NITROGEN AND IRRIGATION REQUIREMENTS OF COTTON IN A SOD-BASED ROTATION

Gueorgui Anguelov
David Wright
Jim Marois
Cheryl Mackowiak
University of Florida, IFAS-NFREC
Quincy, FL
Duli Zhao
USDA-ARS
Canal Point, FL

Abstract

The sod-based rotation is becoming an important part of conservation agriculture in the southeastern USA. Bahiagrass (*Paspalum notatum* Flugge) in rotation with cotton (*Gossypium hirsutum* L.) and peanut (*Arachis hypogaea* L.) has shown positive impacts on crop yields and economics. Integrating livestock/perennial grasses/cover crops with conservation-tillage and perennial grasses has also shown to benefit soil quality and crop productivity. Oats (*Avena sativa* L.) were grown as winter-cover crop between major crops in a 9-yr sod-based rotation with perennial grasses being in place for 2 out of every 4 years. Cattle recycle nutrients and keep nitrogen and potassium in the root zone for use by the following crop. Leaf water potential (LWP) was found to be lower, less stress, on winter forage, cotton and peanut when rotated with bahiagrass in 2008-2009 growing seasons. Soil nitrate levels were also found to be higher with grazing and in the sod based rotation as compared to the conventional rotation using annual cover crops alone. These data indicate that less nitrogen will be needed in the sod based rotation and even less where cattle graze either winter forage or the perennial grass.

Introduction

Irrigation is needed for high-yielding cropping conventional systems. Cotton is among the crops that respond to irrigation, especially during the blooming period (Katsvairo et al., 2009). According to Rhoads (2002) cotton needs up to 8 mm water per day in the southeastern US. Water deficit can have a negative effect on physiology, yield, and quality (Gerick et a., 1996; Zhao and Oosterhuis, 1997). Excess water in cotton-based crop rotations however, can also lead to problems such as increase crop vulnerability to insects and diseases or nutrient leaching, especially when irrigation is applied with higher fertilization rates. Nitrogen management is of upmost importance for high-yielding cotton systems (Gerik et al., 1998). Both N deficiency and excess can negatively affect lint yield and fiber quality. Insufficient N supply often reduces leaf area, photosynthetic rate, and biomass production in cotton (Zhao and Oosterhuis, 2000), resulting in low yield and poor quality (Heagle et al., 1999). However, yield of irrigated cotton is not always increasing with the increase of N fertilizer (Wood et al., 1992; Zhao et al., 2005); when N rate reaches a certain level, any further increase of N fertilizer may not improve or even limit lint yield if fruit abscission is increased due to insufficient light for example. Excess use of N fertilizer increases not only production cost but also the potential for ground water pollution. Galloway et al. (2008) highlighted that the fate of majority (65%) of nitrogen inputs to terrestrial biosphere is undefined and the uncertainty whether nitrogen is accumulated in soil, vegetation or groundwater remains large at every scale. Thus, nitrogen leaching from agricultural land is a major concern throughout the world including southeastern states. A winter cover crop is thought to be beneficial for conservation agriculture by decreasing soil run-off and recycling potential residual nitrogen (Zhao et al., 2009). The objective of this study was to assess the impact of conservation-till conventional and sod-based rotations on leaf water potential (LWP), nitrogen status, and cattle impacts.

Materials and Methods

A large scale rotation project of 2 years of bahiagrass followed by peanut/winter grazing and then cotton/winter grazing was initiated to determine the impacts of cattle traffic from a cow/calf operation on the following cotton crop. Crops grown in each of the quadrants in the rotation were bahiagrass-bahiagrass-peanut-cotton (B-B-P-C). Winter grazing is planted after both cotton and peanut. The study is under a 139 acre variable rate center pivot irrigation system with dry corners amounting to 40 acres in each quadrant. Three large exclusion areas, 16X16 meters square, were fenced off in the rotation scheme where cattle traffic was never allowed in the areas of bahiagrass, or winter grazing behind cotton or peanut. However, other normal agricultural operations such as cutting hay, winter grazing, or row crop planting were allowed and fences taken down for these operations. All crops were planted with no-till or conservation tillage methods. Areas outside exclusion cages were designated for similar measurements as within the cages. Plots were mapped with GPS coordinates so that fences could be erected in the same location after each crop sequence. Small replicated trials were accomplished at NFREC in Quincy and a conventional rotation of two years of bahia followed by peanut and then cotton were compared to two years of cotton followed by a single year of peanut using oat cover crops after each annual crop and conservation tillage methods of planting in both systems. Water status of crops were determined during the 2008-2009 growing season by leaf water potential (LWP) of uppermost fully expanded leaves was measured with a plant water status console (Soil Moisture Inc., CA); LWP was measured in a conventional cropping system as compared to the sod based rotation with conservation tillage methods used for planting both systems in 2008 and 2009 crops, as well as on oats during the winter. All production practices followed normal Florida extension guidelines.

Results and Discussion

Rainfall for NFREC Quincy is shown in Figure 1. Higher than normal rainfall occurred at times during the year and harvest was delayed in the fall due to excessive rainfall. Rainfall was similar at both Marianna and Quincy NFREC locations for 2009.

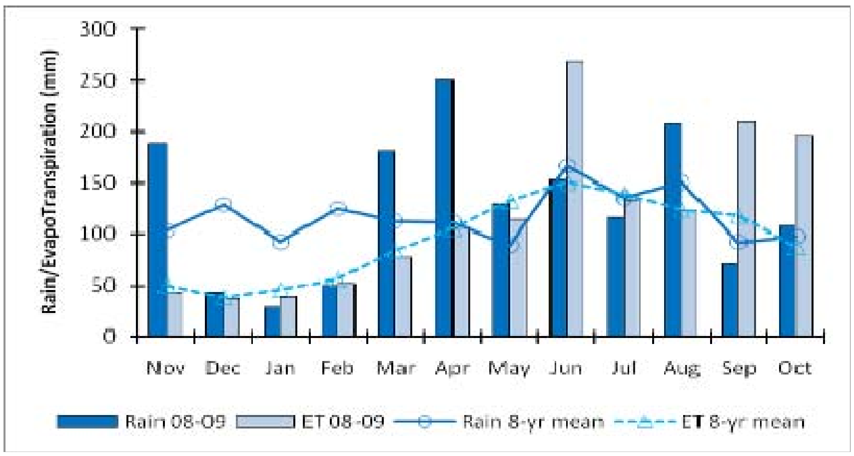

Figure 1. Monthly climatic water balance for NFREC-Quincy.

Cation exchange capacity of the soil was increased by grazing indicating recycling of nutrients in the root zone of the winter grazing prior to planting cotton. Non grazed areas had about 25% less CEC capacity as where cattle were allowed to graze the oat/rye winter forage (Fig. 2). Even though all plots were fertilized equally, cattle kept nutrients in the top 20 cm preventing leaching of nutrients below the root zone.

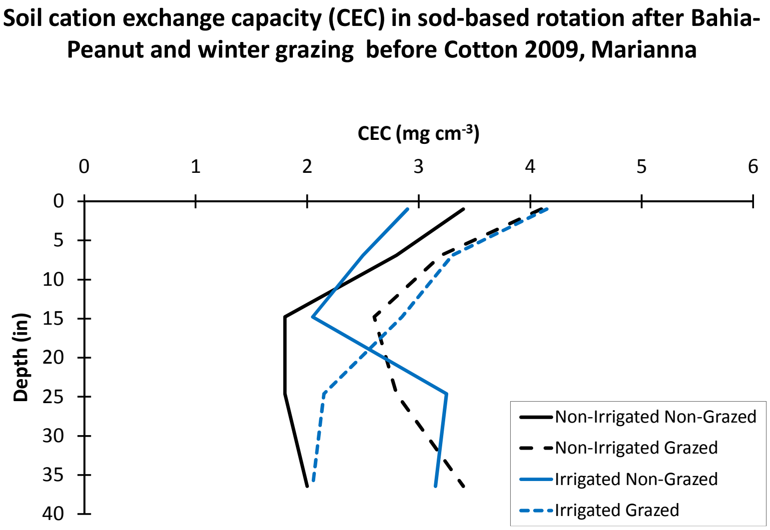

Figure 2. Soil cation exchange capacity with and without irrigation and cattle grazing winter forage in a sod based rotation.

Of special importance to producers in Florida is the fate of nitrates in crops as well as in the soil after harvest or prior to planting another crop. Figure 3 shows that cattle kept 2-3 times as much nitrates in the top 20 cm of the soil profile while nitrates in the irrigated plots had a tendency to move through the soil profile faster than in non irrigated sections. Irrigation can always results in needing more nitrogen since rainfall may occur immediately after an irrigation event. Nitrates move in soil solution and if excess water is drained through the soil profile nitrates will be moved with it can result in a nitrogen deficiency. Not only do cover crops help prevent nitrate loss but cattle can be an important component as well.

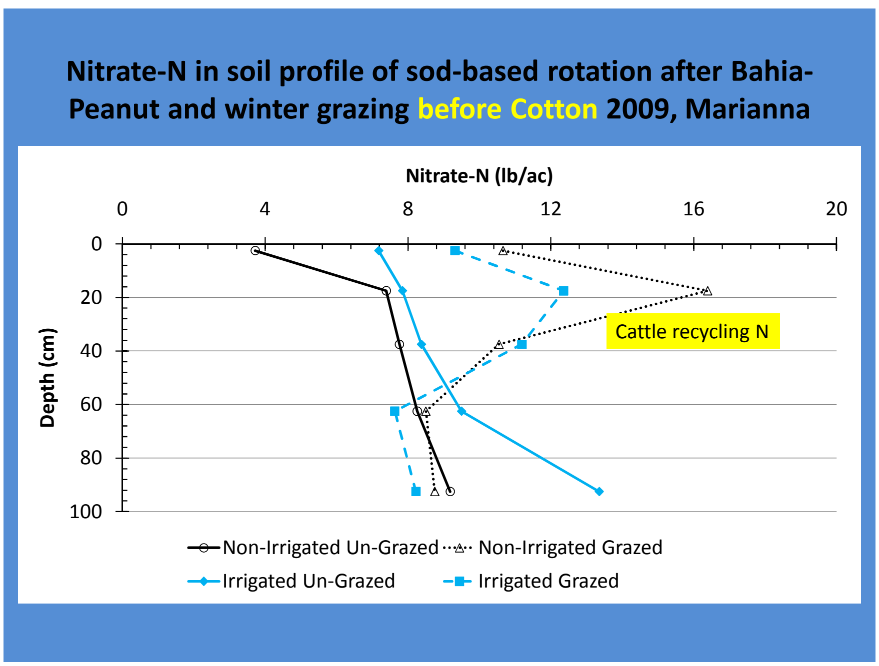

Figure 3. Nitrate nitrogen in the soil profile with and without irrigation and grazing

Without cattle at Quincy, the sod based rotated cotton had higher nitrate nitrogen at the beginning of the reproductive stage of growth but was depleted by the end of the season while the conventional rotation had some residual nitrate remaining (Figure 4).

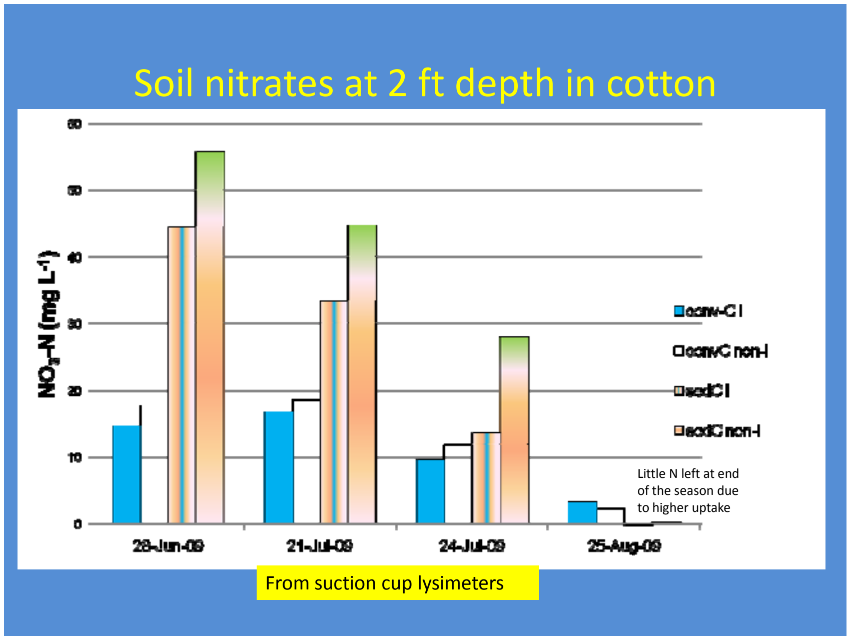

Figure 4. Nitrate nitrogen accumulated in suction cup lysimeters in cotton in a conventional system vs. the sod based cotton both irrigated and non-irrigated.

In dry years we have found that the sod based rotated cotton often does not reach stress levels that will trigger irrigation as compared to the conventional rotation. Cotton following sod actually showed slightly more stress but with the larger leaf area index and plant size noted in Figure 5, this is not unexpected. In 2009, leaf water potential from the two systems never reached the critical level of 1.5 MPa that would trigger irrigation for cotton with or without nitrogen fertilization. (Figures 6 and 7) since it was a good rainfall year for most crops.

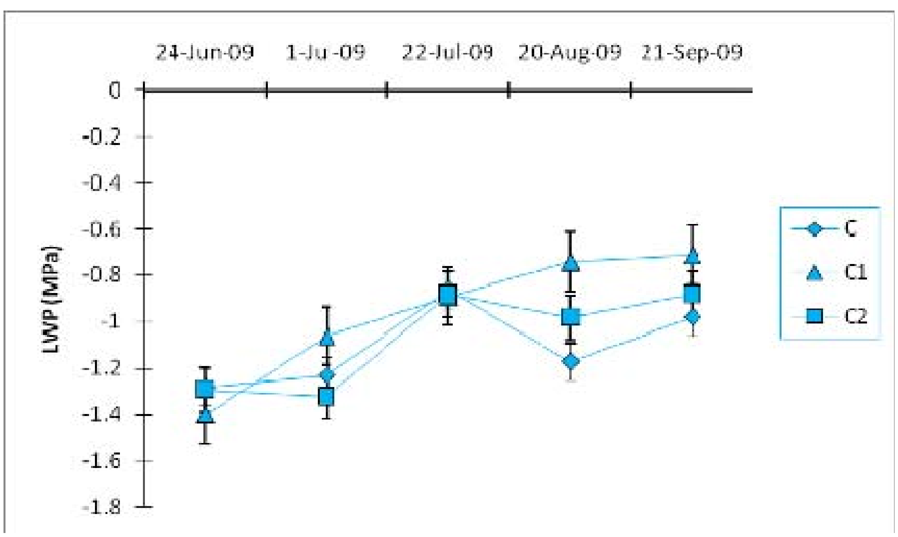

Figure 5. Leaf water potential of irrigated non-fertilized cotton (C-sod, C1&C2 1&2 year conventional).

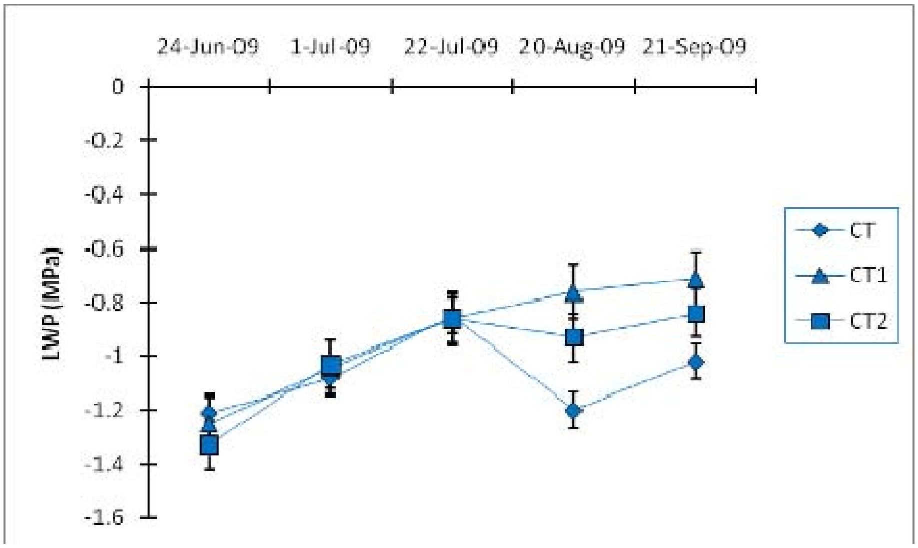

Figure 6. Leaf water potential of irrigated fertilized with N67cotton (C-sod, C1&C2 1&2 year conventional).

There was not as much difference in yield in 2009 between systems as we have experienced in past years (Figure 7). Although we did have an increase in yield due to nitrogen application, the sod based system did not have a significantly higher yield. This may have been due to a shorter season variety that cut out in mid August even with nitrogen application. The sod based system had not responded to nitrogen over the past several years due to the increase in organic matter that we had noted in that system and the use of Delta Pine and Land 555 cotton variety.

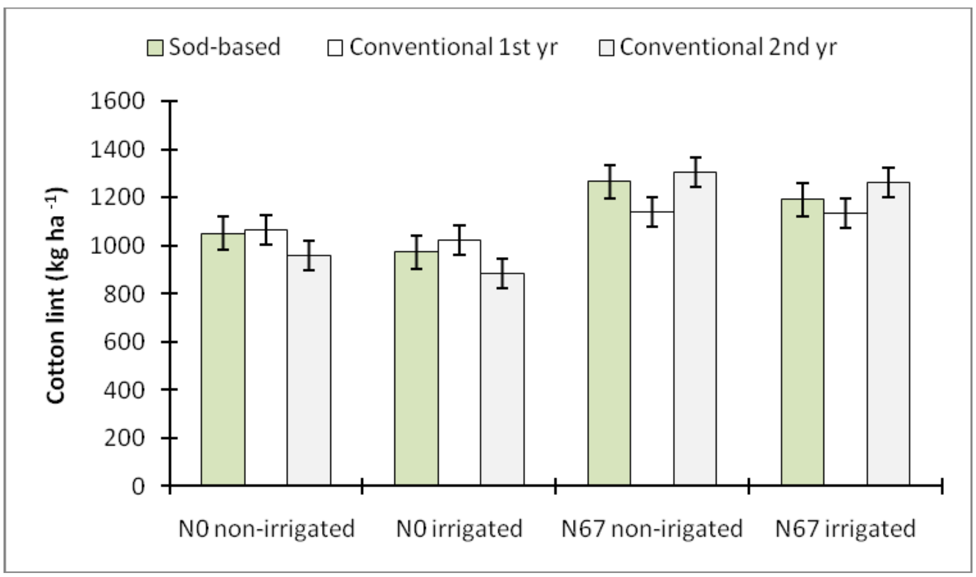

Figure 7. Cotton yield as influenced by nitrogen application and rotation system.

Summary

There is potential to reduce irrigation and nitrogen applications in the sod based rotation as compared to conventional conservation cropping systems. Cattle will recycle nutrients and the sod based rotation will conserve water, and improve crop-water and nitrogen-use efficiency. Winter forages help conserve nutrients or provide animal feed. Crops in the sod-based system generally have less water stress in both dry and wet years resulting in higher yields, efficiency and overall profitability.

Acknowledgement

Special thanks go to Brian Kidd, Ricky Beasley, Maynard Douglas, Chuck Dickson, Stoney Hall and Kelly O'Brien for assistance in the studies. This research was supported in part by cooperative research agreements with Cotton Incorporated, USDA/ARS, and Northwest Florida Water Management District.

References

Galloway, J. N., Townsend, A. R., Erisman, J. W., Bekunda, M., Cai, Z., Freney, J. R., Martinelli, L. A., Seitzinger, S. P. & Sutton, M. A. (2008). Transformation of nitrogen cycle: Recent trends, questions, and potential solutions. *Science*, 320, 889-892.

Gerik, T.J., K.L. Faver, P.M. Thaxton, and K.M. El-Zik. 1996. Late season water stress in cotton: I. plant growth, water use, and yield. Crop Sci. 39: 914-921.

Gerik, T.J., D.M. Oosterhuis, and H.A. Torbert. 1998. Managing cotton nitrogen supply. Advn. Agron. 64:15–147.

Karlen, D.L., G.E. Varvel, D.G. Bullock, and R.M. Cruse. 1994b. Crop rotations for the 21st century. Adv. Agron. 53:1–45

Katsvairo, T.W., D.L. Wright, J.J. Marois, J.R. Rich and P.J. Wiatrak. 2009. Comparative Plant Growth and Development in two Cotton Rotations under Irrigated and Non-Irrigated Conditions. Crop Science 49: 2233-2245.

Rhoads, F. 2002. Florida cotton production guidelines: water requirements for cotton. University of Florida, Institute of Food and Agricultural Sciences Extension. NFREC9 (http://edis.ifas.ufl.edu).

Wood, C.W., P.W. Tracy, D.W. Reeves, and K.L. Edmisten. 1992. Determination of cotton nitrogen status with a hand-held chlorophyll meter. J. Plant Nutr. 15:1435–1448.

Zhao, D., and D.M. Oosterhuis. 1997. Physiological responses of growth chamber-grown cotton plants to the plant growth regulator PGR-IV under water-deficit stress. Environ. Exp. Bot. 38:7-14.

Zhao, D., D. Wright, J. Marois, C. Mackowiak, and M. Brennan. 2009. Agr. Sustain. Dev. DOI: 10.1051/agro/2009045