An Energetic Perspective on Sweet Potato: Food Versus Fuel

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Abstract

Sweet potato (*Ipomoea batatas* L.) is a major starch-based crop that can be consumed as a nutritious dietary staple or converted into fermentable sugars for ethanol production. There are over 8000 varieties of sweet potato that have been bred for specific purposes. Varieties used for fuel generally have higher dry matter and starch contents, resulting in improved storage and increased ethanol yields, respectively. A high-dry matter sweet potato variety, CX-1, is being evaluated as a replacement crop for failing citrus groves in Florida since it can grow in hot climates, requires minimal irrigation and nutrients, and has a short growth cycle (150 days). The research objective is to determine whether sweet potatoes in Florida should be grown for human consumption or fuel production based on agronomic yield, potential energy production from both roots and culls, and nutrient recovery for animal forage. Varieties for comparison include Beauregard (food) and CX-1 (fuel). Ninety-six (96) plants of each variety were planted on June 6, 2014. Growth monitoring is conducted every six weeks and root/vine yields will be measured at harvest. Net energy values from ethanol production are twice that of edible energy for humans. Specific methane yields obtained from anaerobically digesting the culls were 333 and 255 LCH_4/kgCOD for Beauregard and CX-1, respectively. CX-1 culls have higher crude protein, nitrogen and phosphorus, while Beauregard are higher in fiber (CF, NDF, and ADF) and in vitro organic matter digestibility. Preliminary results favor CX-1 for ethanol production, but agronomic yields are essential for conclusive results.

Introduction

- Failing citrus crops in Florida provide new agricultural opportunities. Approximately 125,000 hectares (ha), or 37%, of citrus groves have been lost since 2000 [1].
- Sweet potatoes (SP) are a fruitful alternative
  - Dry conditions are favorable
  - Crops are heat tolerant
  - Yields of 7 to 10 dry tons/ha [2,3]
- Global distribution of SP production and use
  - Africa and the Americas grow SP mostly for food
  - China is the world's largest producer of SP (79 Mt in 2013), which are grown mostly for industrial processing of fuel ethanol, edible alcohol, starch, organic acids, and degradable plastics

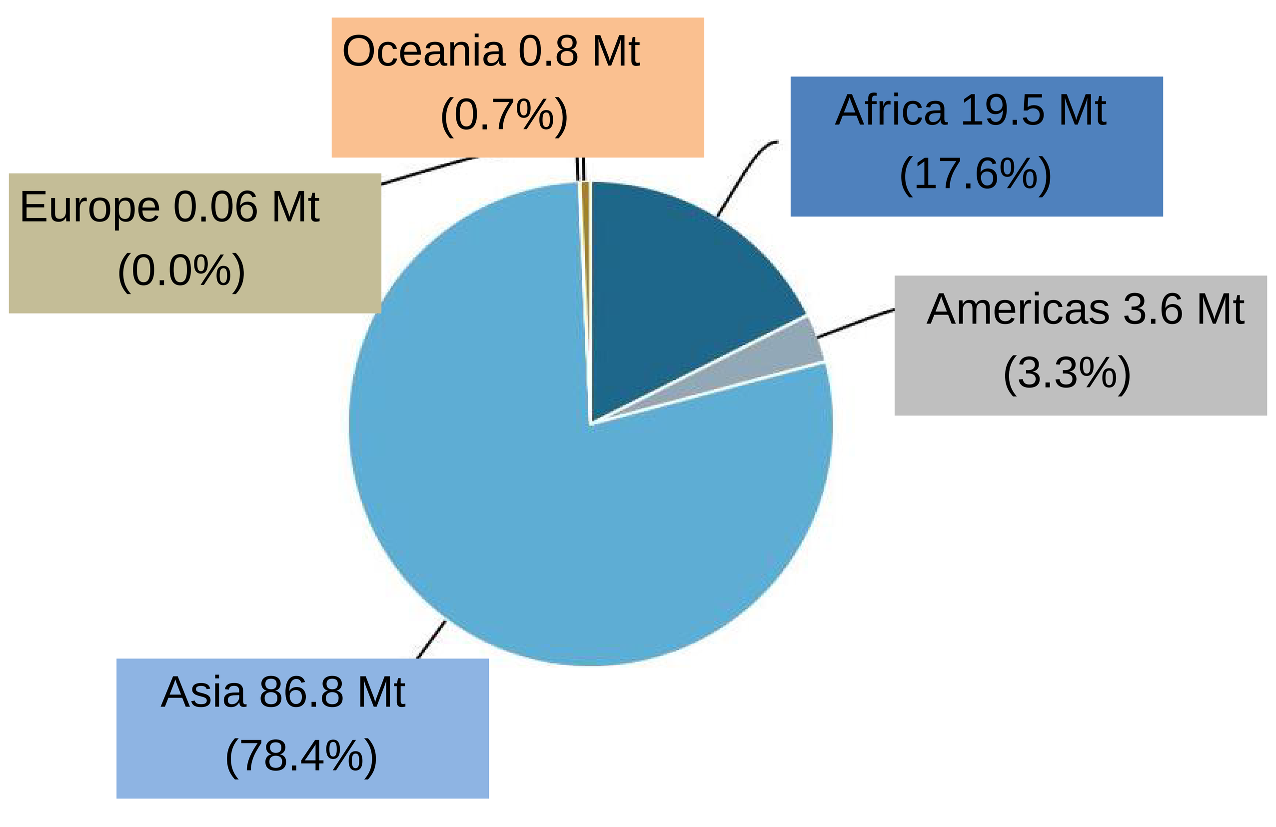


Figure 1. Global Production of Sweet Potato in 2013 [4]

Objective

Determine the overall energy potential from an industrial sweet potato (CX-1) grown for fuel production versus a common table variety (Beauregard) used for human consumption based on

- agronomic yields in Florida soils
- net energy value of roots
- net energy value of culls

Image from http://www.chow.com/recipes/30879-baked-ginger-sweet-potatoes

Figure 2. Sweet potato for fuel ethanol (left) or human food (right)

Image from Dr. Janice Ryan-Bohac (CAREnergy)

Figure 3. CX-1 at 12.2 kg (left) and Beauregard at 0.4 kg (right)

Methods

- Measure and compare agronomic yields of both cultivars in Florida soils
  - -- 660 ft² field trials
  - -- 96 plants (three replicates) of each cultivar
- Compare energy value of each cultivar from fuel and food perspectives
- Evaluate cull potatoes:
  - --Methane potential assays in lab-scale, anaerobic digesters at 35ºC for 36-day digestion period
  - --Nutritional value as animal forage determined by proximate analysis, TKN, TP, and IVOMD

Results

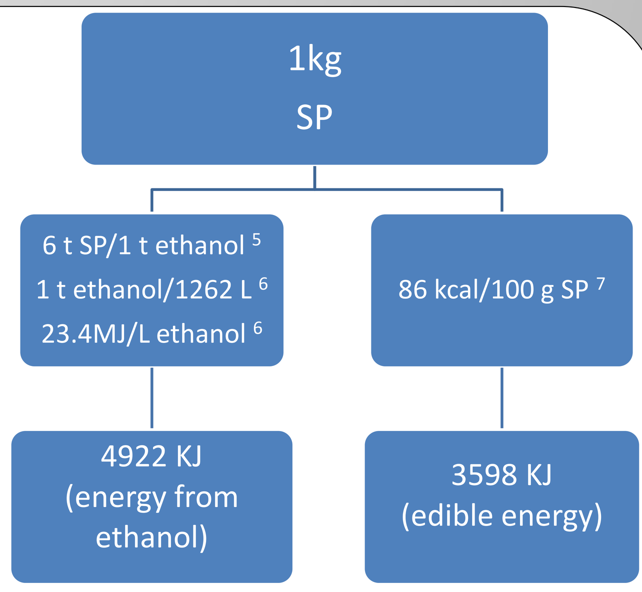
Table 1. Growth Monitoring Results From Field Trials

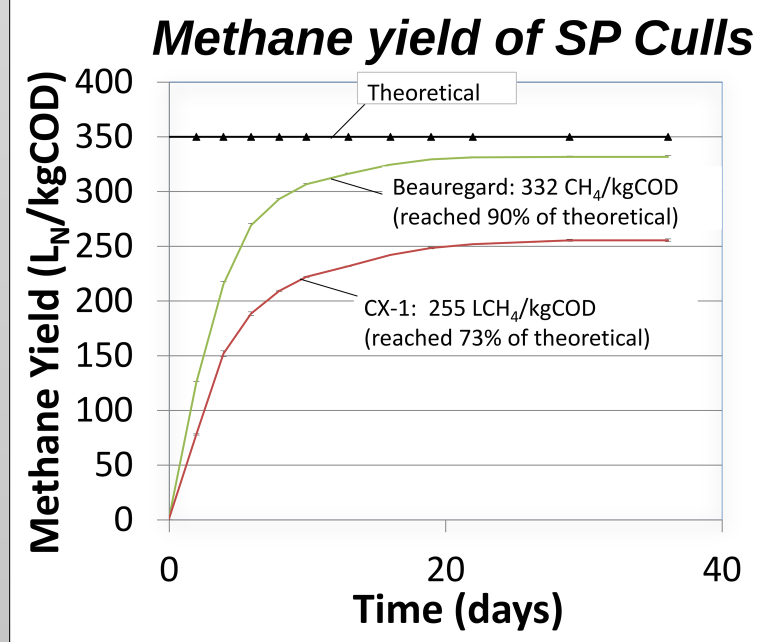
	CX1 Industrial Variety	Beauregard Table Variety
Initial Planting	96 plants	96 plants
After 6 Weeks		
Survival Rate	99%	90%
Avg Plant Height	11″	10″
Range Vine Length	0 to 25″	0 to 34″
After 12 Weeks		
Avg Plant Height	18″	14″
Range Vine Length	39 to 55″	70 to 103″
After 24 Weeks		
Vine yield	__ton/acre	__ton/acre
Root yield	__ton/acre	__ton/acre

CX-1: 12-week growth

Beauregard: 12-week growth

Image from Dr. Janice Ryan-Bohac (CAREnergy)





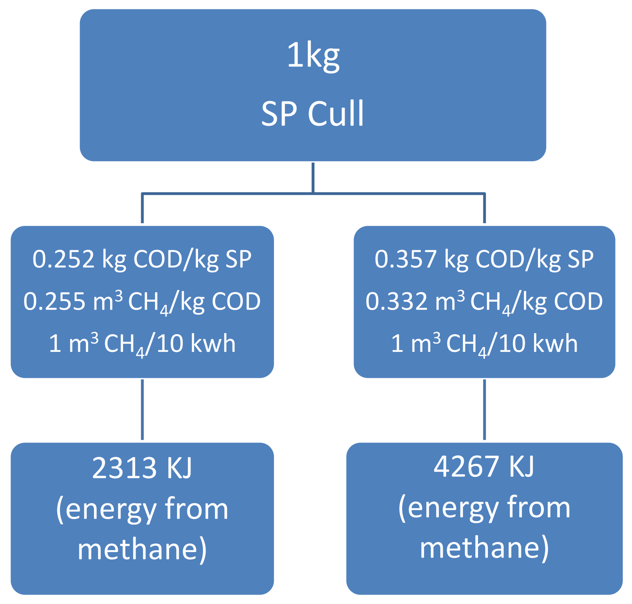


Table 2. Nutritive Value of SP Culls

	CX1 Industrial Variety	Beauregard Table Variety	Corn [8]	Wheat [8]
pH	5.9	6.0		
Brix (%)	2.8	5.8		
Dry Matter (%)	35.4 ± 0.4	21.8 ± 0.3		
Org Matter (% DM)	94.2 ± 0.0	94.0 ± 0.1	98.5	98.5[3]
IVOMD (%DM)	91.4 ± 0.9	94.9 ± 0.7		
TKN (%DM)	0.88 ± 0.02	0.76 ± 0.02		
TP (%DM)	0.12 ± 0.00	0.17 ± 0.01		
NDF (%DM)	5.4 ± 0.4	8.4 ± 0.2	9.3	11.3
ADF (%DM)	4.8 ± 0.3	7.2 ± 0.3	3.3	4.2
CF (%DM)	2.8 ± 0.0	4.8 ± 0.1		
CP (%DM)	5.5 ± 0.1	4.8 ± 0.1	9.7	15.8

Conclusions

- SP root yields for each cultivar (to be determined at harvest) will determine overall energy productivity
- Gross energy values of SP roots (either eaten or converted to ethanol) and anaerobically digested culls are: CX1 – 7235 kJ/kg; Beauregard – 7865 kJ/kg
- Nutritional value of SP culls is similar for each cultivar, but cereal grains are superior in terms of CP and NDF.
- CX-1 has a lower in-vitro organic matter digestability (IVOMD) as also evidenced by anaerobic digestion study.

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Acknowledgements

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