What kind of competition food vs fuel in sweet sorghum?

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Working together for tomorrow’s agriculture

(www.cirad.fr)
(umr-agap.cirad.fr)
A staff of 1800, including 850 researchers

A scientific hub in Montpellier

700 staff members based outside metropolitan France
**Coordinator:** CIRAD

**Budget:** Total = ~ 5 million € for a contribution from the EC ~ 3 million €

**Duration:** = 5 years (2009-2013)

**10 partners:** CIRAD, ICRISAT, EMBRAPA, KWS, IFEU, UniBO, UCSC, ARC-GCI, UANL, WIP

**Objective:** Development of ethanol production from sorghum in temperate and semi arid tropics through development of new varieties adapted to the target environments.

**Web site** www.sweetfuel-project.eu
Global oil production is rapidly approaching its peak.

It is urgent to find alternative and sustainable energies.

Biofuels, defined as solid, liquid or gas fuels derived from biomass, are today the only direct substitute for oil on a significant scale particularly in the transport sector.

CO₂ atmospheric concentration in Aug. 2012 = 392.41 ppm

Evolution of price at the gas station:
- Diesel = 1.4€/l
- Gasoline = 1.59€/l
Poorest countries will be lead to grow biofuel crops

- Less arable surfaces available for food production
- Increasing staple food world market prices  
  (good for producers, bad for urban consumers)

- Instability of the staple food market
- Increase of food insecurity
What are the main plants currently used?

Bio-ethanol 1G

Bio-ethanol 2G

Bio diesel
Sorghum: a multi purposes crop

Biomass sorghum

Grain sorghum

Sorghum for silage

January 2013, Gainesville
Combination of 2 essential traits:

1. Production of grains
2. Accumulation of sugars in the stalks
Why sorghum for producing ethanol?

Sugar cane

Tropical zone

VS

Sweet sorghum

Sorghum

Maize

Intrant needs
sorghum < < maize

Water requirement
1/3 less than maize

Nitrogen Use Efficiency
sorghum > > maize

Adaptation to dry environments
sorghum > > maize

Adaptation to marginal soils
sorghum > > maize

Grain
sorghum << maize

Biomass
sorghum ⇔ maize
(25 to 40T DM ha-1)

Advantage sorghum

Hudge potential of improvement and adaptation
Respect of environment
Development of rural zones
Low competition with food crop
Better sustainability of the production system

Uses
Sugar, Fuel
Food, Feed, Fuel

Length of cycle
12-16 months 4-5 months

Water requirements
36 000 m³ 8000 m³

Adaptation to dry zones
Irrigation yes

Adaptation to marginal soils
Can < < sorghum

Grain production
0 < < up to 6T / ha (2 cycles)

Ethanol production (l ha⁻¹)
6500 5600 (2 cycles)

Propagation
Cuttings seeds

Propagation
Cuttings seeds

Propagation
Cuttings seeds

Advantage sorghum

SSEA Annual Meeting, January 2013, Orlando/USA
2nd generation EtOH or methane production: a biomass sorghum with the following traits:

- **High biomass** production (30-40 TDM ha\(^{-1}\)) which means a plant height > 3.5-4m and a long cycle (4-5 months)

- **Good tolerance to low temperature**

- **A photosensitivity** adapted to induce late flowering

- **A good quality** of the raw material which must be poor in lignin (\textit{bmr} trait) to increase digestibility of the tissues

- **A good tolerance to lodging** (antagonistic with \textit{bmr} trait)

- **Tolerance to water deficit / high water use efficiency** for that purpose, grain production is not essential
2nd generation EtOH or methane production: a biomass sorghum

Possible combination of:
- high stalk biomass
- low lignin content
- good digestibility of fibres

ADL/NDF

INNDFD

Mean dry weight of main stem (g)

106 accessions

Mean dry weight of main stem (g)

SSEA Annual Meeting, January 2013, Orlando/USA
Photosensitivity
What sorghum for what biofuel ?

1st generation EtOH or cogeneration: a sweet sorghum with the following traits:

- **High biomass** production (30-40 TDM ha$^{-1}$) which means a plant height > 3.5-4m
- High accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose
- **Juicy** stalks
- High **energetic value of the bagasse** for cogeneration which means more fiber with lignin)
- A **photosensitivity** adapted
- Adaptation to **marginal soils** (acidity, Al toxicity, P deficiency)
- **Adaptation of crop cycles** (complementary with sugar cane)

For that purpose, grain production is not wishable
1st generation EtOH or cogeneration: a sweet sorghum (Brazil)

106 accessions

Possible combination of:
- °Brix% with juice
- °Brix% with stalk biomass
- Al tolerance
- complementarity sugar cane cycles (1.8 million ha)

gene for tolerance to aluminum toxicity: AltSB
1st generation EtOH combining grain and fodder: a sweet sorghum with the following traits:

- **High biomass** production (20-30 TDM ha\(^{-1}\)) which means a plant height ± 3m and a long cycle (4-5 months)

- a mean production of **grain** (1.5 to 3 T ha\(^{-1}\))

- high accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose

- **juicy** stalks

- high value of the **bagasse as fodder** which means high digestibility (=\(bm_r\) trait = low lignin content in bagasse)

- adaptation to **marginal soils** and **rainfall distribution** (stay green, adapted photosensitivity)

for that purpose, grain production is essential
Processes of accumulation are not well characterized

What is the right kinetic of sugar accumulation in stalks?

Is there a competition between sugar accumulation and grain production?
Decrease in yield for late sowing

(Source: Gutjahr 2012)

Accumulation of sugar in stalks

Sensitivity to photoperiod

Genotypes

Glucides content per stalk (g)

Sowing in June
Sowing in July

Decrease in yield for late sowing
Fluoride concentration (mg/g)

Flower
Maturity

Glucides content (g/stem)

Flower
Maturity

Glucides are accumulated before flowering

(Source: Gutjahr 2012)

Accumulation of sugar in stalks
Ablation of panicule has low influence on sugar accumulation. Competition between sugar accumulation and grain production seems low. How the excess of glucides is « consumed » when there is no panicule?
Sweet sorghum: a multiple purpose crop

- Food
- Feed
- Fuel
- Fertilizer
- Fibers
- Bioproducts
**Project “Biomass for the future” (BFF)**

**Coordinator:** INRA - Institut Jean-Pierre Bourgin (IJPB)

**Budget:** Total = ~ 30 million € for a contribution from the government ~ 10 million €

**Duration:** = 8 years (2013-2020)

**24 partners:**
- public institutions (INRA, CIRAD, Armines)
- + Private sector (from the sectors of breeding, thermoplastics compounds, cement, automotive parts, automotive, plant biotechnology etc.)
- + local authorities

**2 objectives:**
1. Development of local miscanthus (North of France) and sorghum biomass (South) production and valorization chains focused on heat-generation, anaerobic digestion and bio-based construction materials and plastics.

2. Creation of new varieties and culture systems for miscanthus and fiber sorghum, with improved lignocellulosic biomass yield, reduced environmental footprint and a composition tailored for industrial uses, including second generation biofuels and platform chemicals.
Thank you