2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

CONSERVATION SYSTEM IMPACTS ON COTTON WATER RELATIONSHIPS AND PRODUCTIVITY AT THE LANDSCAPE LEVEL

J.A. Terra
Department of Agronomy and Soils
Auburn University, AL and
National Institute of Agricultural Research (INIA), Uruguay
D.W. Reeves
USDA-ARS
J. Phil Campbell Sr. Natural Resource Conservation Center
Watkinsville, GA
J.N. Shaw, E. van Santen, and P.L. Mask
Department of Agronomy and Soils
Auburn University, AL
R.L. Raper
USDA-ARS
Soil Dynamics Research Unit
Auburn, AL

Abstract

The ultimate goal of site-specific agriculture (SSA) is to optimize inputs for agronomic and environmental benefits. Interactions of soils, landscapes, biological processes and management practices within fields results in significant spatial variability of crop yields. Yield spatial variability has been frequently related to soil properties and landscape features affecting plant available water holding capacity, drainage and aeration. Research in the southeastern USA has shown that conservation tillage systems with crop rotations incorporating high production of residues improve soil quality, crop water use efficiency and productivity. However, how these systems interact with soil variability across landscapes to impact cotton (*Gossypium hirsutum* L.) productivity has not been evaluated.

We evaluated cotton water relationships and productivity responses to soil management practices and their interactions with landscape and soil attributes in a 24-acre strip trial located in central Alabama at the Alabama Agricultural Experiment Station's E.V. Smith Research Center. Data for this study was collected in 2001 and 2002. Soils at the experiment are mostly Aquic and Typic Paleudults.

The field was divided into 496 cells of 60 × 20-ft; composite soil samples (12-in depth) were collected and analyzed for soil organic carbon (SOC) and texture at the beginning of the experiment in 2000. A soil survey (order 1 level), topography, and soil electrical conductivity (EC) maps were obtained and combined with SOC and soil texture information to delineate three potential management zones using cluster analysis.

Four treatments were established in a randomized complete block design (RCB) with 6 replicates in 20-ft wide strips traversing the potential management zones in a corn (*Zea mays L.*)-cotton rotation. Both phases of the rotation were present each year of the study. Treatments were a conventional system with (CTM) or without dairy bedding manure (CT), and a conservation system with (NTM) and without manure (NT). In CT and CTM, tillage consisted of chisel plowing/disking + in-row subsoiling; no cover crop was used in winter. The NT and NTM consisted of no-tillage with non-inversion in-row subsoiling and winter cover crops of a white lupin (*Lupinus albus L.*) and crimson clover (*Trifolium incarnaatum L.*) mix prior to corn and a black oat (*Avena strigosa* Schreb.) and rye (*Secale cereale L.*) mix prior to cotton.

Soil water content (12-in depth) was measured at 120 sampling cells using time domain reflectometry (TDR) two times a week during the critical 4-week period during bloom each year. At the same time, crop canopy temperature was obtained in the same cells using a handheld infrared thermometer in order to infer crop water stress. Additionally, leaf transpiration rate and stomatal conductance was measured with a LI-1600 steady state porometer in 48 of the sampling cells. Porometer measurements were made from upper-most mature single leaves from 5 individual plants per cell. Seed cotton yield was determined across the field with a spindle-harvester equipped with GPS and yield monitors during 2001 and 2002.

Yield was analyzed as a RCB but accounting for the spatial correlation using the modeled semivarigram. The rest of the variables were analyzed as a conventional RCB. The MIXED procedure in SAS was used for statistical analysis. For the overall mixed model, treatment (manure addition and management system), year and their respective interactions were considered to be fixed effects, while replication and interactions with treatments and year were random. For analyses within years, treatment and management X manure interactions were fixed effects whereas replication and replication X treatments were random. An F statistic with $P \leq 0.05$ was used to determine the significance of fixed effects.

The 2002 season had 50% less rainfall compared to the 2001 season during the critical period between first and peak bloom. As a result, soil water content, stomatal conductance, transpiration rates and consequently yields were significantly lower in 2002 compared with 2001. No clear significant effect of the manure application was found on stomatal conductance, canopy temperature or soil water content in either year.

On average during the 4-week measurement period of 2001, the conservation system resulted in higher stomatal conductance (18% greater), higher volumetric water content (15.6 % vs. 14.2 %) and lower cotton leaf canopy temperature (1.5 °F lower) than the conventional system. In 2002, these differences were even more evident and frequent: stomatal conductance (48% greater), soil water content (12.3 % vs. 9.9 %) and canopy temperature (2.5 °F lower) with the conservation system compared to the conventional system. The data implies that infiltration rate was higher in the conservation system than in the conventional system and clearly demonstrated the ability of the conservation system to minimize drought stress.

Seed cotton yield was significantly affected by soil management system in both years. No interactions were found between years and treatments despite yield being 50% lower in 2002. Cotton seed yield averaged 1320 lb acre^{-1} in 2002 vs. 2670 lb seed cotton acre^{-1} in 2001. Manure addition increased cotton yield by 7% in the conventional system but did not have any effect on yield in the conservation system. The NT and NTM yields (2120 and 2125 lb seed cotton acre^{-1}, respectively) were significantly higher than the CTM system (1925 lb seed cotton acre^{-1}); the lowest yields occurred with CT (1800 lb seed cotton acre^{-1}). Conventional systems (CT and CTM) yields were 10% lower than the conservation systems (NT and NTM) in the average rainfall year (2001) and 19% lower in the dry year (2002).

In 2001, both management systems had higher stomatal conductance values on zones of high yield compared with zones of low yield (70 % higher). Soil water content in conservation systems was lower in zones of high yields (15.3 %) than in zones of low yield (16.3 %), but in conventional systems no differences in soil water content were found between zones. The 2001 data suggest that infiltration rate was not only higher in conservation system than in conventional but also more uniform across the landscape. In the dry year 2002, both systems presented the lowest soil water content in zones of high yields and no significant differences on stomatal conductance between zones were found for either management systems.

Cotton yields were higher in the conservation systems than the conventional systems in all zones created both years. Significant statistical interactions between management systems and management zones (cluster analysis) were found. Averaged across years, yields with the conservation system in zones 1 and 2 were statistically similar (2170 lb seed cotton acre^{-1}) and higher than those in zone 3 (1960 lb seed cotton acre^{-1}). However, the conventional system showed a yield reduction in zone 2 (1790 lb seed cotton acre^{-1}) compared with zone 1 (2080 lb seed cotton acre^{-1}) and zone 3 (1620 lb seed cotton acre^{-1}) compared with zone 2 ($P \leq 0.05$). In the conservation system, manure applications did not affect cotton seed yield on any zone. In the conventional system, manure applications minimized yield reduction on zone 2 (1900 lb seed cotton acre^{-1}) and zone 3 (1770 seed cotton lb acre^{-1}) suggesting that manure amendments should be prioritized to degraded areas of the field presenting higher yield restrictions.

The conservation system had significantly higher stomatal conductance, soil water content and lower canopy temperature than the conventional system during blooming. These indicators of reduced water stress resulted in higher seed cotton yields in both years. These differences were more significant and frequent under increased stress conditions, suggesting that conservation systems have greater impacts in drier years and in field zones with lower yield potential. No clear effect from dairy bedding manure application was found on crop water relationships, but there was a greater trend for manure to affect yield responses in the conventional than the conservation system. Our data suggest for degraded soils in warm humid climates like those in the southeastern USA, that a conservation system including no-tillage and high-residue producing cover crops can minimize drought risk and increase cotton yield and yield stability. Additionally, in order to optimize inputs with site-specific management of cotton on these soils, we speculate that fewer and more simple management zones may be needed for conservation management practices than for conventional tillage practices.