Sweet Sorghum
- an alternative energy crop

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What is sorghum ?

Biomass sorghum

Sorghum for silage

Broom corn sorghum

Grain sorghum

Sweet sorghum

Sorghum for tinctures

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A great and untapped diversity

Why producing ethanol from sorghum ?

Tropical zone

VS

Propagation
Cuttings seeds

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
Cane < < sorghum

Grain production
0 >> up to 6T / ha

Ethanol production (l ha-1)
6500 5600

Uses
Fuel or sugar Food, Feed, Fuel, (Fiber)

ADVANTAGE SORGHUM

Temperate zone

VS

Intrant needs
sorghum < < maize

Water requirements)
sorghum < < mayze

Nitrogen Use Efficiency
sorghum > > maize

Adaptation to dry environments
sorghum > > maize

Adaptation to marginal soils
sorghum > > maize

Biomass
sorghum < maize
(25 40TDM ha-1)

ADVANTAGE SORGHUM

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

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2 projects on ethanol production from sorghum

Sweetfuel

Objective: develop ethanol production from sorghum in temperate and semi arid tropics through genetic enhancement as well as improvement of cultural and harvest practices

FP7 project / GA 227422 – 01/2009 to 30/06/2014

Total budget :	5 million € (3 from the Commission)
10 partners	CIRAD, EMBRAPA, ICRISAT, IFEU, KWS, UniBO, WIP, UCSC, UANL, ARC-GCI
Project website:	www.sweetfuel-project.eu
Data available from	www.sweetfuel-project.eu/completed_deliverables

S3F for Haiti

Objective: develop a multi purpose (food, feed, fuel) sorghum in Haiti

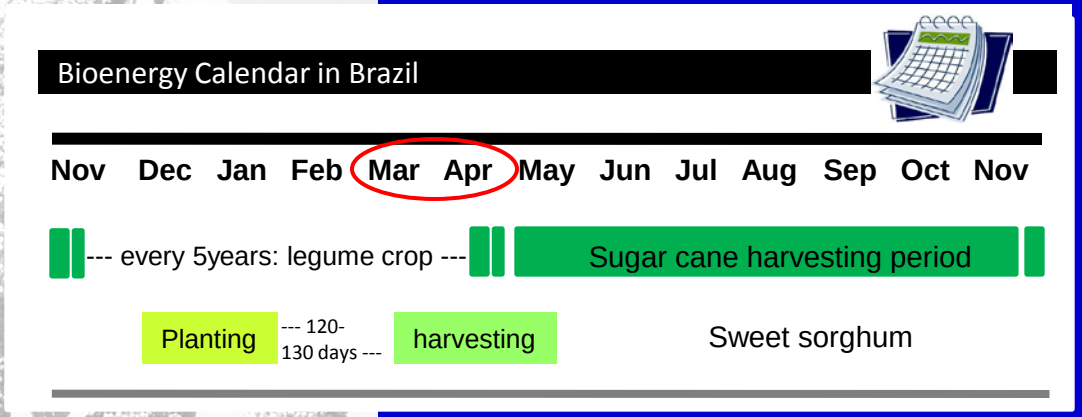
Project suported by the French Agency ANR – 07/20010 to 12/2014

Total budget :	868 000 € (400 000 from ANR)
3 partners:	CIRAD, CHIBAS Foundation, University Quisqueya
Project website:	http://s3f-haiti.cirad.fr/
Data available from	http://s3f-haiti.cirad.fr/resultats_rapports

Main scientific and technological results

The great importance of cropping cycles

Case of Brazil + North Argentina and potentially all sugarcane area



From December to April the sugarcane plants are not operating.

After 5 years production, the sugarcane is removed and before replanting, one cycle of a legume crop is intercropped which could be replaced by sweet sorghum

In Brazil, each year 1.8 million ha are potentially available for sweet sorghum

Short term objective: extend the operating window to April and March →

→ up to 25% increase in production (without using grain)

↗ production without
- additional investment
- extension of cropping area

Case of India: potentially the same situation in term of complementarity, but

sugarcane plants are not equiped with a unit for ethanol production
mechanization is low
Land belongs to small holders (mean farm area = 1 to 2 ha) which requires a great organization for feeding the plant

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Case of Brazil + North Argentina and potentially all sugarcane area

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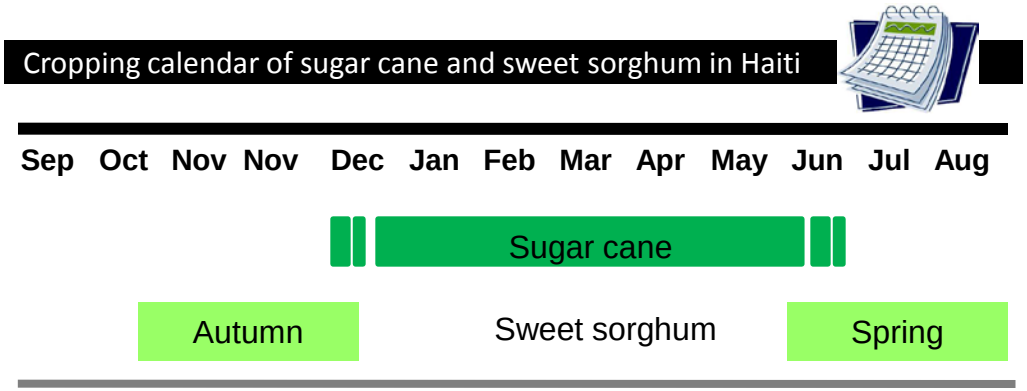
Main scientific and technological results

Case of Haiti



2 possibilities to complement sugarcane with sweet sorghum

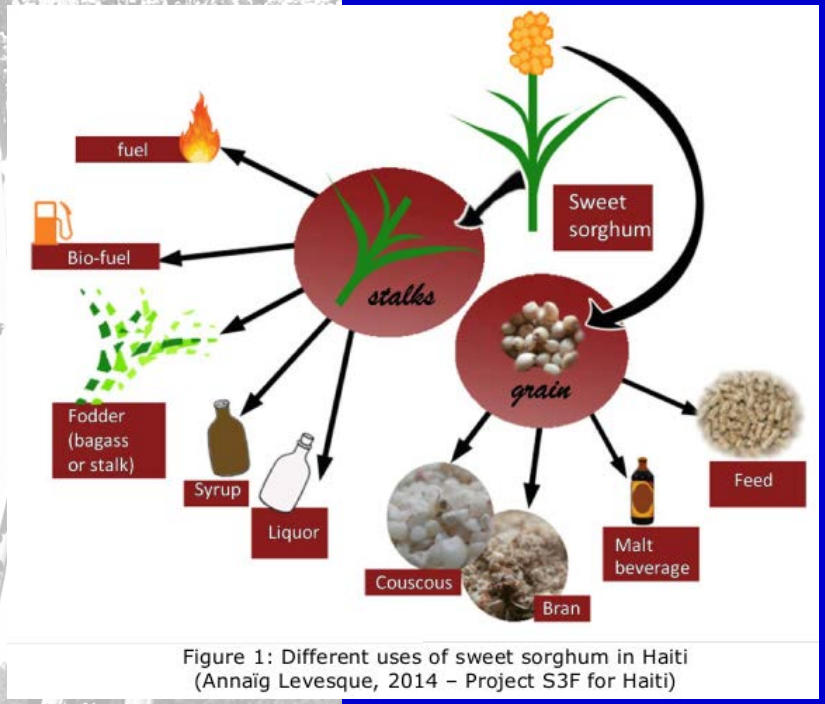


Figure 1: Different uses of sweet sorghum in Haiti
(Annaïg Levesque, 2014 – Project S3F for Haiti)

Development of sweet sorghum will:

→ revitalize the sugarcane sector

→ increase grain production (human and animal)

→ increase in fodder disponibility

Main bottlenecks: organizing the collect of the production
+ adapt policies

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Case of Haiti and India

No unit for distillation

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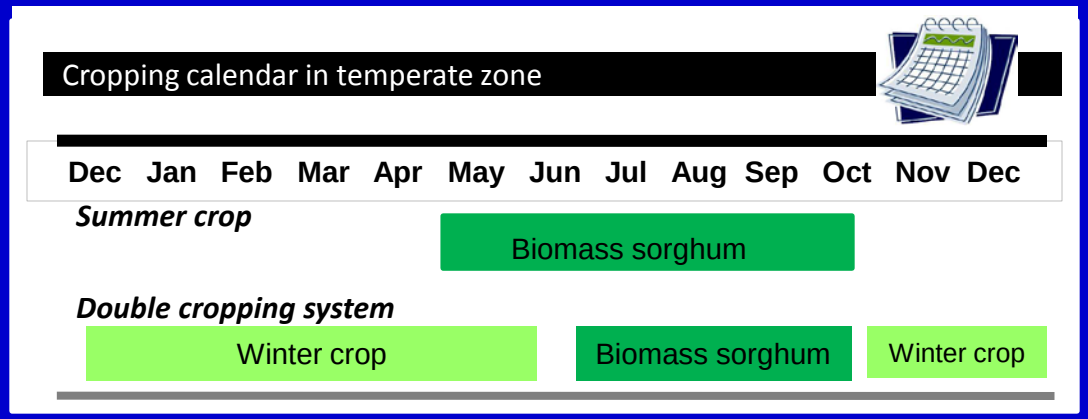
Main scientific and technological results

Case in Europe 2 options



But due to seasonality:

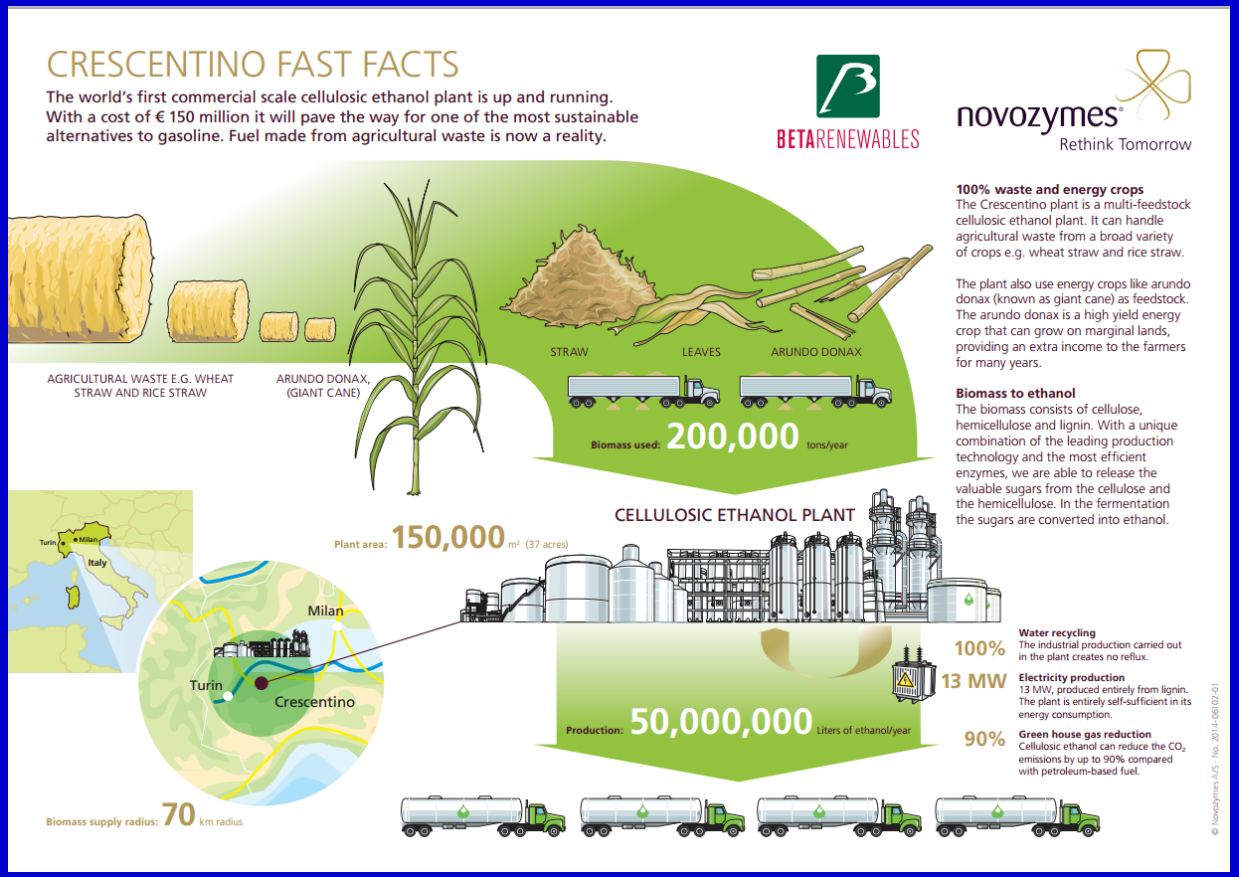
→ harvesting period is short

→ necessity to oversize the plant or to find a solution for storing the biomass (what about cost for handling & storing ?)

Europe / temperate zone

Biogaz production

2G ethanol production



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Caracteristics of Dekabès variety

(Contact: gael.pressoir@chibas-bioenergy.org)

CHIBAS

Dekabès

Parcelle paysanne

Parcelle expérimentale

Tableau. Rendement en essais (faible niveau d'intrants)

	Rendement / caractéristique		
Caractère	**Stress hydrique**	**Optimal**	**Commentaires**
Rendement Grain	2,3 T/ha	4 T/ha	
Rendement tiges	25 T/ha	45 T/ha	
Rendement sucre	1100 kg/ha	2100 kg/ha	
Brix	17-18		
Période d'Utilisation Industrielle	48 jours		PUI : 0-48 jours après maturité
Grain	Semi-dur (3)		Semi-dur, Légèrement farineux
Couleur grain	Blanc		
Jour à maturité	125 jours		
Photopériodique (o/n)	oui/non		légèrement photopériodique

Essai à 57 000 plantes par ha

AGENCE NATIONALE DE LA RECHERCHE ANR

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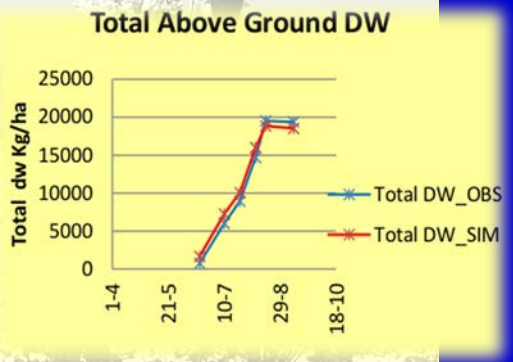
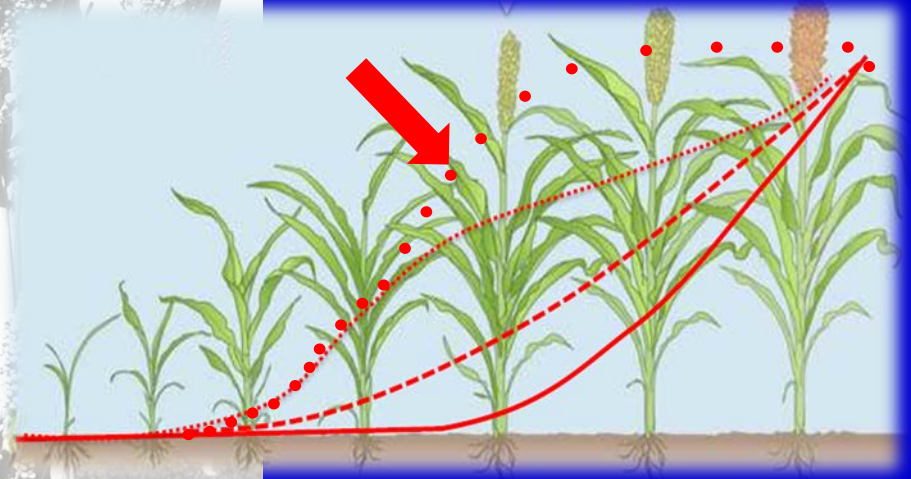
Results



- Recommendations on cultural practices (density, fertilisation, crop cycles...)
- Definition of new ideotypes better adapted to the environment and transformation process
- 2 models: Samara-Sorghum and Ecoméristème
- Thorough knowledge of plant functioning, particularly the competition grain versus sugar accumulation in stem
- identification of QTLs for high sugar accumulation, for tillering, genes linked to drought response



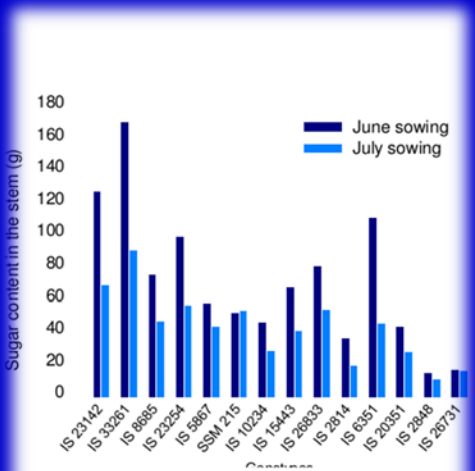


Figure 7: Sugar production by plant stem of the 14 genotypes grown in Mali in 2010 (Sotuba experimental station of IER) with two sowing dates. Genotypes are ordered by decreasing level of photoperiodism from the left to the right

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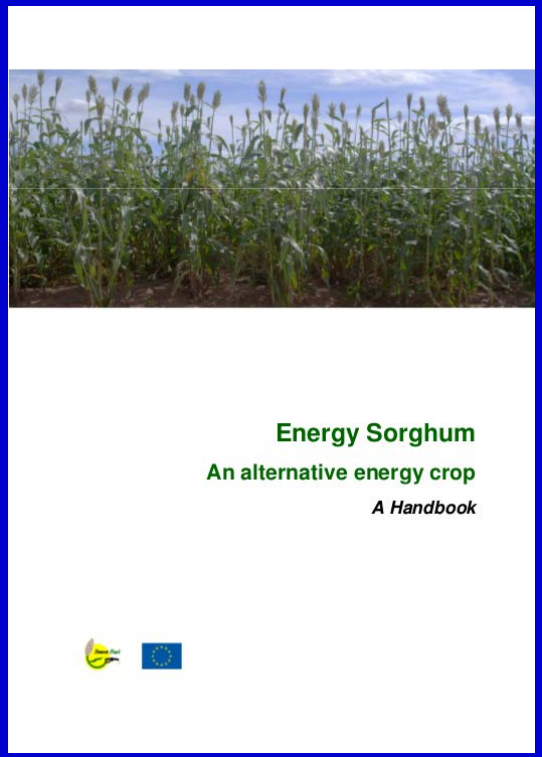
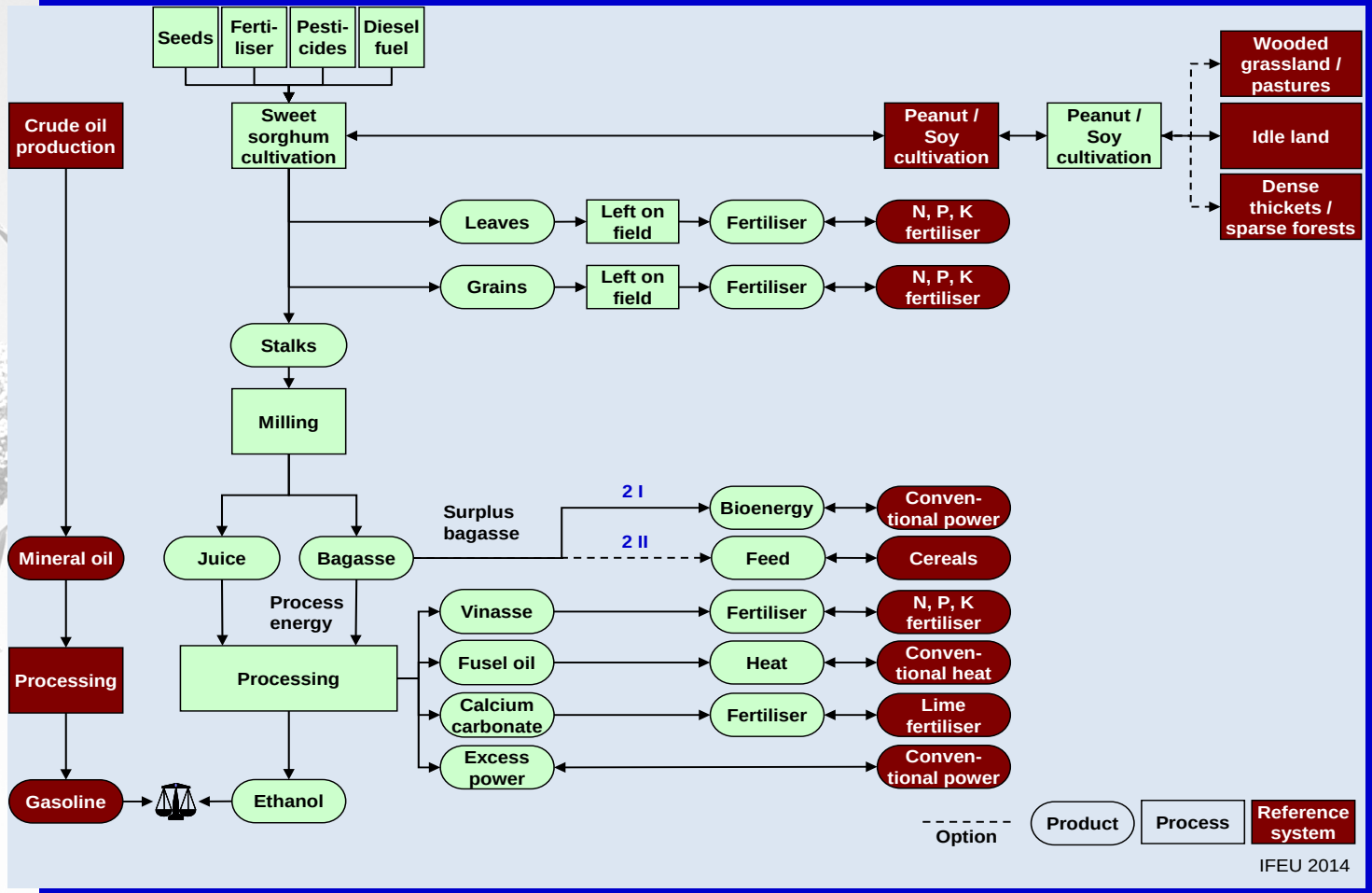
Results

- A handbook on Energy sorghum (English, Spanish, French) (available from http://www.sweetfuel-project.eu/publications)
- A handbook for cropping sweet sorghum in Haiti (available from http://s3f-haiti.cirad.fr/resultats_rapports)
- Identification of the potential pathways for developping sweet sorghum (grain, forrage, alcohol, syrup, …) as well as their bottlenecks



Sustainability of ethanol production from biomass and sweet sqorghum

- Definition of the different scenarios



- for each scenarios and their options, an impact assessment was done at economic, social and environmental level, as well as a SWOT analysis, which results in various recommendations (see deliverables D6.2 to D6.6)

Main recommendations from the impact assessment

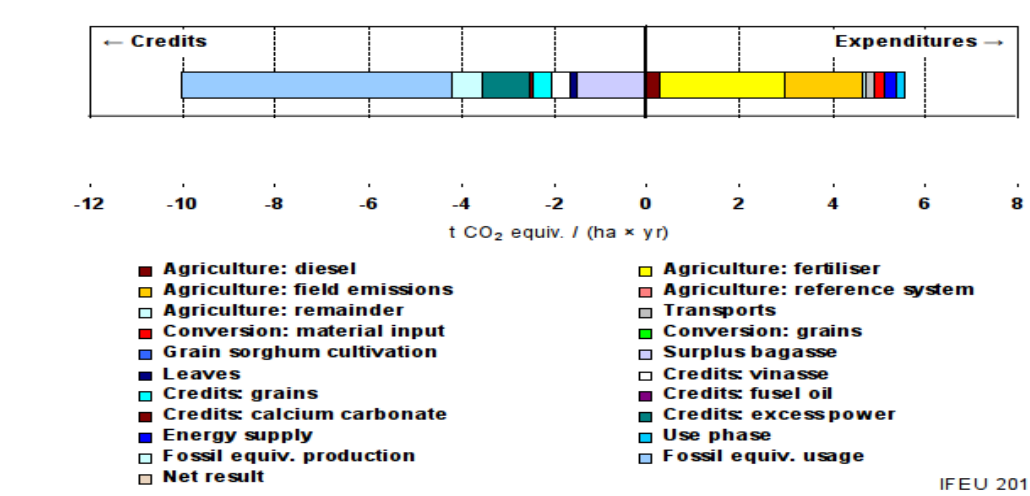


Fig. 4-1 Contributions of individual life cycle steps (coloured sections) to the overall net result (light brown bar) of sweet sorghum ethanol production in the cane fallow scenario for the environmental impact category greenhouse effect. Results are based on typical cultivation and conversion conditions.

- the production and use of sweet and biomass sorghum can cause a wide spectrum of potential impacts ranging from significant benefits to distinctly detrimental impacts
- social impacts are mostly neutral to positive as long as land rights are respected
- where grain is not demanded for food purpose, plants should utilize both stalk and grain of sweet sorghum as it is more profitable than stalk alone (extension of operating window + increase of production)
- a concept for full utilization of the leaves and the surplus bagasse should be compiled as any use of these co-products improves both profitability and environmental impacts
- converting juice to syrup at village level is neither economical nor environmental beneficial unless significant improvement are realized (based on results from India)
- for biogas production, combined production and utilization of power and heat should be preferred over power only
- direct combustion of biomass sorghum for combined heat/power production is the environmentally most beneficial use option and is profitable

What is the future of energy production from sorghum ?

- biomass sorghum (temperate zone)

  for 2G ethanol production, the main problem will be to store the raw biomass or develop multifeedstok plants for operating all year long

  for biogas production, sorghum is a good opportunity but again, combination with other crops and silage is necessary to operate 7/7d

  even if burning the biomass may be an option, there is probably better (most profitable and sustainable) things to do but…

- sweet sorghum (tropical area)

  for 1G ethanol production, it **must be combined with another crop**. sugar cane is the best option (under industrial development in Brazil), but additional research is needed to improve the cropping system (fertilization, density of plantation…) and develop harvester able to harvest also grain.

  potentially, other crops like cassava could be tested (need research).

  In area where grain is not needed, combination stalks + grain could be possible.

Sweet sorghum: a multiple purpose crop

Food

Feed

Fuel

Fertilizer

Fibers

Bioproducts

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Thank you for your attention

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