

Land, Labor, and Energy Efficiency of Alternative Biofuel Feedstock Crops at Three Small Farm Scales

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Abstract

Sweet sorghum (*Sorghum bicolor* L.) and sweet potato (*Ipomoea batatas* L.) are promising crops for advanced biofuel production because they may be better suited than corn (*Zea mays* L.) to low input production on small farms in Kentucky. A four-year study was initiated on organic land in 2008 to measure land, labor and energy efficiency of these crops at three production scales: 1) BioIntensive (BI), relying entirely on hand tools; 2) Market Garden (MG), relying on no machinery larger than a walk-behind tractor; and 3) Small Farm (SF), relying on 4-wheeled tractors and smaller equipment. Land use efficiency was higher in SF than BI plots in 2008, but no farm scale effect was observed in 2009. Labor efficiency was highest in SF and lowest in BI plots in 2008 and 2009. BI plots were more energy efficient than SF plots in 2009 only. When scale effects were observed, MG plots were between SF and BI. Sweet sorghum gave the greatest return to land, labor and energy across production scales and years. Small-scale, low-input production of biofuel feedstock crops may be more energy efficient than large-scale production, but offers a poor return to labor: A small farmer's decision to dedicate a portion of yield to on-farm biofuel production is more likely to be motivated by concern about self-sufficiency, resource-cycling, or waste reduction than economics. Sweet sorghum shows greater potential than corn or sweet potato as a biofuel feedstock crop for small-scale, low-input production in Kentucky.

Introduction

Kentucky State University's Land Grant Program is committed to developing sustainable agriculture systems suitable for adoption by small and limited resource farmers. These include systems that meet national organic standards.

Organic farms often depend on fossil fuels, which could possibly be replaced by biofuel produced on farm. This study evaluates land, labor, and energy efficiency of organic farms growing food and biofuel feedstock crops at three scales.

Results will determine what proportion of a farmer's land and labor is needed to meet farm energy needs at each farm scale, and what crops are best adapted to organic farms producing food and fuel.

Materials and Methods

Farm plots representing three production scales were established on certified organic land in 2008 using a randomized complete block design with four replicates. The three farm scales were: 1) Biointensive; 2) Market Garden; and 3) Small Farm. Biointensive plots (300 sq ft) were managed entirely with manual labor and hand tools. Market Garden plots (1400 sq ft) were managed with manual labor and walk-behind tractors. Small Farm plots (7500 sq ft) were managed with four-wheeled tractors, walk-behind tractors and manual labor, with a preference given to mechanized solutions to reduce manual labor inputs. Each plot was planted to food and biofuel feedstock varieties of four crops, grown in a four-year rotation (Table 1). A cover crop of winter rye and hairy vetch was planted after each harvest and incorporated into the soil before planting each spring.

Labor use, fossil fuel consumption, and yield were recorded at each farm scale each year. Only inputs used within plot boundaries were recorded. Data from the first three years of the ongoing four year study are reported here.

Table 1. Food and biofuel feedstock varieties grown in rotation.

Crop	Food	Fuel
Soybean, <i>Glycine max</i>	Butterbean ^a , Midori Giant	2A71
Corn, <i>Zea mays</i>	Luscious ^a , Brocade	56M30
Sweetpotato, <i>Ipomoea batatas</i>	Beauregard	Beauregard
Sweet sorghum, <i>Sorghum bicolor</i>	Dale	M81E

^a2008 crop year only

Results and Discussion

Biointensive production, using hand tools and manual labor, was more labor intensive but not necessarily more energy efficient than mechanized production. The energy used to feed the farmer was usually comparable to the energy used to fuel machinery in larger scale systems.

Land use efficiency varied considerably between years, and was lowest in the drought year of 2010.



BCS walk-behind on Market Garden Plot
Ford Tractor in background on Small Farm Plot



Record keeping of fuel used



Biointensive plot maintenance



Corn, Field Soy, Edamame, and Sweet Sorghum in Small Farm Plot



Farmall in Small Farm Plot



Tye Seeder in Small Farm plot

