Development of new sorghum ideotypes to meet the increasing demand of bioethanol

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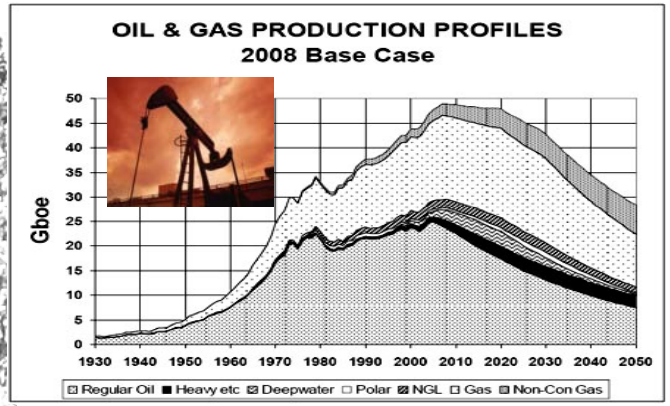
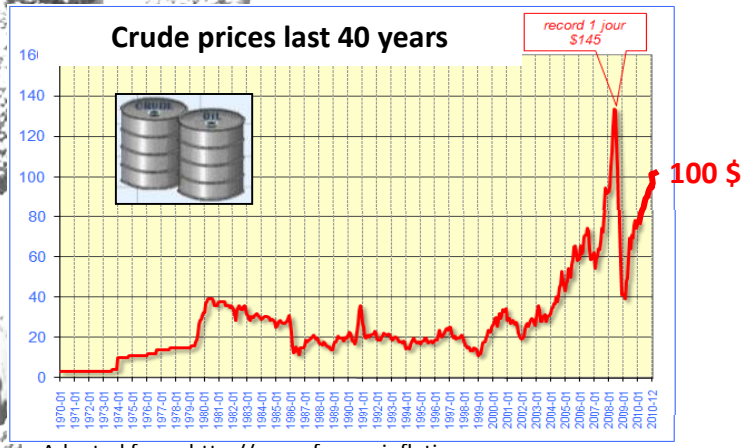
Context

Global oil production is rapidly approaching its peak

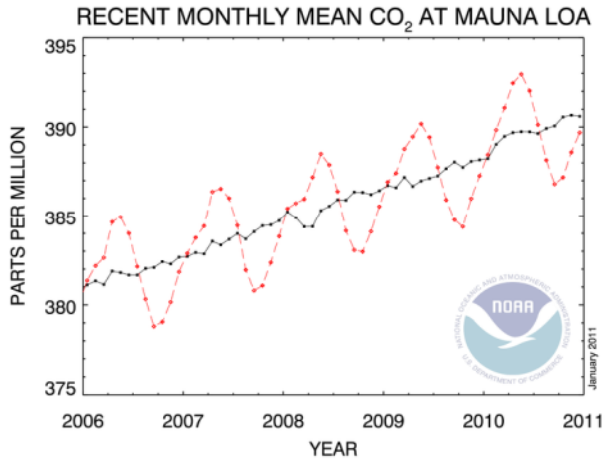


http://www.oildecline.com/

Oil is now being consumed four times faster than it is being discovered, and the situation is becoming critical.



Adapted from http://www.france-inflation.com



Actual CO_2 atmospheric concentration = **381.2 ppm** (WMO source)

It is urgent to find alternative and sustainable energies

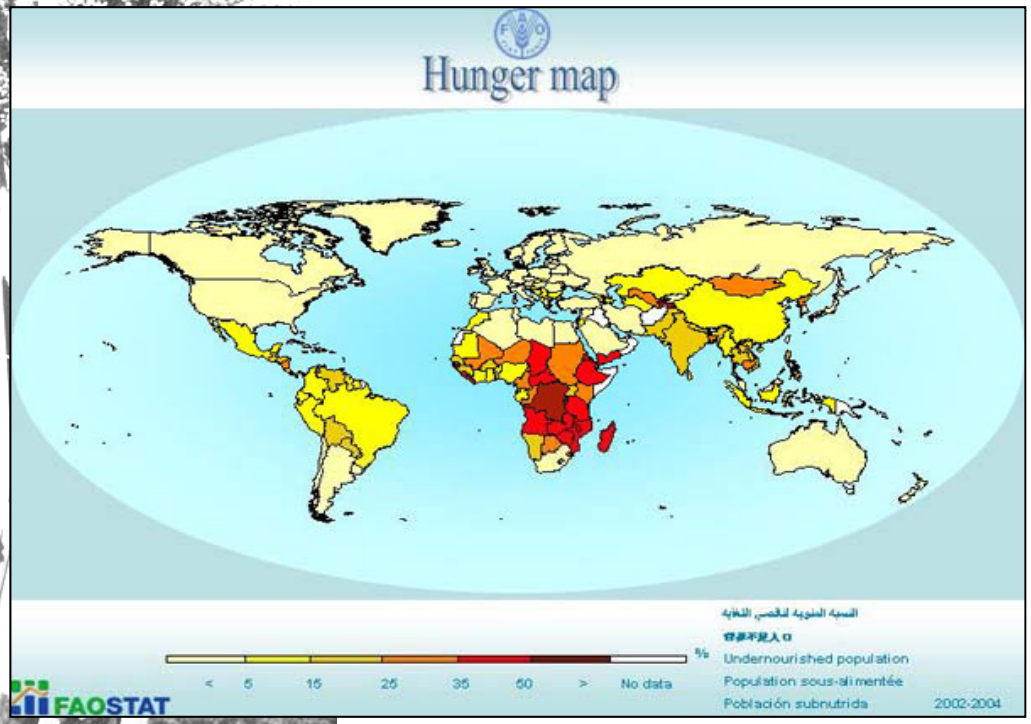
Biofuels or agrofuels, defined as solid, liquid or gas fuels derived from biomass, are today the only direct subsitute for oil on a significant scale particularly in the transport sector

Context

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

Which plant for producting bio ethanol ?

In the tropics

Sugar Cane

Sweet Sorghum

+ almost any staple food crops

In temperate area

Mayze

Sorghum

+ sugar beet and other promising biomass crops (switchgrass, miscanthus, alfalfa…)

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 (2 cycles)

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

Uses
Fuel Food, Feed, Fuel

Temperate zone

VS

Intrant needs
sorghum < < maize

Water requirement
1/3 less than maize

Nitrogen Use Efficiency
sorghum > > maize

Adaptation to dry environments
sorghum > > maize
(stay green)

Adaptation to marginal soils
sorghum > > maize

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

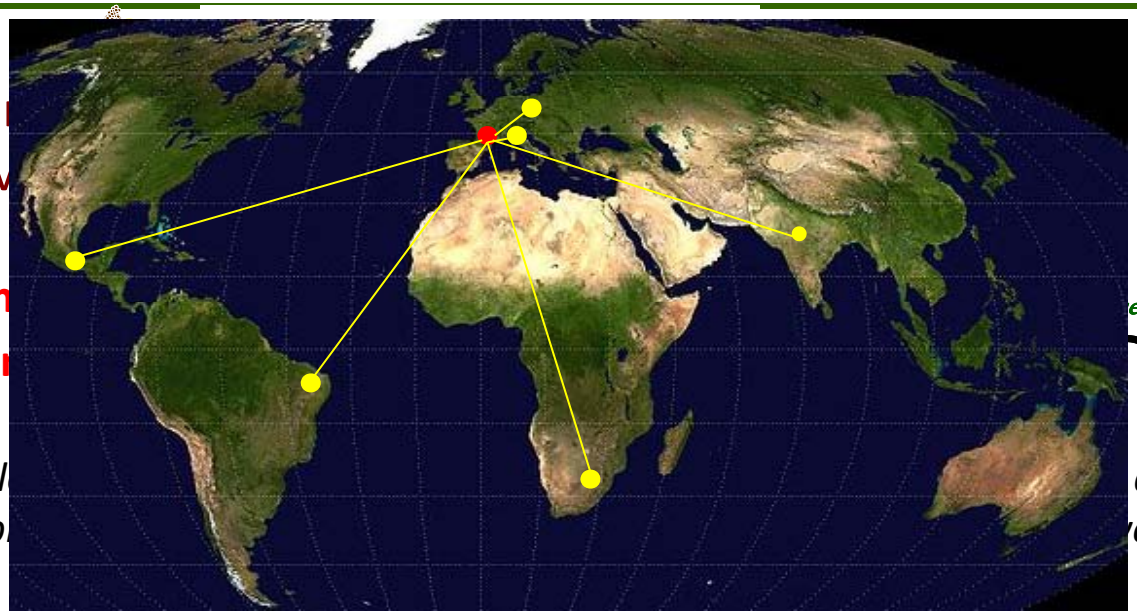
Hudge potential of improvement and adaptation
Respect of environment
Development of rural zones
Low competition with food crop
Better sustainability of the production system

ADVANTAGE SORGHUM

What is the bottleneck for sorghum development ?

Among diffe
different env

Developn
Sweet so



Overall objective: *devel* *and*
trop *est*
and

Scientific consortium: *10 partners from 7 countries and 3 continents*

Cirad, Icrisat, Embrapa, KWS, Ifeu, UniBO, UCSC, ARC-GCI, UANL, WIP

Target area: *temperate and tropical area (particularly semi arid tropics)*

Duration: *5 years (01/2009 – 12/2013)*

Budget: *5 millions € including 3 millions contribution from EC*

Definition of the new sorghum ideotypes

Temperate area

- EtOH 2e generation
- Centralized system

New sorghum ideotype **« Biomass » sorghum (sweet or not, with or without grains)**

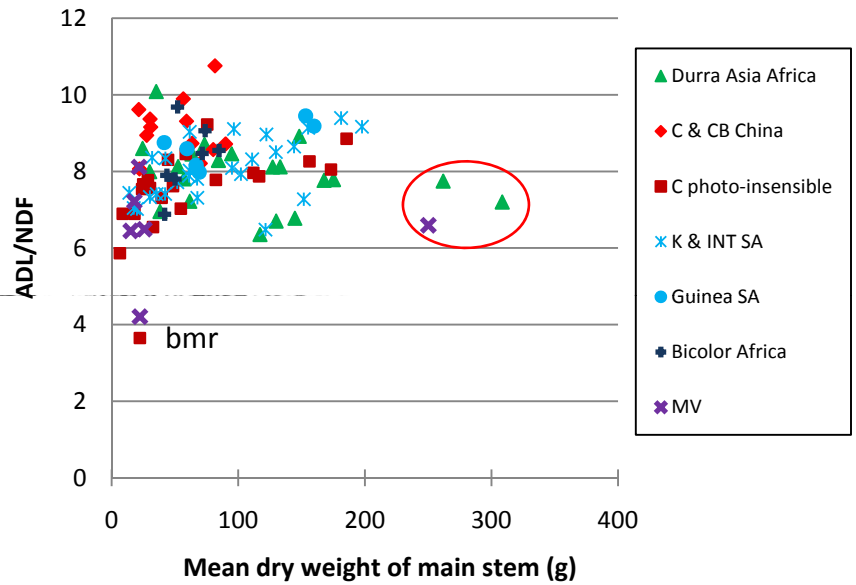
Essential traits

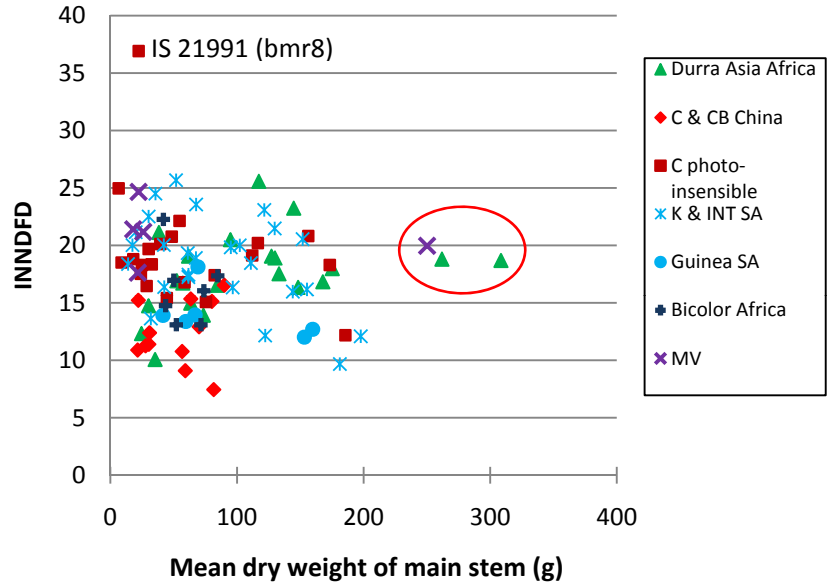
- High biomass production with a good quality and homogeneity (low lignin content = *bmr* trait and good digestibility)
- Adaptation to low temperature to enlarge sowing (and thus harvesting) window
- Drougth tolerant / high WUE
- Photosensitivity for increasing cycle duration

Develoment of new sorghum ideotypes

Temperate area

106 accessions





(Source: Grassbiofuel project / 2009 report)

Possible combination of
+ high stalk biomass
+ low lignin content
+ good digestility of fibres

Development of new sorghum ideotypes

Tropi

In Brazil

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Centralized system

Decentralized system

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Target ideotype **Triple purpos**

Essential traits

- Decentralize

Target ideotype **Triple purpos**

Essential traits

Development of new sorghum ideotypes

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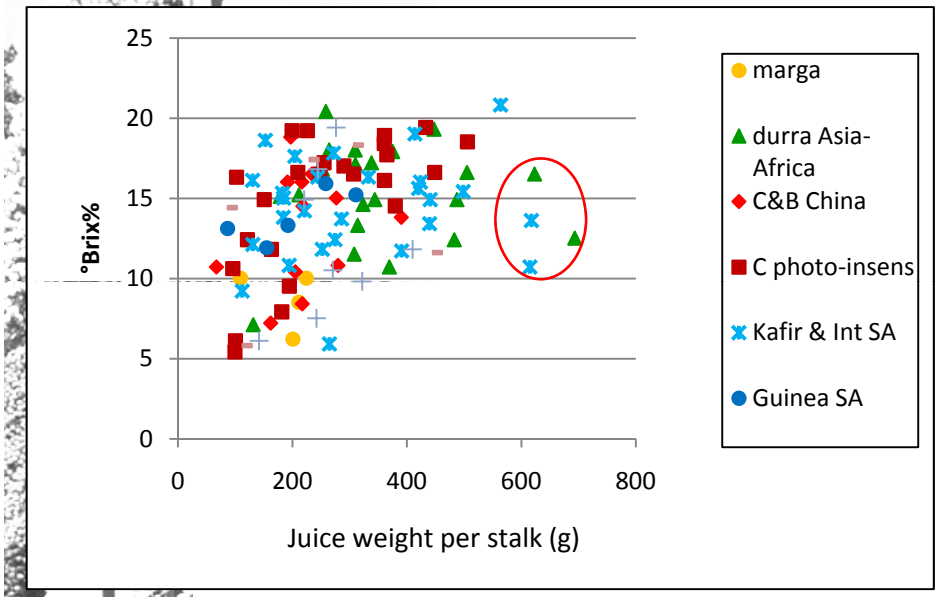
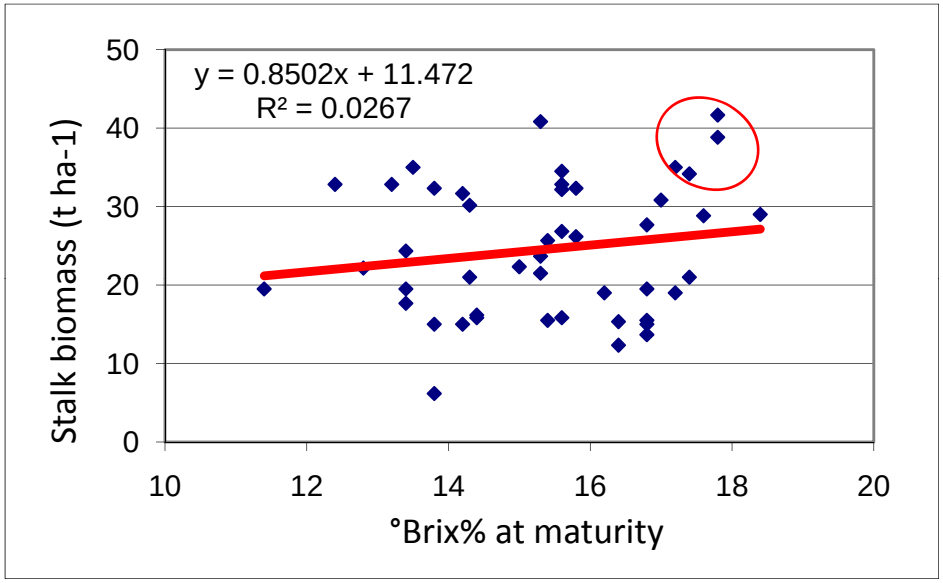


(source Grassbiofuel 2008)

46 lines



(source Nataima Colombia 2007)

Possible combination

°Brix% + juice
°Brix% + stalks biomass

Development of new sorghum ideotypes

Identification of the gene for tolerance to aluminum toxicity : ***Alt$_{SB}$***

→ and incorporation in the best lines in EMBRAPA

Develoment of new sorghum ideotypes

Tropical area

In India

EtOH 1st generation

+ anticipa

- Centralized syste ... p

Target ideotype: **Triple**

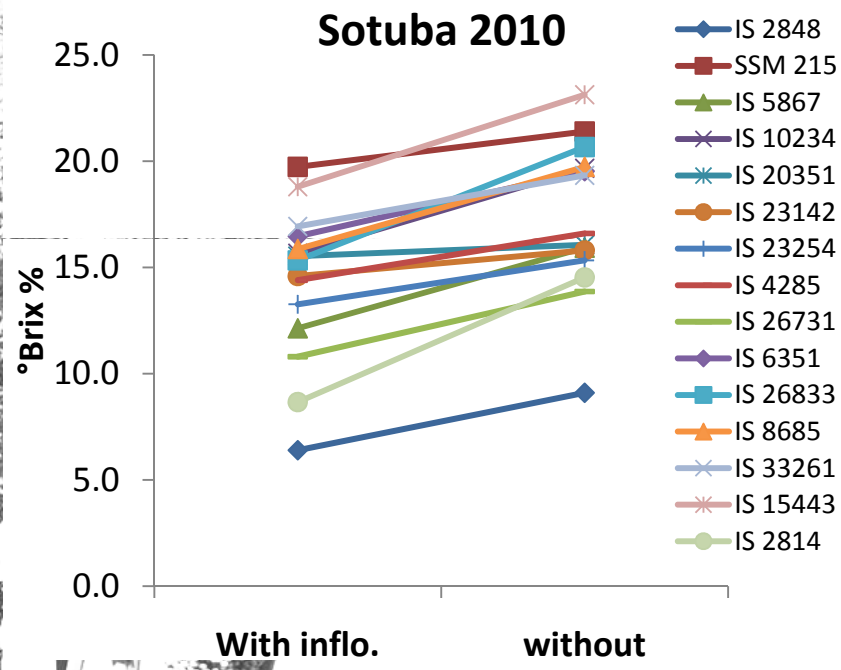
Essential traits

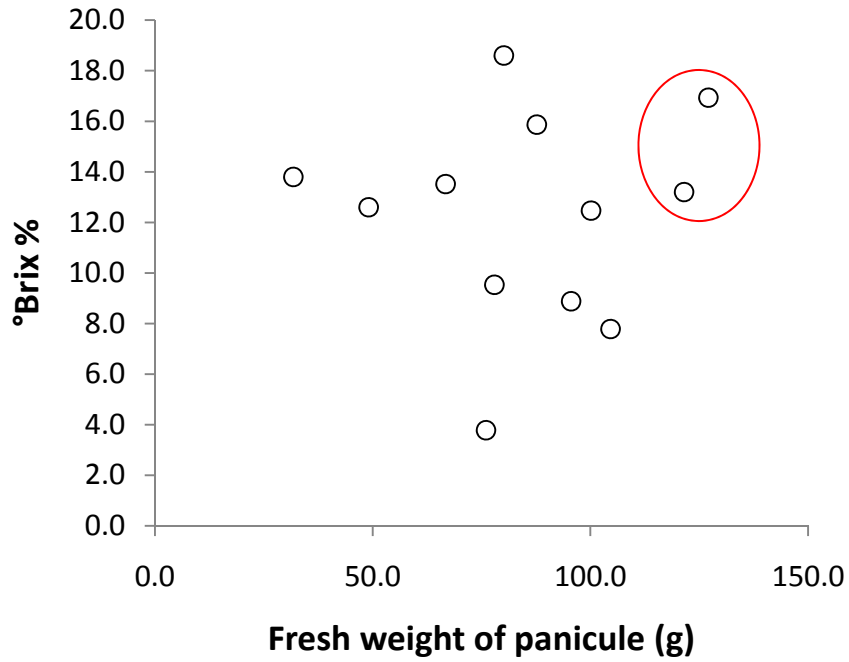
- Decentrali

Target ideotype **Triple p**

Essential traits

Development of new sorghum ideotypes





Source: Sweetfuel project / PhD S. Gutjahr

There is a competition °Brix% / grain, but also a great diversity

Development of new sorghum ideotypes

Identification of the best lines combining sugar and biomass

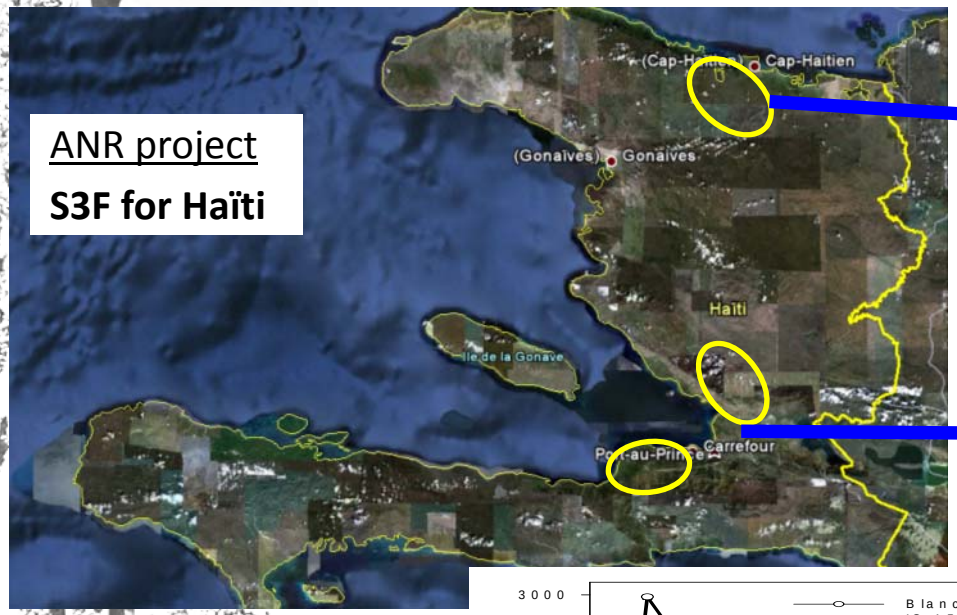
1.63 to 2.36 t ha^{-1} 8.25 to 72.43 t ha^{-1}

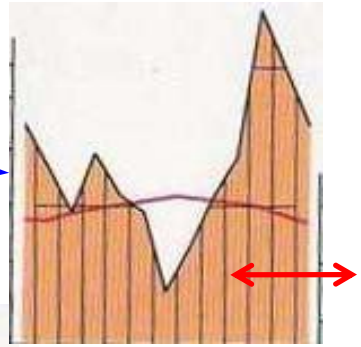
Identification 2 stay-green QTL lines S 35 SG 06002 and 19-S35 SG 06019 having °Brix% >15

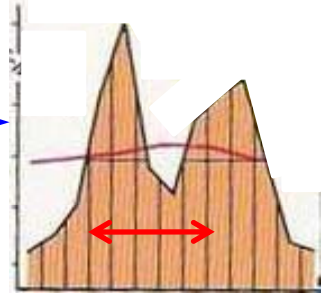
Development of new sorghum ideotypes

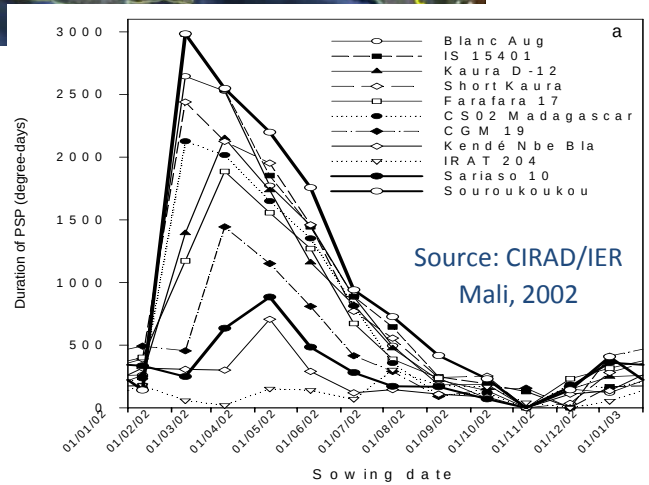
Case of Haïti

Target ideotype: triple purpose sorghum: grains + ethanol + fodder









Adapted phenology is essential

Development of a new sorghum model

SAMARA model is a new model for cereals (simulator of morpho-physiological adaptability to abiotic stresses, and of annual graminaea yield).

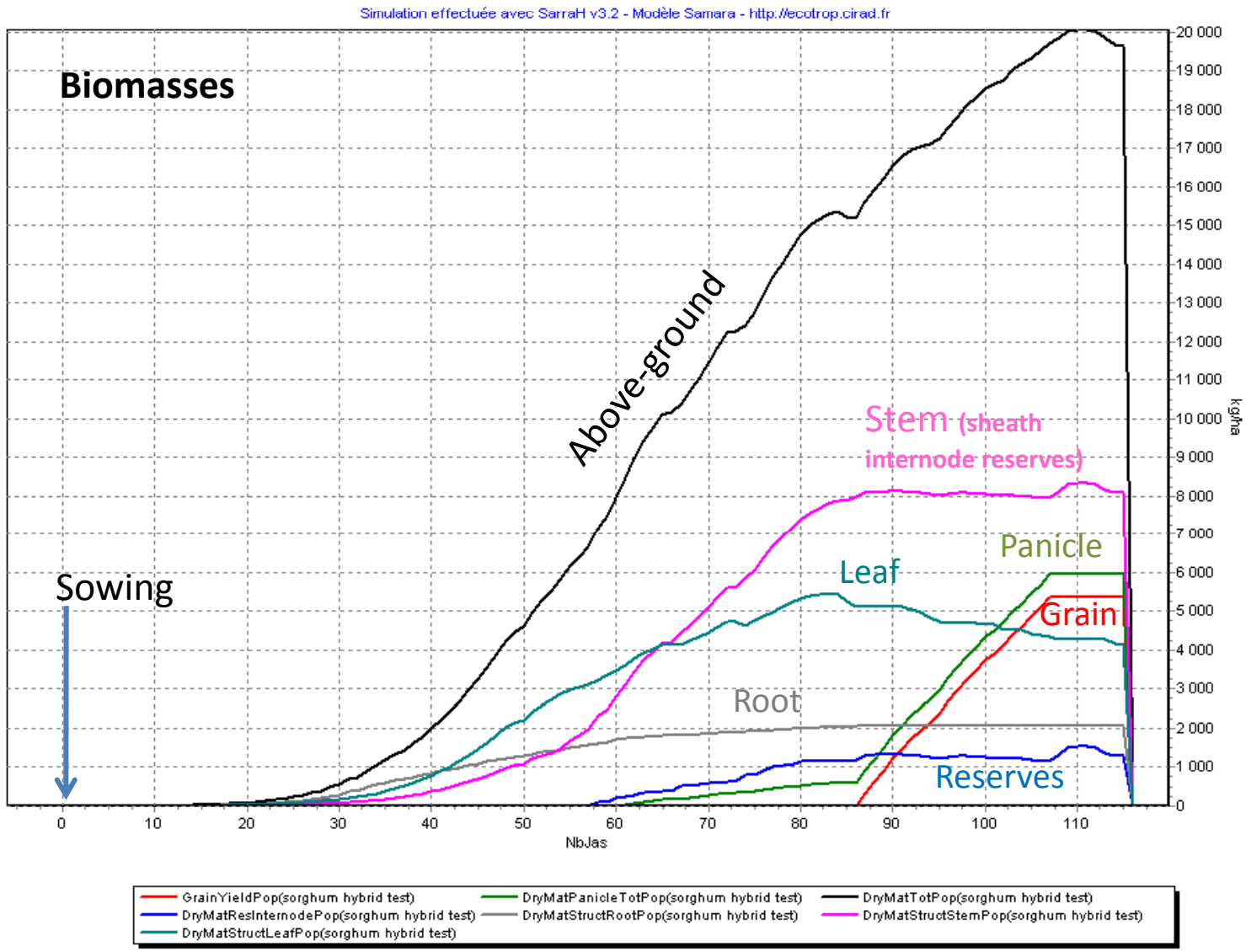
Objectives:

- identification of TPE, study the adaptation to CC and CV as well as interaction variety x cultural practice x environment…
- + conception of ideotypes and their adaptation to the environment
- (at plant canopy scale)

Main characteristics:

- based on ECOTROP software
- based on hydric balance and phenology module from SARRAH
- trophic relationships and competitions between organs are inspired by ECOMERISTEM

Development of a new sorghum model



Development of new sorghum model

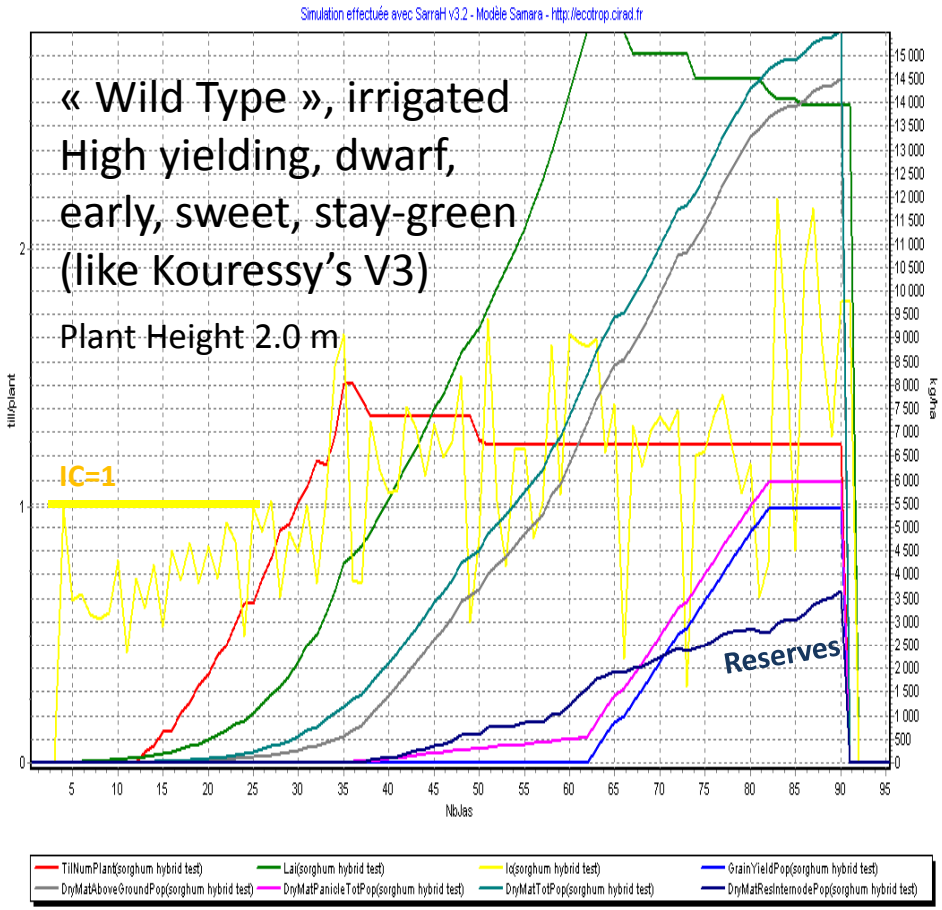
Sensitivity analysis were done by:

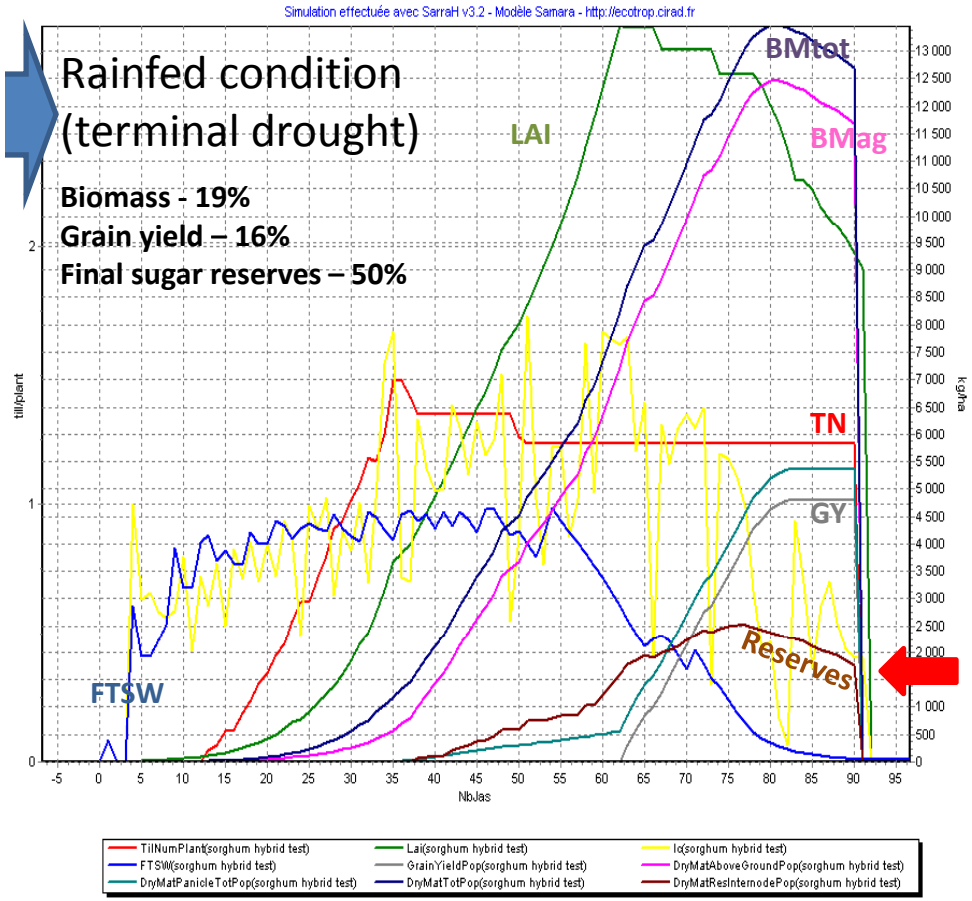
Modifying varietal parameters (plant height, cycle duration, stay green…)
or
agronomic practices (irrigation, plant density…)
or
combining 2 parameters (i.e. height + duration)

Analyzing evolution of output values (panicule and grain yield, total and above ground biomass, sugar yield, LAI, tillering, plant height etc…)

Development of a new sorghum model

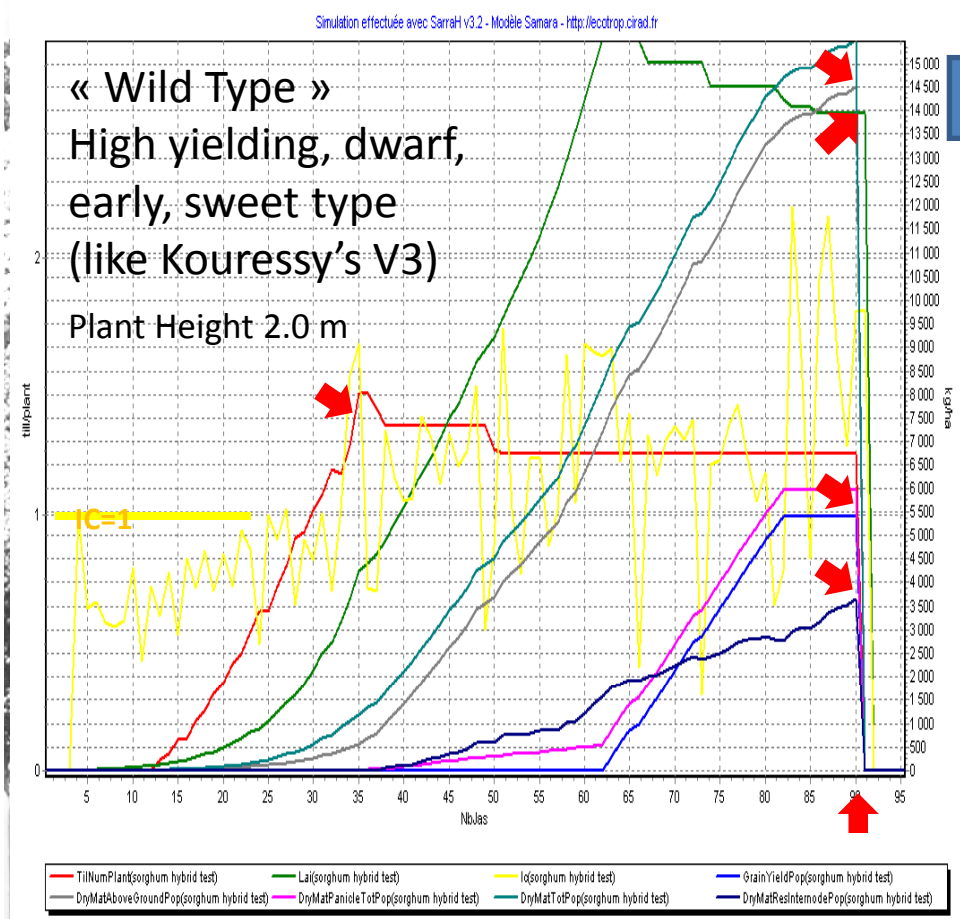
Effect of terminal drought

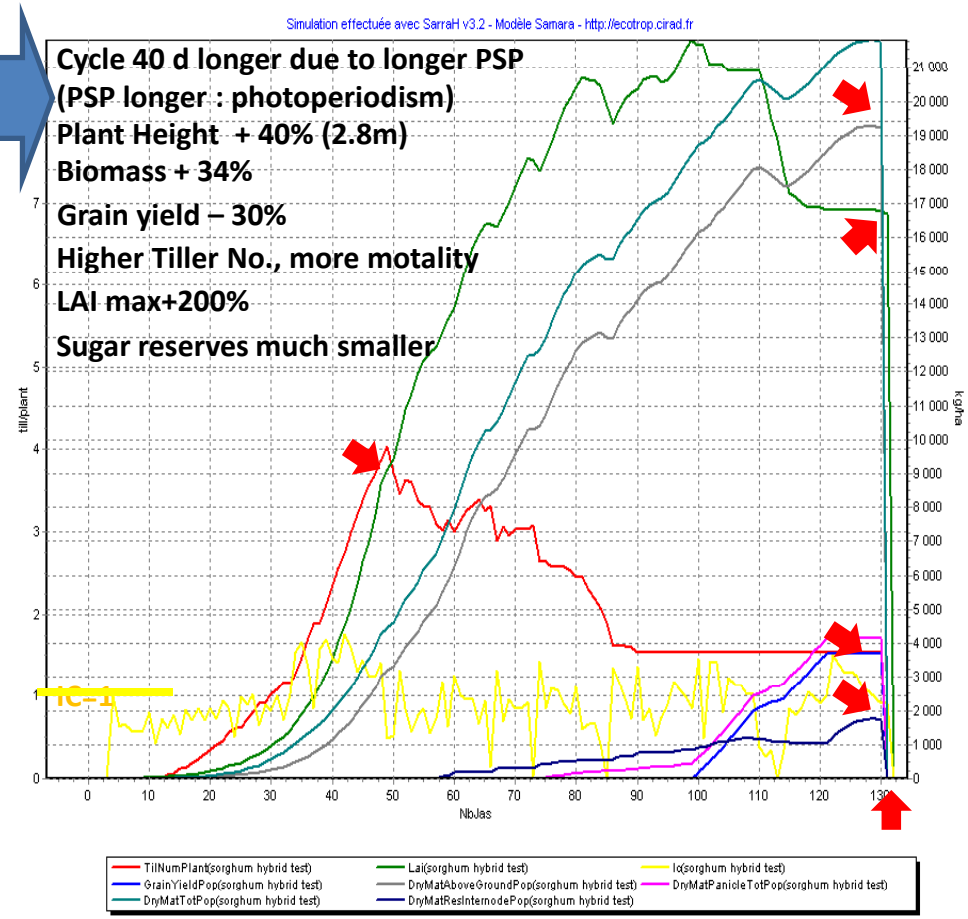


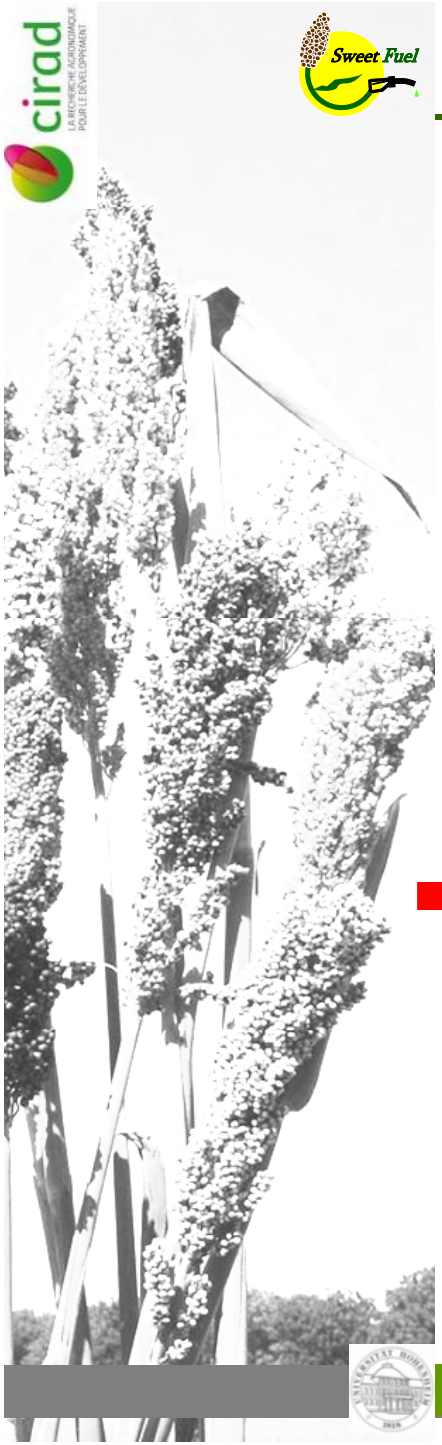


Development of a new sorghum model

Effect of lateness (photosensitivity)







Development of new sorghum model

Calibration of SAMARA for sorghum is possible in many different environments

Results from sensitivity analysis are quite conform to the reality on a qualitative basis

We must now conduct some specific trials to validate this model


Thank you for your attention
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www.sweetfuel-project.eu