Seventh framework programme
Food, Agriculture and Fisheries, and Biotechnology

Specific International Co-operation Actions
Small or medium scale focused research project

Sweet Fuel

Sweet Sorghum
an alternative energy Crop

Grant Agreement n° 227422

Deliverable 7.2:

Five final regional workshop reports

Composition of the consortium

CIRAD
ICRISAT
EMBRAPA
KWS
IFEU
UniBO
UCSC
ARC-GCI
UANL
WIP

During the project, five regional workshops were organized to promote the production of ethanol from sweet sorghum, in Brazil, Mexico, South Africa and Europe. The objectives of the workshops were to inform all stakeholders including representatives of National Agricultural Research Systems and/or Extension services, seed companies, farmers, farmers' organization, industrial sector, entrepreneurs, policy makers, on the opportunity to develop the production of bio-ethanol from sweet sorghum.

The first regional workshop was organized in Brazil, as things were moving fast there.

The second workshop was organized during in Monterrey the biennial Congress of the Mexican Society of Plant in September 2012.

The third one was organized in Potchefstroom (South Africa) in February 2013.

A Regional and a International workshops were organized in India in March 2014 at Icrisat-Hyderabad, just before the last annual meeting.

The last regional workshop was organized on 26th June 2014, as a satellite meeting of the 22nd European Biomass Conference and Exhibition.

Regional workshop in Brazil

Production of ethanol from sugar cane in Brazil is huge and the pressure from the government to increase it is important. Embrapa organized this workshop to inform the sugar cane sector that a scenario in which sweet sorghum complements the sugar cane production during the off season, could be an efficient solution to increase ethanol production without additional investments or additional extension of the sugar cane surfaces.
The Regional workshop was organized on the 20 and 21st of September 2011 at SeteLagoas and involved up to 90 persons from the private sector (sugar cane industrials, seeds Companies, agribusiness Companies...).

The three following documents were published from the workshop

Documentos

ISSN 1518-4277
Agosto, 2012 138

Sistema Agroindustrial do Sorgo Sacarino no Brasil e a Participação Público-Privada: Oportunidades, Perspectivas e Desafios

Embrapa

Documentos

ISSN 1518-4277
Agosto, 2012 139

Sistema Embrapa de Produção Agroindustrial de Sorgo Sacarino para Bioetanol Sistema BRS1G – Tecnologia Qualidade Embrapa

Embrapa

Regional workshop in Mexico

SYMPOSIUM ON BIOENERGY CROPS REPORT
MONTERREY, NUEVO LEÓN, MÉXICO
SEPTEMBER 22-24, 2012

During the SWEETFUEL project annual meeting held in April 2012 in Bologna, Italy, was requested by Dr. Francisco Zavala-Garcia (UANL-Monterrey, Mexico), the possibility of organize in advance the symposium scheduled for 2013, as part of the activities of this project. The main reason was that in September 2012, the UANL scheduled the organization of the biennial Congress of the Mexican Society of Plant which is normally attended by more than 500 people (mainly scientists and students) on a regular basis from all parts of the country. Therefore, it was considered advisable to make the symposium as part of this congress, taking advantage of the large number of researchers and the broader impact that could have this symposium on the scientific community and it would be of great value to publicize the activities of the SWEETFUEL Project in Mexico.

Because of the importance of Bioenergy at global scale, and the interest to have awakened these alternative energy sources in Mexico, the federal government initiated a series of activities in order to promote and organize the research and uses of these new alternative energy sources. To do this, one of the first steps was the establishment of policies that could regulate the generation and commercialization of biofuels.

Recently, the federal offices initiated research, aimed at defining the main alternative energy sources that could benefit Mexico, among which was considered the bioenergy from plants. The main crops that are currently under study are: for biodiesel are mainly Jatropha, Castor plant and oil palm, while for bioethanol the most important crops are Sugarcane, Sweet Sorghum and Sugar Beet.

Therefore, considering the importance of bioenergy in Mexico in general, it was decided to organize the symposium with the name BIOENERGY CROPS with the participation of experts in this area and dividing the symposium into four sections (Full program at Annex 1):

1. Mexican national policies aimed at promoting the use of Bioenergy in Mexico.
2. National research programs in bioenergy crops, mainly Jatropha, Castor Plant and Sweet sorghum.
3. Research and development in sweet sorghum:

A) SWEETFUEL Project. Participation of CIRAD, EMBRAPA and ICRISAT (all partners of the consorcium).

B) Sweet sorghum breeding programs of the University of Nebraska and the University of Texas A & M.

C) Research programs in sweet sorghum in Mexico.

D) Sweet Sorghum Ethanol Association in USA.

E) Participation of private companies in research and development in the use of sweet sorghum in Mexico.

4. Field Day.

The symposium was held on 22, 23 and 24 September in the city of Monterrey, Nuevo Leon, Mexico participating as principal organizer Universidad Autonoma de Nuevo Leon, (Member associate of the Sweefuel project), associated with the Mexican Society of Plant Breeding and Genetics (SOMEFI). The venue was the Faculty of Agronomy of the UANL and the Holiday Inn Crown Plaza on schedule which is attached.

The participants of the all congress were more than 500 people, specifically for the symposium on bioenergy crops, which developed simultaneously with other symposia; the attendees during all sessions were more than 50 people.

Regarding the field trip, the goal was to show some genetic material that are working within the SWEETFUELproject, particularly were showed the new hybrids and varieties that are been releasing as part of the activities of the UANL, also we include material from ICRISAT (also partner of SWEETFUEL project) to compare the genetic material. Genotypes from the University of Nebraska, national sorghum improvement programs and private companies were also included. During this field day was important the participation of students who are currently developing their thesis work as part of project activities SWEETFUEL.

The experimental field of the Faculty of Agronomy of the UANL, which took place the field, is located 40 km from the city of Monterrey and was attended by over 40 people from different national and foreign institutions participating in the symposium, including staff officers representing the Government of Mexico, associated with policy decisions regarding the use, research and development of biofuels.

Below are some images showing some of the activities during the symposium, either in oral presentations in the field trip.

ORAL AND POSTER SESIONS AS WELL AS FIELD VISIT





FIELD DAY:





Annex 1: Agenda of the meeting

XXIV Congreso Nacional y IV Internacional de Fitogenética
Septiembre 24-28 de 2012
Monterrey, N. L.

BIOFUEL CROPS SYMPOSIUM
PROGRAM
SEPTEMBER 24-26, 2012

MONDAY 24:

15:30 -15:45	Opening sesión
15:45-16:25	Bionergy law and policies for the production, use and marketing of biofuels in México. *Jaime Antonio Paz Arrezola. SNITT. SAGARPA.*
16:25-17:05	National net of research and innovation in bioneregy. *Alfredo Zamarripa Colmenero.INIFAP. SAGARAPA.*
17:05-17:45	Potential use and market of biofuels in México. *Rembio*
17:45-18:00	Break
18:00-18:40	Jatropha bioenergy crop in México. *Guadalupe López Puc. CIATEJ.*
18:40-19:20	Commercial production of bioenergy in México. Jatropha case. *Biodiesel Chiapas (to confirm)*

TUESDAY 25:

9:00-9:35	Moringa bioenergy crop in México. *Biaani Martínez Valencia. INIFAP. SAGARPA*
9:35-10:10	Castor plant bionergy crop in México. *Maria Antonieta Goytia Jimenez. UACH*
10:10-10:45	Sweet sorghum bionergy crop in México. *Noe Monetes García. INIFAP. SAGARPA*
10:45-11:40	Poster session and break
11:40-12:15	Sweetfuel project. Sweet sorghum for ethanol production. *Serge Braconnier. CIRAD. Francia.*
12:15-12:50	Sweet sorghum for ethanol production in Brasil. *Bob Schaffert. EMBRAPA. Brasil.*
12:50-13:25	Sweet sorghum for ethanol production in Asia. *Srinivasa Rao. ICRISAT. India*
13:25-15:00	Meals
15:00-15:35	Sweet sorghum breeding program in Nebraska. *Ismail Dweikat. University of Nebraska, USA.*
15:35-16:10	Sweet sorghum breeding program in Texas A & M. *Bill Rooney. Texas A & M University. , USA*
16:10-16:45	Sweet Sorghum Ethanol Association. *Scott Gibson, USA*
16:45-17:40	Poster session and break.
17:40-18:15	Seed demand for bioenergy crops. Enphasis in sweet sorghum. *Julian Barrera Sánchez. ENERALL.*
18:15-18:50	Semicormercial production of sweet sorghum for bioethanol. *Agricultor Cooperante.*
18:50-19:25	Infraestructure needs for bioethanol production using sweet sorghum. *Tranquilino Najera. THAES*

WEDNESDAY 26:
8:00-13:00 Field day

Campus de Ciencias Agropecuarias de la U.A.N.L.
General Escobedo, N. L.
Tel: 83294000 Ext .3515 y 3516
somefi.uanl@gmail.com
www.somefi.mx

Regional workshop in South Africa

Sweetfuel Farmer's Day, 21 February 2013 report

A successful Sweetfuel Workshop/Farmers' day was held at the ARC-GCI, Potchefstroom on 21 February 2013. The Workshop/Farmers' day is a deliverable of the EU's DoW (Description of the work) Sweetfuel FP 7 programme.

The Sweetfuel Programme has 8 work programmes (WP's) and ARC is involved in 3 of them: WP1 "breeding for temperate environments", WP2 "breeding for drought prone environments" and WP5 package production and crop modelling" (agronomical aspects: cultivar evaluations, harvesting techniques).

The main aim of the Workshop/Farmers' day was to reach farmers and to introduce the Sweetfuel: bioethanol programme to them and other stakeholders and to discuss on ways how all can get involved in the new value chain.

Information was shared with 55 attendees (see annex 1) regarding the new direction of the biofuel strategy in South Africa and the agronomical aspects of sweet sorghum, processing thereof, etc. Attendees represented people across the biofuel industry, tertiary institutions and farmers.

This day was organized in two sessions: the first dedicated to presentations in meeting room (photo 1 and 2), and the second for visit of field trials at ARC (photo 3 and 4).

Agenda of the presentations:

- Dr KingstoneMashingaidze - ARC Division Manager: Plant Breeding, welcomed all present.
- Dr S Braconnier from CIRAD/France (coordinator: Sweetfuel Project) introduced the attendees to the whole Sweetfuel concept and the applications thereof as potential bio-ethanol crop and additional applications such as animal feed crop and as a source of starch and nutritional value to human consumption.
- Dr G Reinhardt from Germany (WP6 leader) addressed the issue regarding the sustainability of biofuels from sorghum (photo 2).
- Dr I Chiyanzu and Me B Ndaba from the North West University, Potchefstroom explained the technological processes involved in bio-ethanol production.
- Mr W Snijman introduced the agronomical programme of the ARC-GCI involving the investigation into sweet sorghum cultivars adaptation to various climatic regions.

Topics and discussions covered the biofuel spectrum regarding sorghum as potential bio-ethanol crop and the ARC-GCI's role in the whole production chain of bio-ethanol. Although the emphasis has moved to grain sorghum, the ARC has already established

itself as one of the major role players in the biofuel strategy and industry in South Africa.

A lively discussion followed when the floor was opened to the attendees. Matters of concern which were brought up were:

- the sustainability of biofuels in South Africa
- what is in it for the farmers
- when will the production of biofuels and blending start
- what will be the cost involved

It was discussed about the current initiative in South Africa in the domain of bio ethanol. Soon five plants dedicated to ethanol production, should be operational in South Africa, one at Bothaville, Free State Province and the others in Cradock, Eastern Cape Province.

Based on the information available, it seems that ethanol will be produced from starch feedstock (except corn), which means that sweet sorghum is not included in the scheme of production. But all the rules are not known yet. From a previous meeting in the Mpumalanga Province a day before, it seems that the government will impose specific rules for biofuels production, particularly taking into account the water resource. This meeting as well as the farmers' day in Potchefstroom showed that many farmers are quite interested in biofuel production, but all are waiting for a support from the government.

During the field visit Dr Nemera Shargie demonstrated the promising sweet sorghum varieties, field evaluation and juice extraction procedures (photo3) to the group (Photo 4).

The ARC will benefit from this programme as being a leader in the bio-ethanol production industry and future projects. To create income from the biofuel activities in South Africa will be a definite spin-off. After the farmers' day a number of individuals showed interest in the project. Two lecturers from the University of Limpopo asked to network with the ARC. The *LandbouWeekblad* and *Splipunt* indicated their interest to publish articles regarding the Workshop/Farmers' Day.

Based on the work done in SWEETFUEL, especially in WP6, this project could release some policy recommendation for developing the ethanol chain production in South Africa.

Photo 1

Photo 2

Photo 3

Photo 4

Annex 1: list of attendees

ARC • LNR

Excellence in Research and Development

Sweet Fuel

Sweet Sorghum an alternative energy Crop

SEVENTH FRAMEWORK PROGRAMME N° 227422

Sweet Sorghum Workshop/ Farmers' Day, ARC-GCI Potchefstroom

Registration Form

	Name & Surname	Tel/cell no:	Email address	Signature
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Sweet Fuel

Sweet Sorghum an alternative energy Crop

SEVENTH FRAMEWORK PROGRAMME

N° 227422

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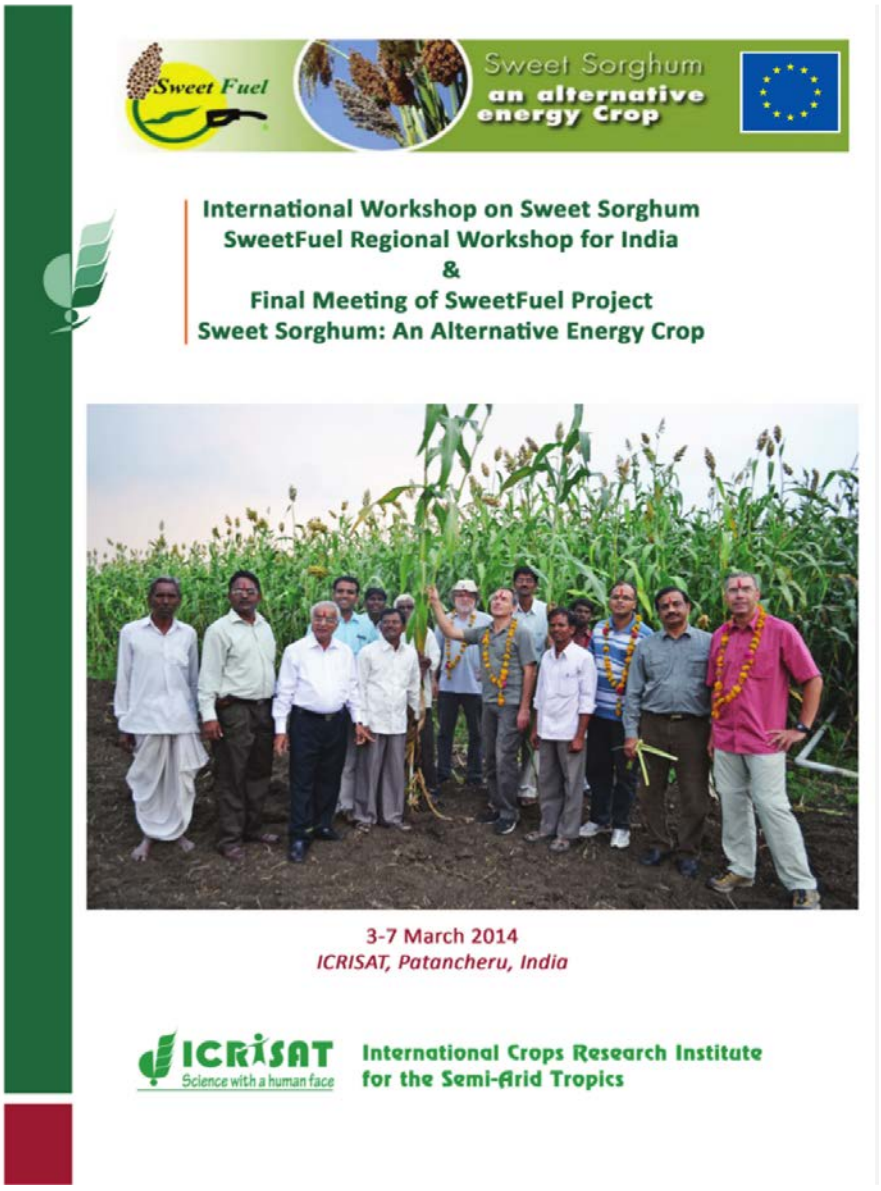
Regional workshop in India

The event was organized at ICRISAT Centre-Hyderabad on March 4th, 2014. During the same week also happened an International Workshop on sweet sorghum (March 3rd, 2014) and the last annual meeting of Sweetfuel project (5-7 March 2014).

More than 80 peoples attended the two workshops, coming from India, Kazakhstan, Zambia, Senegal, South Africa, Colombia, Mexico, Brazil, Haïti, Philippines, USA, Germany, Italy, and France. We had also some video talks from China, USA and Canada.

During the first session, a Policy Brief for sweet sorghum value chain, produced by ICRISAT was released (see document here after).

Progamme of the Regional Workshop



March 4 2014

Regional workshop Agenda

CHAIR : JASWINDER SINGH **RAPPORTEUR: RAMILAN T**

09:00 **DBT ROLE- SWEET SORGHUM ECONOMY**
SANGITA KASTURI, PSO, DBT, GOVT. OF INDIA

09:25 **EXPERIENCE WITH SWEET SORGHUM**
SATYADEV, ADVANTA INC, INDIA

09:45 **ENABLING BIOECONOMY THROUGH INDUSTRIAL BIOTECHNOLOGY**
RANJAN PATNAIAK, DKC, DUPONT INC

10:05 **DISCUSSION**

10:30	***Coffee/Tea Break***	***212 Buld***

10:45 **SWEET SORGHUM UTILIZATION FOR LIVESTOCK**
MICHAEL BLUMMEL, ILRI

11:15 **SWEET SORGHUM-NARS CONTRIBUTION IN INDIA**
JV PATIL AND AV UMAKANTH, DSR

11:45 ***The Status and Future of sweet sorghum value chain***
Chair: STEFANIO GRANDO, DIRECTOR, RPDC
Moderators: RAINER JANSSEN, WIP AND P. SRINIVASA RAO, ICRISAT

Panellists:
- BANIBRATA PANDEY, NFCL, INDIA
- NEMERA SHARGI, SOUTH AFRICA
- JASWINDER SINGH, UNIVERSITY OF MONTREAL, CANADA
- PARTHASARATHY RAO, ICRISAT , INDIA
- JV PATIL, DSR, INDIA
- Geraldine Sanchez, Philippines

13:00	***Lunch***	***204 Banquet Hall***

14:00 **VISIT TO SWEET SORGHUM FIELDS- ICRISAT**
P. SRINIVASA RAO, ICRISAT

Policy Brief for sweet sorghum value chain

Policy Options for Promotion of Alternate Feedstocks for Ethanol Production in India: Sweet Sorghum for Ethanol Production

Policy Brief 24
October 2013

G Basavaraj, P Parthasarathy Rao, BVS Reddy, A Ashok Kumar, Cynthia Bantilan, Ch Ravinder Reddy and P Srinivasa Rao

Introduction

To ensure the long-term sustainability of bioethanol production in the semi-arid tropics of India this brief explores the option for augmenting bioethanol production using alternative feedstock like sweet sorghum grown in the drylands in addition to use of existing feedstocks. Policy options for the promotion of alternative feedstocks to sustain the bioethanol supply chain for the benefit of all stakeholders involved in the chain are highlighted and discussed.

Background

Energy consumption is one of the major indicators of the country's economic progress and its use increases with economic growth and development. India ranks sixth in terms of energy demand accounting for 3.6% of the global energy demand (Prasad et al. 2007) and this is expected to increase by 4.8% per annum in the next few years (Gonsalves 2006). India's energy demand is primarily met through nonrenewable energy sources such as coal, natural gas and oil that will continue to play a dominant role in the country's energy scenario in the next few decades. However, being short in domestic production, India mainly depends on crude oil imports that account for about 81% of the oil consumption in the country (Ministry of Petroleum and Natural Gas, 2009) and the imports are slated to increase further with the growth in the economy. The highest demand for energy comes from industry, followed by the transportation sector, which consumed about 16.9% (36.5 m of oil equivalent) of the total energy (217 million t) in 2005-06 (TERI 2007). Within the transportation sector, the consumption of motor spirit (gasoline) grew by 6.64%, from 7.01 million t in 2001-02 to 11.26 million t in 2008-09 and that of high speed diesel (HSD) by 4.1%, from 36.55 million t to 51.67 million t, respectively (GOI 2009). Amid the growing demand for crude, the prices of crude too are increasing and fluctuating, putting a strain on the foreign exchange reserve of the country (import bill of $75.6 billion in 2009-10). Further, increased emissions from usage of fossil fuels are leading to environmental pollution, which is a major cause of concern. Hence, in lieu of the growing concerns of energy security (due to high dependency on fossil fuels) and environmental pollution, securing long-term supply of energy sources that are renewable and non-polluting has been the major thrust of many governments all over the globe, including the Government of India.

Among several alternative renewable energy sources (wind, solar, hydro), energy derived from plant biomass is found to be promising and a sustainable energy source that contributes to reduction in greenhouse gas emissions (Subramanian et al. 2005). Bioenergy derived from plant based biofuels are also found to provide a wide range of social and economic benefits (Gonsalves 2006, Rajgopal 2008). Hence, to promote biofuels as an alternative energy source, the Government of India in December 2009 announced a comprehensive National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE), calling for blending atleast 20% of biofuels with diesel (biodiesel) and petrol (bioethanol) by 2017. The policies are designed to facilitate and bring about optimal development and utilization of indigenous biomass feedstocks for biofuel production.

However, experience has shown that the Government's initiatives have not translated into results on the production and commercialization fronts to meet the country's energy demand through biofuels due to ineffective policy implementation.

This paper highlights the challenges affecting biofuel production particularly for bioethanol and discusses

Policy Brief Release

Photo of the group

Regional workshop for Europe

SWEETFUEL Regional Stakeholder Workshop

Energy Sorghum –
An Alternative Energy Crop for Industrial Use

26th June 2013, 10:15 – 15:00

Hamburg, Germany

on the occasion of the 22nd European Biomass Conference and Exhibition

Workshop Report

SWEETFUEL is co-funded by the European Commission in the 7th Framework Programme (Project No. FP7-227422) – www.sweetfuel-project.eu

The SWEETFUEL Project

The energy crop sweet sorghum (Sorghum bicolor L. Moench) is raising considerable interest as a source of either fermentable free sugars or lignocellulosic feedstock with the potential to produce fuel, food, feed and a variety of other products. Sweet sorghum is a C4 plant with many potential advantages, including high water, nitrogen and radiation use efficiency, broad agro-ecological adaptation as well as a rich genetic diversity for useful traits. For developing countries sweet sorghum provides opportunities for the simultaneous production of food and bioenergy (e.g. bio-ethanol), contributing to increase access to renewable energy sources without compromising food security. In temperate and usually more industrialised regions (e.g. in Europe) sweet sorghum is seen as promising crop for the production of raw material for 2nd generation bio-ethanol or bio-methan.
The project SWEETFUEL (Sweet Sorghum: An alternative energy crop) is supported by the European Commission in the 7th Framework Programme to exploit the advantages of sorghum as potential energy crop for bio-ethanol production. Thereby, the main objective of SWEETFUEL is to breed for improved varieties and hybrids of sorghum for temperate, tropical semi-arid and tropical acid-soil environments. Breeding aims include, depending on region and ideotype, improved tolerance to cold, drought and acid (Al-toxic) soils as well as high production of stalk sugars, easily digestible biomass and grain.
SWEETFUEL outcomes include new germplasm, improvement of cultural and harvest practices as well as commodity chain concepts adapted to target regions within Europe, Latin America, Asia and Africa.

SWEETFUEL Consortium

The SWEETFUEL partnership is coordinated by the Centre International en Recherche Agronomique pour le Développement (CIRAD) from France and comprises the following 10 partners from research, academia and industry:

- CIRAD (coordinator), France
- ICRISAT - International Crops Research Institute for Semi-Arid Tropics, India
- EMBRAPA Maize and Sorghum, Brazil
- KWS SAAT AG, Germany
- IFEU Institute, Germany
- Universita di Bologna (UNIBO), Italy
- Universita Cattolica del Sacro Cuore (UCSC), Italy
- Agricultural Research Council (ARC) – Grain Crop Institute (GCI), South Africa
- Universidad Autónoma de Nuevo León (UANL), Mexico
- WIP Renewable Energies, Germany

SWEETFUEL Coordination

CIRAD, Centre de coopération internationale en recherche
agronomique pour le développement, France
Serge Braconnier
Email: serge.braconnier@cirad.fr
Phone: +33 467 61 7539

Workshop Objectives

In this workshop activities and findings of the SWEETFUEL project will be discussed with international stakeholders representing feedstock suppliers, entrepreneurs, NGO's, policymakers, and agricultural research institutions.
Specific emphasis will be placed on the opportunities and challenges of energy sorghum breeding for industrial applications (e.g. biogas and lignocellulosic ethanol production) in Europe.

Workshop Organisation

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CIRAD, Centre de coopération internationale en recherche agronomique pour le développement, France
Serge Braconnier
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Workshop Details

Conference Venue:	*CCH – Congress Center Hamburg, Hamburg, Germany on the occasion of the 22nd European Biomass Conference and Exhibition (EU BC&E) in Hamburg on 23-26 June 2014*
Conference Language:	*English*
Project website:	*www.sweetfuel-project.eu*

Workshop Report

The SWEETFUEL Regional Stakeholder Workshop in Hamburg was opened by **Rainer Janssen** from WIP Renewable Energies, Germany. Mr. Janssen highlighted the excellent cooperation among all SWEETFUEL project partners during the past five years and underlined the importance to continue breeding efforts on energy sorghum despite the current lack of political support for energy crops in Europe. Due to the long time span required for breeding of improved energy crop varieties, continuity of research and development is urgently needed to meet potential future demands within a global bio-based economy.

Serge Braconnier, SWEETFUEL coordinator from CIRAD, France provided an overview on main activities and results of the SWEETFUEL project. With respect to ***new sorghum lines or hybrids for temperate zones***, project partners have developed new male lines for hybrid biomass sorghum, new female A/B early lines for hybrid biomass sorghum, and new female A/B lines with low lignin content.

For semi-arid tropics, new sorghum lines or hybrids include four sweet sorghum varieties available at commercial level in Brazil (i.e. BRS 506, BRS 508, BRS 509 and BRS 511), new hybrids adapted to different cropping seasons in India (i.e. ICSV 93046, ICSV 25311 + ICSV 25308 adapted to terminal stress and ICSV 25300 adapted to mid-cycle stress), five dossiers submitted to record new sweet material in the national catalogue in Mexico, as well as five sweet cultivars available in South Africa.

For each scientific SWEETFUEL result ***Exploitation Flyers*** have been elaborated and a ***Handbook "Energy Sorghum - an alternative energy crop"*** was published in June 2014. These publications are available at the project website www.sweetfuel-project.eu.

In conclusion, Mr. Braconnier stated that (sweet or biomass) sorghum is an efficient crop for producing energy (biogas, biomethane, bioethanol, heat), but due to its seasonality it must be combined with another crop. Its efficiency, its impacts on environment (LCA, GHG balance, energy balance) depend on biomass production and transformation processes, as well as the specific location of the production system.

Magdalena Chobotova from KWS Mais GmbH, Germany presented an industry perspective on the breeding of energy sorghum for temperate climates. Based on incentives provided by the German Renewable Energy Sources Act (EEG, Novelle 2004), breeding of energy sorghum in KWS started in 2007. Main breeding targets include a potential yield comparable to energy maize (also on sandy soils), high biomass yield (high dry matter yield: 25 - 30 t/ha at 600 mm rain per year, dry matter content at harvest: 28%), stability, fast young development (increase of cold tolerance, fast and homogenous germination power), as well as disease resistance.

Mrs. Chobotova provided an overview of KWS breeding locations in Germany and Italy as well as results from the breeding programme for the years 2007-2011 showing improved dry matter yield and dry matter content at harvest. However, the target values have not been achieved yet and improvements are still required with respect to lodging tolerance and early vigour (cold tolerance).

The following five important steps for successful biomass sorghum growing have been identified by KWS:

(1) ***Location choice***: warm soils, light soils (sandy soils are better than clay and heavy soils), no areas with high grass pressure, soil analysis necessary (pH value, nutrition in soil).

(2) ***Seed bed preparation***: very precise seed bed preparation, soil preparation after rye, direct sowing after rye not recomended, soil pressure after sowing necessary.

(3) ***Sowing***: right choice of machinery, temperature of soil (min 12°C in 10 cm depth), sowing depth of 3-5 cm, max. 150 kg of nitrogen fertiliser per ha (lodging risk at higher fertiliser rate), row distance of 22-45 cm.

(4) ***Weed control***: correct herbicide (mixture) selection and timing

(5) ***Optimal harvest time***: panicles are open, kernels on panicles are developing, maturity of kernels between milk and waxy stadium.

Guido Reinhardt from IFEU, Germany presented results from the environmental assessment performed in the framework of the SWEETFUEL project. The full "Report on Environmental Assessment" is available at the project website www.sweetfuel-project.eu. For the assessment the following energy sorghum scenarios were investigated:

(1) Biomass Sorghum: ***Biogas*** (Cultivation of biomass sorghum on idle land, biogas or biomethane production, temperate climate zones)

(2) Sweet Sorghum: ***Cane fallow*** (Intercropping between two sugar cane cycles instead of peanuts/soy, subtropical to tropical climate)

(3) Sweet Sorghum: ***Grain – food*** (Replacement of grain sorghum cultivation, semi-arid climate)

(4) Sweet Sorghum: ***Syrup*** (Replacement of e.g. cotton cultivation, decentralised syrup production, centralised ethanol production, subtropical to tropical climate)

The Life Cycle Assessment (LCA) for all energy sorghum scenarios shows environmental advantages as well as environmental burdens, following the same pattern observed for other biofuels. Energy sorghum LCA displays a remarkable bandwidth of results depending on specific conditions, and thus a large potential for optimisation was identified. With respect to GHG balances of the "Biogas" scenario the following results were obtained:

- The higher the biomass yields the more greenhouse gases can be saved. Breeding efforts should focus on optimised crop cultivars. Cultivation methods should aim at highest yields possible.
- Digestate storage tanks should be covered and sealed gas-tight.
- The digestate should be incorporated into the soil as fast as possible.
- If biogas is further refined into biomethane, the use of biomethane in a combined heat and power unit should be favoured over a use as natural gas substitute or fuel.
- Direct combustion in CHP units is favourable compared to the "Biogas" scenario, whereas the production of second generation biofuels is less attractive.

Rafael Parrella from EMBRAPA Maize and Sorghum, Brazil reported on ethanol production from sweet sorghum in Brazil. For industrial application in the sugarcane sector sweet sorghum is being proposed to be planted at the beginning of the rainy season in areas of sugarcane renovation (see Figure 1) to increase the period of operation of large distilleries in Brazil by up to 100 days (initially 15 - 60 days).

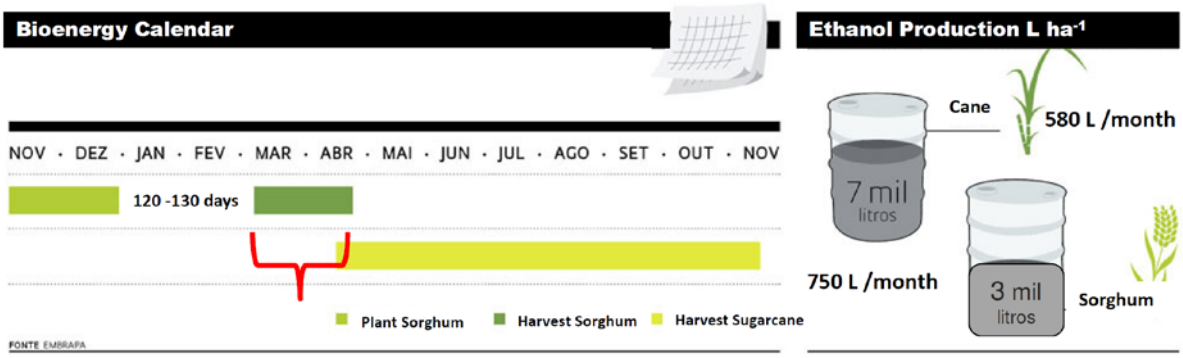

Figure 1: Industrial application of sweet sorghum in the sugarcane sector

The following minimum economic thresholds for industrial application of sweet sorghum in the sugarcane sector are estimated:

- Biomass production (t/ha): >60 (value achieved 2013/2014: >50)
- Total sugar (% juice): >14 (2013/2014: >12.5)
- Ethanol production (l/t): >70 (2013/2014: >60)
- Ethanol production (l/ha): >4200 (2013/2014: >3000)
- Period of Industrial Utilisation (PIU) (days): >30 (2013/2014: >30)

In the past years EMBRAPA has released several improved sweet sorghum varieties (BRS 506, 508, 509 and 511) with the following production system recommendations:

- Best row spacing: 0.5 or 0.7 m
- Best plant density: 120,000 to 140,000 plants per ha
- Nitrogen: 120 kg per ha (40 kg at planting and 80 kg at 4 leaf stage)
- Insect control when necessary

In order to facilitate industrial application, however, further improvements on sweet sorghum hybrids are necessary especially with respect to an increased Period of Industrial Utilisation (PIU). The main challenge thereby is to develop sweet sorghum A and B lines that are juicy, sweet and produce hybrids with small panicles. For applications in Brazil the “ideal” sweet sorghum idiotype has a small panicle (less lodging, less competition with sugar accumulation, and reduced harvesting and processing complications) and no tillering (better control of stem population, larger stem diameter, better juice quality).

Recently, there is also growing demand in Brazil for biomass sorghum for the production of process steam and electricity in industrial CHP applications. New biomass sorghum hybrids have been developed by EMBRAPA including the new hybrid CMSXS7015 validated in early 2014.

The **panel discussion on "Sweet Sorghum Valorisation in Semi-arid Tropics – Food and Fuel Production"** was moderated by Serge Braconnier from CIRAD, France and included the following panellists:

- Srinivas Rao, ICRISAT, India
- Francisco Zavala-Garcia, Universidad Autónoma de Nuevo León, Mexico
- Wikus Snijman, Agricultural Research Council, South Africa
- S.Z. Li, Tsinghua University, China

Srinivas Rao from ICRISAT, India presented results from two sweet sorghum demonstration activities in Hupari and Shirol, both in the sugar bowl area of Maharashtra (located between Hyderabad and Mumbai). Economic calculations showed significant potential retuns on investment for distilleries as well as farmers involved in the sweet sorghum demonstration trials.

Francisco Zavala-Garcia from the Universidad Autónoma de Nuevo León, Mexico highlighted the need for combined grain and ethanol production in Mexico as the country is dependent on grain imports. Recent legislation mandates blending of ethanol in gasoline in three major cities whereas the production of ethanol from grain is forbidden in Mexico. Thus, opportunities for sweet sorghum as dual purpose crop may arise, even though the current price level for ethanol set by the national petrol company PEMEX is too low to stimulate investment.

Wikus Snijman from the Agricultural Research Council, South Africa reported on the rather low interest in sweet sorghum in South Africa during the past years. This, however, may change due to the mandatory blending (5% biodiesel, 2-10% bioethanol) adopted in 2013 which will be effected from October 2015. Even though the currently identified feedstock for ethanol production is sugarcane and sugar beet, opportunities may exist for sweet sorghum due to the South African focus on rural development and areas under-used for existing agriculture.

Shi-Zhong Li from Tsinghua University, China presented an innovative technology for the production of ethanol from sweet sorghum, namely the Advanced Solid State Fermentation (ASSF) which has already been successfully demonstrated in China. Advantages of the ASSF technology include a reduced fermentation time, lower water consumption and waste water levels, reduced energy consumption as well as overall lower investment costs. Recently, Mr. Li is engaged in establishing a cooperation for the implementation of sweet sorghum based ethanol production in South Africa. By using 1.5 million ha of potentially available arable land (9% of the total) in South Africa to grow sweet sorghum, 10 million tons of ethanol, 4.5 million tons of sorghum grain, and 20 billion kWh of electricity (sold to the national grid) may be produced, leading to the creation of 100,000 jobs in the ethanol industry sector and 500,000 jobs in the agriculture sector.

Walter Zegada-Lizerazu from University of Bologna, Italy reported findings on the agronomy of energy sorghum in temperate climates. With respect to sowing, a well cultivated seed bed is needed and sowing depths of 2.5 to 3.5 cm are recommended. Maize planters can be used for energy sorghum and no-tillage sowing is possible. Furthermore, early spring sowing is not recommended due to low cold tolerance and reduced growth rates and late spring sowing is not recommended due to the reduced effective growing season. With respect to nutrient management, energy sorghum shows low fertilization requirements (~ 40% < maize), lower N uptake, and more N uptake at later growth stages. Excessive N fertilization can reduce biomass yields, juice quality, and ethanol yields. Several harvesters are being tested worldwide, but harvesting machinery for energy sorghum still needs to be improved. The fast decay of the harvested material constitutes a major problem for energy sorghum production systems.

In the field of agronomy the current main bottlenecks are limited availability of certified commercial seeds, the need for improved genotypes for different environments, soil conditions, and available agro-techniques, as well as the lack of appropriate harvest and post-harvest logistic systems.

Karen Zeise from the Bavarian Technology and Support Centre (TFZ), Germany presented recent developments on biomass sorghum for biogas in Germany. Stimulated by the favourable feed-in tariffs for biogas units established in the Renewable Energy Sources Act (EEG), Germany is currently dominating the primary energy production from biogas in Europe with more than 7500 biogas plants in operation in 2014. The increase of cultivation area under silage maize in Germany lead to problems with respect to public perception (“maize encroachment”) as well as impacts on occurrence of pests and diseases, soil structure and organic matter content.

The diversification of crops, the cultivation of alternative crops, as well as mixed cropping, intercropping and catch cropping systems are promoted in order to reduce energy maize cultivation. Mrs. Zeise presented results from energy sorghum field experiments performed at TFZ including an analysis of the methane yield of different sorghum

varieties. Further developments are still required with respect to lodging resistance and early maturing cultivars. Thereby, extensive instead of intensive cultivation systems should be targeted and strategies for fertilizer use, soil preparation, sowing and designing crop rotation shall focus on benefitting from the higher nutrient and water efficiency of sorghum as well as its suitability for catch cropping.

The **plenary discussion on "Industrial Use of Energy Sorghum in Europe**" was moderated by Dominik Rutz from WIP Renewable Energies, Germany and included the following panellists:

- Magdalena Chobotova, KWS SAAT AG, Germany
- Karen Zeise, Bavarian Technology and Support Centre (TFZ), Germany

The following topics were highlighted:

- The revised feed-in tariff structure within the German Renewable Energy Sources Act (EEG), coming into effect on 1 August 2014, cancels the bonus for biogas production from energy crops and thus negatively affects industry interest in energy sorghum.
- Due to the EEG revision the biogas sector in Germany is expected to "freeze" in its current state (i.e. few new plants will be built). The limit of maximum 60% maize use in biogas plants may provide opportunities for energy sorghum.
- Potential new markets for energy sorghum may arise in South-East Europe and France.
- Opportunities may also exist for the production and pelleting of biomass sorghum in South Africa. Sorghum pellets are well suited for use in combustion units due to their low chlorine and sulphur levels.
- Further research and demonstration is needed on the breeding of improved biomass sorghum hybrids, especially with respect to lodging tolerance and early vigour (cold tolerance).
- In the coming years, continuity of research and development will need to be facilitated by the private sector as well as by research institutions despite the currently unfavourable framework conditions.

All presentations held at the SWEETFUEL Regional Stakeholder Workshop in Hamburg are available at the project website www.sweetfuel-project.eu.

Annex 1 – Workshop Agenda

Thursday, 26 June 2014

09:45 *Registration*

10:15 **Welcome to the Workshop**

RAINER JANSSEN, WIP RENEWABLE ENERGIES, GERMANY

10:20 **SWEETFUEL Activities and Results**

SERGE BRACONNIER, CIRAD, FRANCE

10:40 **Breeding of Energy Sorghum for Temperate Climates – Industry Perspective**

MAGDALENA CHOBOTOVA, KWS SAAT AG, GERMANY

11:00 **Environmental Assessment of Energy Sorghum**

GUIDO REINHARDT AND CHRISTINE CORNELIUS, IFEU, GERMANY

11:20 **Ethanol Production from Sweet Sorghum in Brazil – Industrial Application in the Sugar Cane Sector**

11:50 **Panel Discussion on Sweet Sorghum Valorisation in Semi-arid Tropics – Food and Fuel Production**

12:30 *Lunch Break*

13:20 **Agronomy of Energy Sorghum in Temperate Climates**

WALTER ZEGADA LIZERAZU AND ANDREA MONTI, UNIVERSITY OF BOLOGNA, ITALY

13:40 **Sorghum for Biogas in Germany**

KAREN ZEISE, BAVARIAN TECHNOLOGY AND SUPPORT CENTRE (TFZ), GERMANY

14:00 **Discussion with the audience: Industrial Use of Energy Sorghum in Europe**

MODERATION:

14:50 **Summary**

RAINER JANSSEN, WIP RENEWABLE ENERGIES, GERMANY

15:00 *End of the workshop*

Annex 2 – Workshop Participants

22 nd EUROPEAN BIOMASS CONFERENCE & EXHIBITION

SWEETFUEL Workshop

Date 26 June 2014

	Name	Organisation	Signature
	Ramses Janssen	WIP	
	Francisco Zavala-Garcia	UANL Mexico	
	Karin Elise	TFZ Germany	
	Serge BRACONNIER	CIRAD	
	Daniel Ruß	WIP	
	Rafael A.C Parrella	Embrapa	
	Nádia Parrella	UFSJ	
	MAGDALENA CHOBOTOVÁ	KWS MAIS GmbH	
	Wilkus Snijman	ARC-GCI	
	Guido Reinhardt	IFEU	
	ANDREA RONTI	UNIBO	
	Nils Rettenmaier	IFEU	
	Walter Zegada	UNIBO	
	Paulo Hartmann	Embrapa Labex	
	Bruna Moraes	CTBE/CNPEM	
	Shi Shiyong	Tsinghua Uni.	
	Srinivas	ICRISAT	
	Maurizio Cocchi	ETA	
	Teresa Gonzalez	CICYTEX SPAIN	
	Marisol Berti	North Dakota State Univ, USA	
	STEFANO AMADEI	VCSC	
	Claudia Tramón	U. of Concepcion CHILE	

ROCIO DIAZ-CHAVEZ IMPERIAL COLLEGE