Switchgrass Yield Response to Nitrogen on Four Soil Types in West Tennessee

***Christopher N. Boyer[1], Roland K. Roberts[1], Burton C. English[1], Donald D. Tyler[2], James A. Larson[1], and Vivian Zhou[1]**

[1] Agricultural and Resource Economics, The University of Tennessee, Knoxville, TN; [2] Biosystems Engineering & Soil Science and West Tennessee Research & Education Center, The University of Tennessee, Jackson, TN

BACKGROUND

- Nitrogen (N) fertilizer is needed to produce yields large enough to make growing switchgrass for biofuels economically viable.
- Yield-maximizing N rates for switchgrass have varied depending on spatial and temporal factors (Haque et al. 2009).
- Few papers have gone beyond estimating yield-maximizing N rates to estimate profit-maximizing N rates.
- Little is known about the influence of soil quality and landscape on switchgrass production (Fike et al. 2006).

OBJECTIVE

To determine the profit-maximizing: 1) N rates, 2) expected yields, and 3) net returns for switchgrass grown on four landscapes in Tennessee.

EXPERIMENT

Switchgrass yield data were obtained from experiments at the University of Tennessee Milan Research and Education Center at Milan, TN. Four landscapes were selected to represent the predominant landscapes found in West Tennessee:

1) a well-drained level upland (WDLU);
2) a well- to moderately well-drained flood plain (WDFP);
3) a moderate- to somewhat poorly-drained eroded sloping upland (MDSU); and
4) a poorly-drained flood plain (PDFP).

The WDLU and WDFP landscapes are well suited for row crop production in Tennessee while the MDSU and PDFP landscapes represent marginal land for crop production in Tennessee. More details about the landscapes can be found in Mooney et al. (2009).

A RCB experiment with a strip-plot arrangement of treatments and four replications was designed for each landscape. 'Alamo' switchgrass was established in 2004. In 2005, blocks were split into strips for N fertilization at four rates: 0, 67, 134 and 200 kg ha^{-1}. Plots were harvested annually following senescence from 2005-2011.

To find the profit-maximizing N rate, we assumed prices for switchgrass and N. Since there is no established market for switchgrass, the price of switchgrass was based on breakeven prices from the literature. We selected three prices of switchgrass: \$40, \$60, and \$80 Mg^{-1} (Mooney et al. 2009). The average price of N from ammonium nitrate from 2005-2011 was selected to be the price of N, \$1.30 kg^{-1} (USDA NASS 2011).

METHODS

The producer's objective was

$$\max_x E(\pi) = pE(y) - rx$$

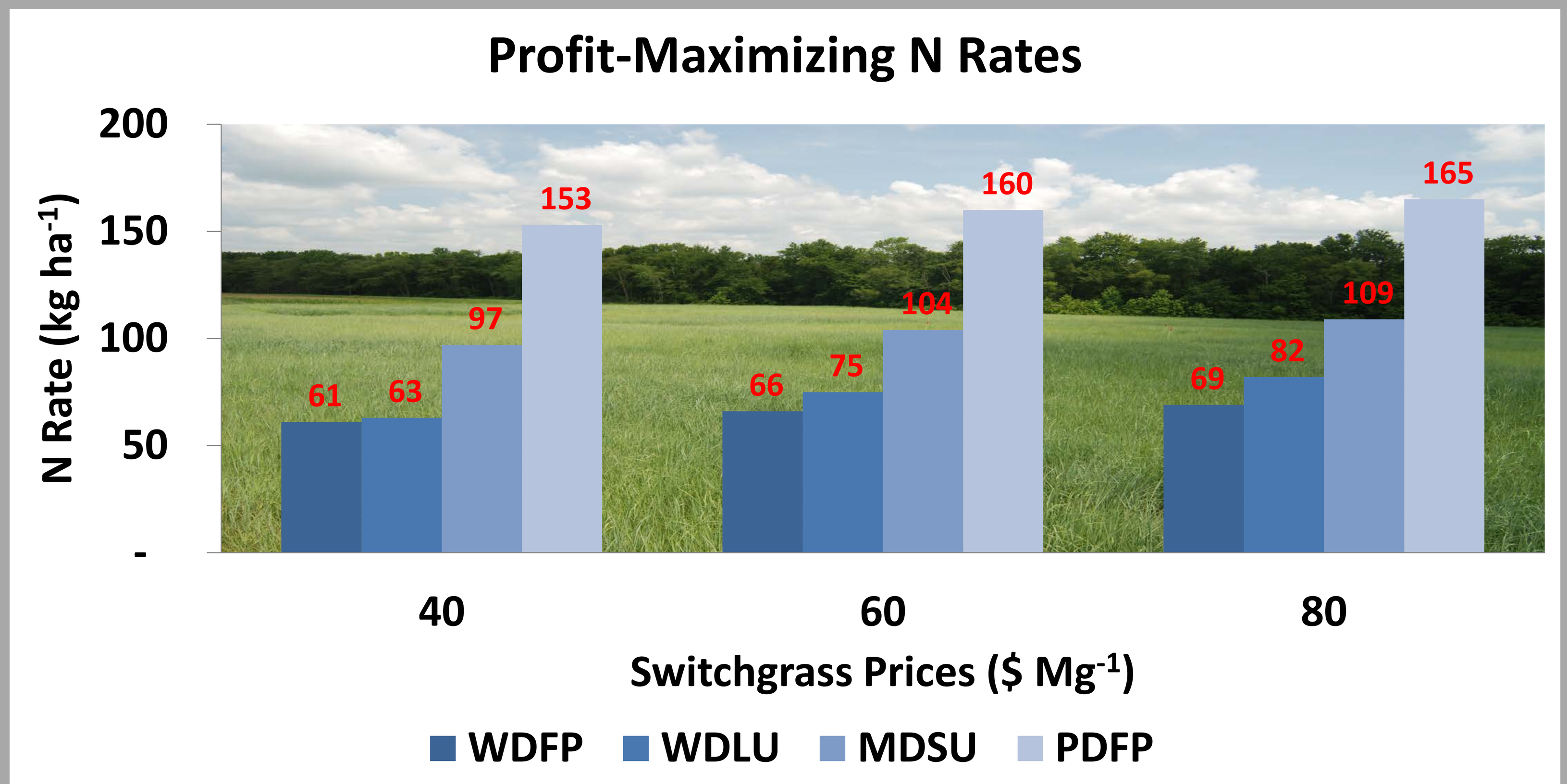
where $E(\pi)$ is the producer's expected net returns in \$ ha^{-1}; p is the price of switchgrass in \$ Mg^{-1}; $E(y)$ is the expected switchgrass yield in Mg ha^{-1} and is a function of N; r is the price of N in \$ kg^{-1}; and x is the quantity of N applied in kg ha^{-1}.

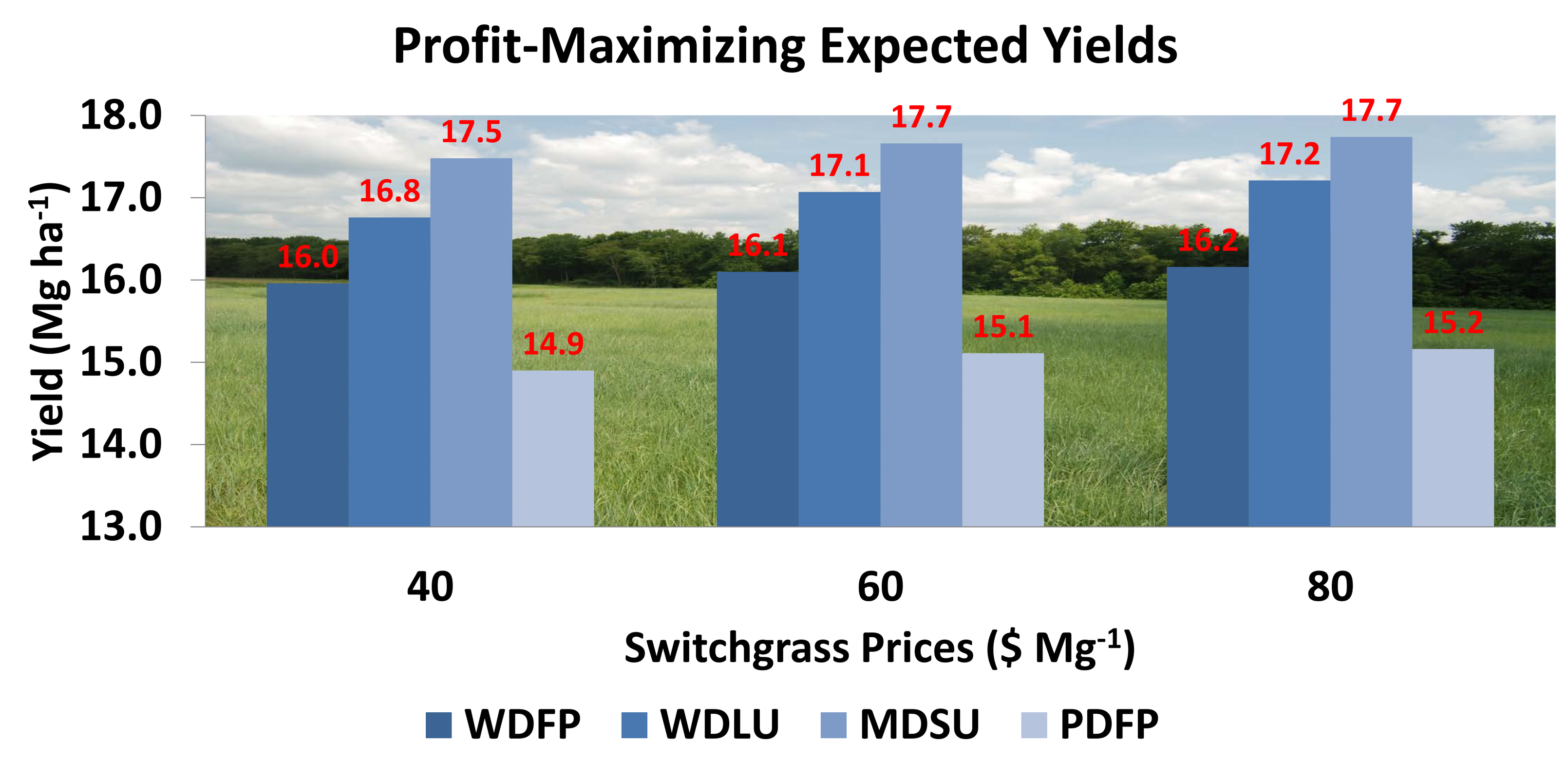
For each landscape, the yield response to N was modeled using Tembo et al.'s (2008) linear response stochastic plateau function. This response function was

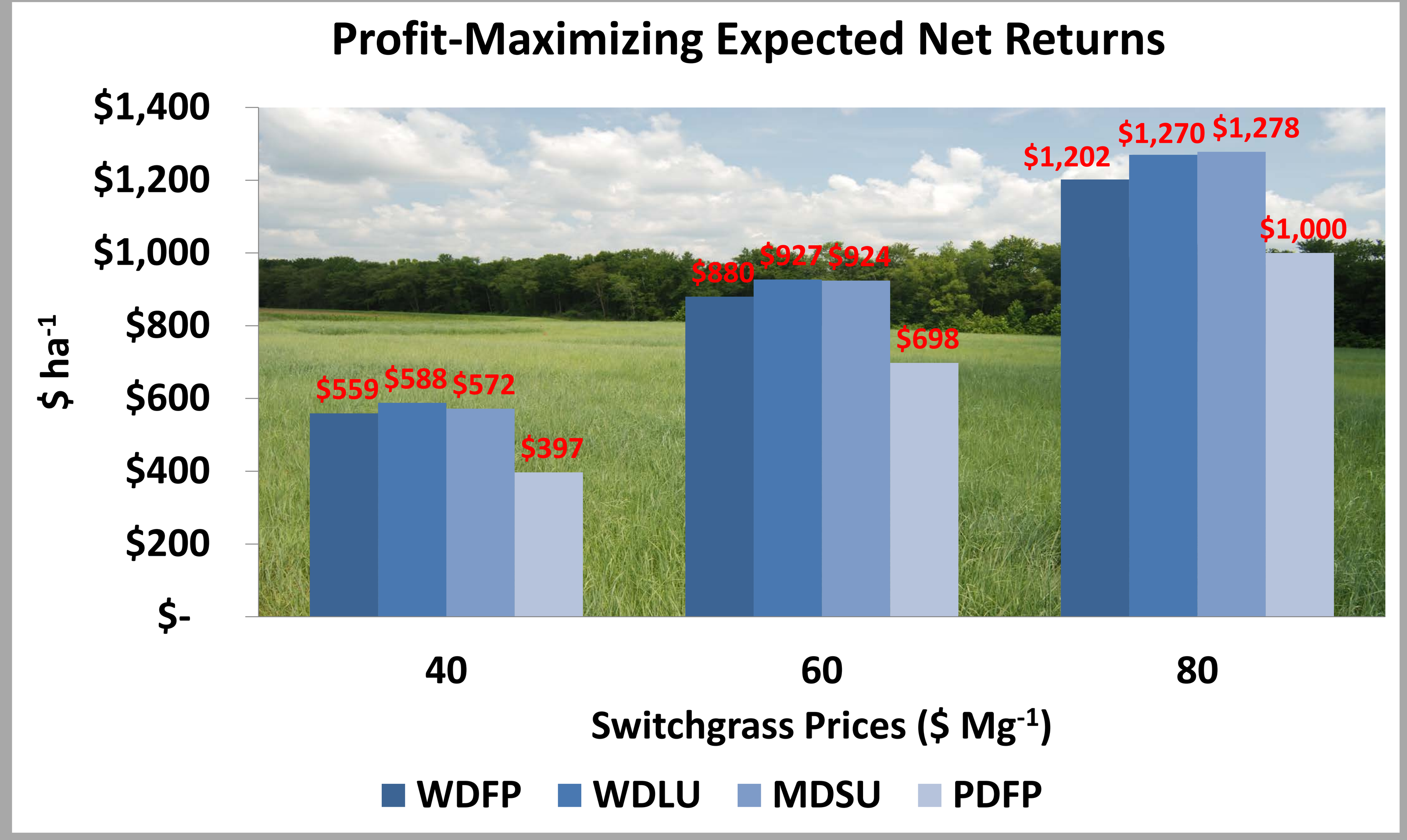
$$y_{ti} = \min(\beta_0 + \beta_1 x_{ti}, \mu_m + u_t) + v_t + e_{ti}$$

where y_{ti} is the switchgrass yield in Mg ha^{-1} in the *t th* year on plot *i*; β_0 and β_1 are coefficients; x_{ti} is the quantity of N applied in kg ha^{-1}; μ_m is the expected plateau yield in Mg ha^{-1}; $v_t \sim N(0, \sigma_v^2)$ is the intercept year random effect; $e_t \sim N(0, \sigma_e^2)$ is the random error term; and $u_t \sim N(0, \sigma_u^2)$ is the year plateau random effect. Independence was assumed across the three stochastic components. Results for the yield response functions can be found in the published proceedings.

RESULTS







CONCLUSIONS AND FUTURE RESEARCH

- Yield varied across the four landscapes.
- Landscapes impacted profit-maximizing N rates, expected yields, and expected net returns.
- Marginal landscapes produced switchgrass yields comparable to the higher quality landscapes.
- Further research is needed to compare the profitability of corn and switchgrass in side-by-side experiments on marginal lands and land well-suited for row crop production.
- Research is needed to quantify the economic benefit from the environmental services that producing switchgrass provides.

REFERENCES

Fike et al. (2006). Long-term yield potential of switchgrass-for-biofuel systems. *Biomass Bioenergy*, 30, 198-206.

Haque et al. (2009). Nitrogen and harvest frequency effect of yield and cost for four perennial grasses. *Agron. J.*, 101, 1463-1469.

Mooney et al. (2009). Yield and breakeven price of 'Alamo' switchgrass for biofuels in Tennessee. *Agron. J.*, 101, 1234-42.

Tembo et al. (2008). Crop input response functions with stochastic plateaus. *Am. J. Agric. Econ.*, 90, 424–434.

USDA NASS. (2011). Agricultural prices.

***Corresponding Author**
Christopher Boyer, Department of Agricultural and Resource Economics at University of Tennessee-Knoxville, 302-I Morgan Hall, Knoxville, TN 37909, email:cboyer3@utk.edu; phone: 865-974-7468

Acknowledgments
The authors thank Dr. Blake Brown and the staff at the Milan Research and Education Center, Milan, TN, for field research support and the Department of Energy for funding support though the UT Switchgrass Demonstration Project, DE-FG36-04GO14219