2004). Plants need water to grow, but each species varies in the amount of water required (Table 1). Additionally, the time when plants receive water relative to their physiological development is crucial (Lamm, 2003; Plaut, 2003). Irrigation systems are used to supplement water needs of crops by supplying water when rainfall amounts are not sufficient. Total rainfall amounts for a specific year can seem normal, but the rainfall distribution during that year might not provide crops with the water they need at the right time during the growing season (Fig. 1).

Table 1. Water requirement of several crops to produce 1kg of food. (Adapted from Pimentel et al., 1997)

Crop	Amount of Water Needed
	---- liters ----
Potatoes	500
Wheat	900
Alfalfa	900
Sorghum	1,110
Corn	1,400
Rice	1,912
Soybeans	2,000

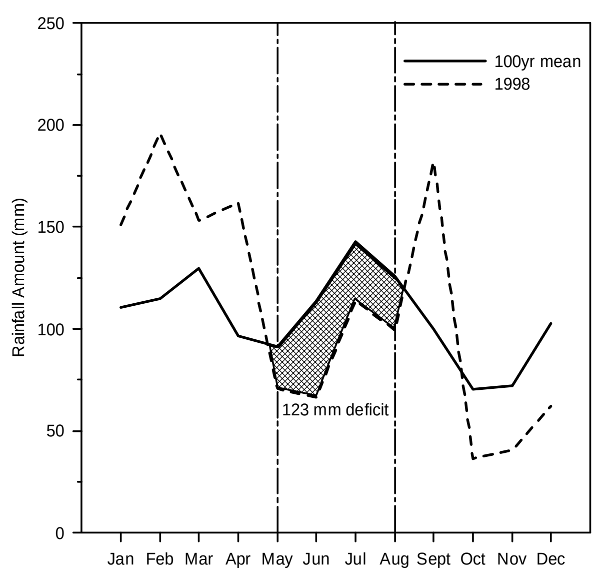

Figure 1. Rainfall distribution for Georgia. Notice that the total 100yr mean amount is 1,270mm and for 1998 the total amount was 1,333mm, but there was a rainfall shortage during the 1998 growing season (USGS data).

Crop yields are reduced if plants do not receive enough water. This is typically more pronounced in soils with reduced water retention capacity, which is often associated with low soil organic matter content. Most soils in the southeastern US are low in organic matter because of climatic conditions, but they also have been subjected to inversion tillage practices which promote soil organic carbon losses. However, there are other management practices that can help buildup soil organic matter. The objective of this manuscript is to provide a brief review on the benefits of conservation tillage as it relates to plant water use.

CONSERVATION TILLAGE

Conventional tillage practices disrupt the soil surface. This disruption tends to bury large amounts of plant residue present on the soil surface, thus leaving the soil exposed to rain drop action and more prone to erosion. Additionally, the mixing action of conventional tillage operations incorporates air into the soil, creating a flush of microbial activity which quickly decomposes organic materials and reduces soil organic matter content. Organic matter is an important soil component that improves soil physical properties, such as infiltration, soil structure, and water retention. Additionally, high levels of organic matter are often associated with improved soil quality (NRCS, 2001). Therefore, completely stopping or at least reducing soil surface disruptions would aid in increasing soil organic matter.

Many soils in the southeast, including Georgia, have subsurface consolidated soil layers. These soil layers impair root growth and effectively reduce the volume of soil crops can exploit for nutrient and water uptake. For this reason many farmers still utilize conventional tillage practices that loosen the growing profile near the soil surface. However, another alternative is available.

Conservation tillage systems frequently use non-inversion deep tillage to break subsurface consolidated soil layers while minimizing soil surface disturbances. These systems can be used in combination with cover crops, such as rye and wheat, to protect the soil from erosion during the winter months and to increase the amount of residue (biomass) on the soil surface. Soil organic matter is increased as this biomass decomposes. Cover crops can also increase water infiltration since they reduce soil crust formation and decomposing roots create channels where water can infiltrate. However, for organic matter to accumulate, surface soil disturbance must be minimized.

One form of conservation tillage does not rely on any tillage operations at all. This is often referred to as no-till. Long-term management of soils in a no-till, or some form of conservation tillage, will increase organic matter and improve soil physical properties (Fig. 2) (Endale et al., 2002; Baldwin et al., 1985; NeSmith et al, 1985). Other additional benefits include crop yield increases, decreased weed pressure, and runoff reductions under conservation tillage, therefore reducing non-point source pollution (Fig. 3). Work conducted in Georgia suggests that under conservation tillage irrigation amounts, and possibly frequency, could be reduced (Fig. 4). Conservation tillage systems can reduce evaporative water losses and increase water use efficiency (Lascano et al., 1994). However, these responses can vary from one year to another.

SUMMARY

Conservation tillage can increase water use efficiency by increasing infiltration, water retention, and reducing evaporation. Most of these benefits can be attributed to the use of non-inversion tillage implements that minimize soil organic carbon losses, and the use of cover crops that protect the soil surface and increase organic matter content in the soil. Although conservation systems have the potential to improve water use efficiency and possibly reduce irrigation needs, there are challenges ahead. Different soils and crops respond differently to certain

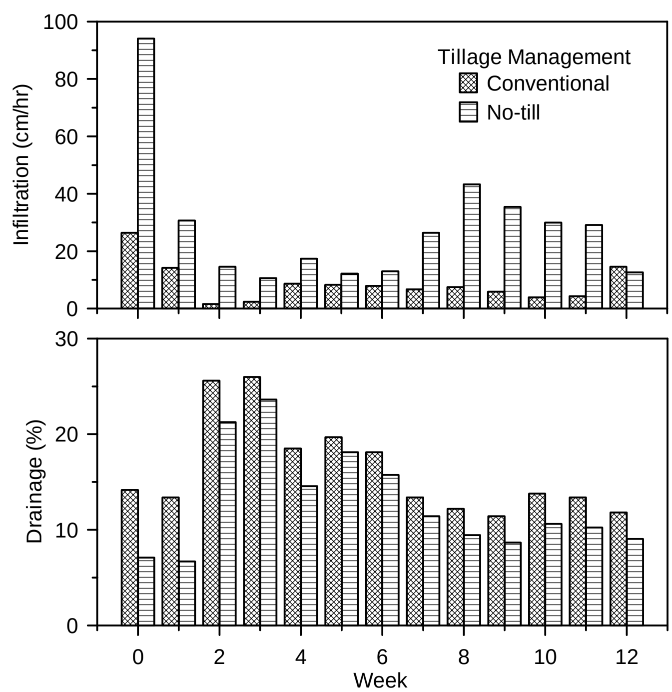

Figure 2. Water infiltration and drainage of a Georgia soil under long-term conventional tillage and no-till management during a 12-week period. No-till soil had almost twice as much organic matter as the conventional till. Drainage is expressed as percent fraction of total water added not retained in the soil after 20 hours. (Adapted from Franzluebbers, 2002)

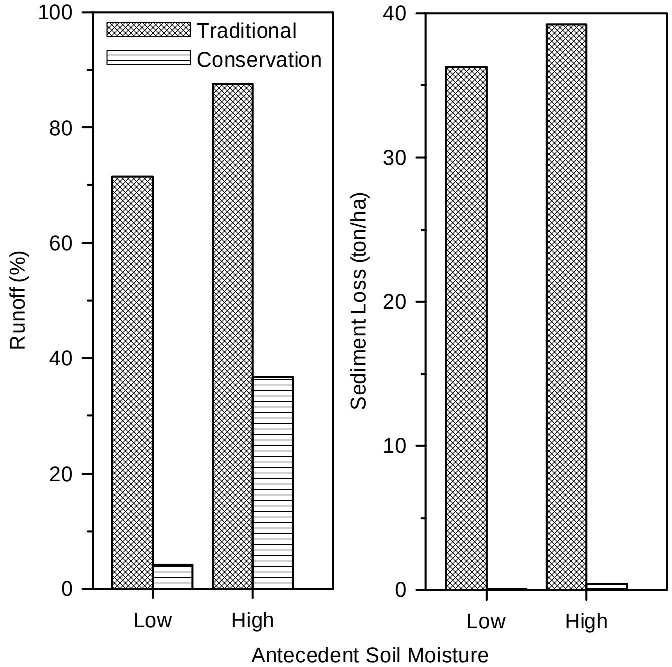

Figure 3. Runoff and sediment loss of a Piedmont soil in Georgia at two levels of antecedent soil moisture and two tillage management systems. (Adapted from Langdale et al., 1978)

management practices. Even slight changes in climate present challenges. There is no universal management system. Tillage and cover crop combinations need to be studied to determine how to integrate them effectively into management systems of cash crops to maximize their benefits.

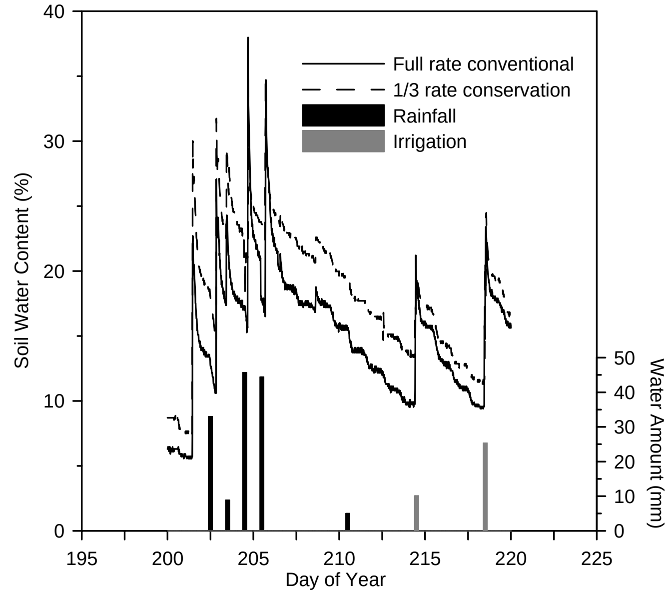

Figure 4. Water content of a soil receiving a typical full water rate from irrigation versus 1/3 of the full rate. (unpublished data)

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