

Introduction

The current concerns over a secure supply of oil and the ever-increasing greenhouse gas concentrations in the atmosphere have led to renewed interest in energy from plant biomass.

Surfing the internet or flipping through newspapers and magazines (popular and scientific) or browsing funding opportunities will all lead to positive claims on the potential for biofuel as a carbon-neutral fuel. However, they will also lead to a series of concerns, apprehensions and challenges presented by a shift to a heavier reliance on biomass energy for an energy-thirsty society.

In particular, there is large uncertainty about greenhouse gas (GHG) emissions during biomass production across spatial and temporal scales. This uncertainty exemplifies the need for an assessment of GHG budgets across different biofuel cropping systems before fully embarking on this new pathway.

In this study, a biogeochemical model, DayCent, was applied to simulate the yield and GHG emissions from switchgrass cropping systems. By using data from literature and two field studies, the model was calibrated and preliminarily validated.

Objectives

- To parameterize and calibrate DayCent for typical switchgrass cropping system.
- To validate the model using realistic data generated by field experiments.

Methods

DayCent – a plant-soil ecosystem model

- Simulates plant production, soil carbon dynamics, soil nutrient dynamics, soil water and soil temperature
- Also simulates GHG fluxes of CH₄ and N₂O

Input information

- Soil data
- Weather data
- Agricultural management data

Model parameterization, calibration and validation

- Using realistic yield data generated by two field experiments.
 - Rock Springs, PA, 2001-2003
 - Davis, CA, 2007
- Basic information about the two sites

Location		Rock Springs	Davis	
Soil Property	Soil Type	Hagerstown silt loam	Yolo silt loam	
	Soil Texture	Sand (%)	28.33	9.96
		Silt (%)	33.44	65.40
		Clay (%)	38.23	24.64
		Organic Matter (%)	0.77	1.30
Management Events	Fertilization (kg N ha ⁻¹)	56	56	
	Harvesting	Every fall, 2001-2003	Fall, 2007	

Carbon dioxide equivalents (CDE) calculated based on the mass and the global warming potential (GWP) of the GHGs.

$$CDE = \sum m_{Gas} GWP_{Gas}$$

Gas	Global Warming Potential (100-yr horizon)
CO ₂	1
CH ₄	23
N ₂ O	296

Results

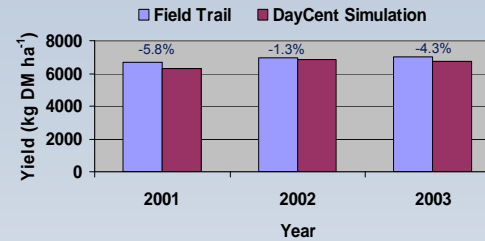


Figure 1: Calibration result of DayCent using switchgrass yield at Rock Springs, PA

The low percent deviation (<10%) of the calibration result indicates that DayCent model was successfully calibrated for switchgrass cropping system using literature data from the field experiment at Rock Springs, PA.

Table 1: Preliminary validation result of DayCent using switchgrass yield at Davis, CA

Location	Year	Field trail yield (kg DM ha ⁻¹)	Simulated yield (kg DM ha ⁻¹)	% deviation
Rock Springs	2001	6690	6304	-5.8%
	2002	6950	6857	-1.3%
	2003	7020	6721	-4.3%
Davis	2007	10742	8666	-19.3%

The simulated yield result for Davis site deviates from the field data. This discrepancy may be attributed to the differences of features between the cultivars used at the two sites.

Table 2: Simulated GHG emissions of the switchgrass cropping systems at the sites of Rock Springs, PA (2001-2003) and Davis, CA (2007)

Location	year	N ₂ O emission (kg N ₂ O ha ⁻¹ yr ⁻¹)	CH ₄ uptake (kg CH ₄ ha ⁻¹ yr ⁻¹)	CO ₂ emission (kg CO ₂ ha ⁻¹ yr ⁻¹)	CDE (100-yr horizon) (kg ha ⁻¹ yr ⁻¹)
Rock Spring	2001	4.09	1.14	776	2013
	2002	4.90	1.12	811	2287
	2003	6.13	0.91	748	2584
Davis	2007	16.58	1.47	1298	6239

According to the simulation, switchgrass cropping systems at both sites had positive value of equivalents of CO₂, indicating that the fields were contributing to global warming.

Compared to Rock Springs, the switchgrass cropping system at Davis has higher yield, N₂O and CO₂ emissions, CH₄ uptake and CDE.

Discussion

The high GHG emissions from the switchgrass cropping systems was unexpected. This result is opposite to some other research which shows that switchgrass fields are environmentally friendly as a sink of GHGs (Corre *et al.*, 1999).

The lack of soil organic carbon data from literature and our field experiment limited the extension of the model calibration and validation.

In our ongoing field experiments conducted at Davis and other three sites in California, Tulelake, Five Points and El Centro, soil organic C, soil organic N, belowground biomass and nutrients of the belowground are going to be measured. The data is going to be used in further model calibration and validation.

Conclusions

DayCent has been well calibrated for yield of switchgrass cropping system using literature data from the Rock Springs site.

The different results of GHG emissions of switchgrass biomass production between this study and other research indicates that environmental impacts of biofuel biomass production vary under different soil, weather and field management conditions.

Further calibration and validation of DayCent is needed by using new data from literature and our ongoing field experiments conducted in four sites in California.