Net Energy Value of Biofuel Ethanol Produced From Corn Grown in the Southeastern USA

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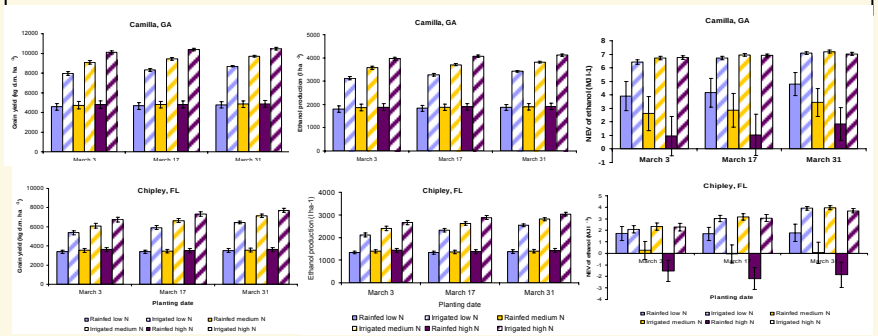
Introduction: The production of bio-fuel ethanol in the USA has increased from 1.10 billion gallons in 1996 to 4.86 billion gallons in 2006. Of the total ethanol produced in the US more than 90 percent is from produced from corn. Corn grain yields vary among years and sites due to climate and soil variability and farming management.

A determination of the impact of weather and soil variation on the net energy value of ethanol produced from corn is crucial to how and where ethanol should be produced to increase its prospects as a substitute to fossil fuels.

Objective: To determine the impact on weather and climate variability at different sites in the southeast US on the net energy value of ethanol produced from corn produced with different farming management practices.

Figure 1. Grain yield, ethanol production and net energy value (NEV) of ethanol (+- standard error) from corn simulated under weather and soil conditions representing Camilla, GA (31°10'N; 84° 11'W) and Chipley, FL (30°46'45"N, 85°32'21"W). Weather input data from 1960 to 1989.



Preliminary results: Net energy value (NEV) of ethanol produced from irrigated corn was significantly higher and varied less among years under most farm management practices than the ethanol produced from corresponding rainfed treatments. For rainfed conditions, the lowest nitrogen fertilization rates resulted in the highest NEV (Fig. 1). NEV of ethanol produced from corn grown under different ENSO at Camilla, Georgia and Chipley, Florida was higher under La Nina years than under neutral and El Nino years (Fig. 2).

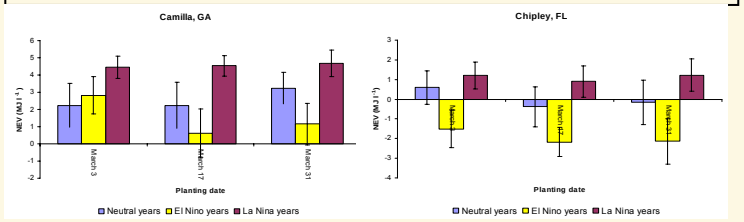
Table 1. Items included in the energy calculation

	Energy input (-) and output	unit	Source
Farming energy			
Seeds	-233	MJ ha^{-1}	Shapouri and McAloon, 2004 Procs of the Conf on Agric as a Producer and Consumer of Energy, Arlington, VA., June 24-25
Equipment use (except harvest)	-2035	MJ ha^{-1}	Peart et al. 1995. J Biogeogr 22:635-42
N fertilizers	-59	MJ kg N^{-1}	Spatari et al 2003 Environm Sci Tech 39:9750-58
P fertilizers	-7.8	MJ kg P^{-1}	Shapouri et al 2002 Agric Econ Report no 814, USDA
K fertilizers	-6.96	MJ kg K^{-1}	Shapouri et al 2002
Pesticides	-356	MJ kg^{-1}	Wang et al. 1999 Argonne National Laboratory Rep no 38
Irrigation	-287	MJ cm^{-1}	Peart et al. 1995
Harvest	-0.060	MJ kg^{-1}	Peart et al. 1995
Drying	-0.54	MJ kg^{-1}	Peart et al. 1995
Processing and transport energy			
Ethanol processing	-13.14	MJ l^{-1}	Shapouri and McAloon, 2004
Grain transport	-25	MJ km^{-1}	Wang et al. 1997 Argonne National Laborator Rep prepared for the Illinois Dept of Commerce and Community Affairs
Ethanol transport	-0.409	MJ l^{-1}	Shapouri et al 2002
Ethanol and by-product energy			
Ethanol	23.5	MJ l^{-1}	National Institute of Standards and Technology http://webbook.nist.gov/
Distillers' dry grain	4.31	MJ l^{-1}	Shapouri et al 2002

Methods: Corn (Pioneer 31G98) yields for multiple years were simulated with the CSM-CERES-Maize model using the DSSAT4 seasonal analyis tool. Simulated grain yields were input to energy balance calcultions. Weather and soil input to the simulations were county specific.

The energy balance of ethanol production takes into account farming energy, and ethanol processing and transportation energy (Table 1). Farming energy was calculated per kg simulated corn grain to link the energy calculation to the weather input data. The calculation of ethanol processing and transport energy assumed that all ethanol are produced in a modern facility in Camilla, Georgia.

Figure 2. NEV of ethanol produced from rainfed corn fertilized with 176kg N ha^{-1} simulated under different El Nino Southern Oscillation (ENSO) phases at Camilla, GA and Chipley, FL. Weather input data from 1939 to 1995.



Conclusion: The net energy value (NEV) of ethanol produced from corn grain varies with farm practices,site specific conditions, and weather and climate variations within the southeastern USA. Irrigation positively affect the net energy value of the ethanol produced.