Title: **PILOT PROJECT BIO-ETHANOL FROM SWEET SORGHUM**

Project No: **DBM01004**

1. Context and reasons to start the project

a. Widjajatunggal Sejahtera (PT SINDOKA / PT Sinar Indonesia Merdeka) own the right to use 3,500 hectares under HGU Certificate previously planted to Hybrid Coconut and Cacao which stops operation few years ago.

b. SINDOKA has decided to utilize the area for Sweet Sorghum – based Bio-ethanol Production Project, with distillation capacity of 100 KLPD. The feedstock will be sweet sorghum fresh stalk from a net plantation area of 2,700 hectares.

c. Since the sweet sorghum bio-ethanol project is the first of its kind in Indonesia, a pilot project has to be started, commencing on the suitability of sweet sorghum granting under the Indonesia Agro-climatic condition. Rabobank was willing to provide co-financing on a project of commercial scale 100 KLPD Bio-ethanol distillery from a feedstock of 3000 Ha sweet sorghum plantation, provided the pilot project show positive results.

d. The project started wit a pilot 5 Ha Research and Development cum Training and Seed Production Area. A funding grant for the Pilot Project of a Sweet Sorghum 36 hectares plantation was obtained by SINDOKA from SENTER NOVEM of the Netherland for this purpose on September 2010 until March 2011.

e. The project got the full support of both the Local Government of Kabupaten Luwu Timur, and the National Government through the Directorate of Food and Industries of the Ministry of Agriculture. It was hoped that the project will benefit the surrounding communities through employment, and participating as contract growers of sweet sorghum for the factory.

2. Objective of the project

The objectives of the Pilot Project were:

a. Evaluate the growth and sugary stalk yield, grain yield, and bio-ethanol yield of four introduce high yield varieties of sweet sorghum obtained from the Philippines, under Indonesia agro-climatic environment.

b. To gather basic agronomic and juice processing data to be used as baseline for a large scale sweet sorghum plantation and bio-ethanol processing plant in the 3000 Ha SINDOKA land.

c. To compare the technical feasibility and financial viability of producing bio-ethanol from sweet sorghum versus the common bio-ethanol feedstock of cassava and molasses.

3. Activities undertaken in the project

Four varieties of Sweet Sorghum were obtained from the Philippines namely:

- SPV-422
- ICSR-93034
- ICSV-700
- NTJ-2

Preliminary planting of these varieties was done in September 2009 at Serang, Banten. After it was clear that growth and yield performance were imperative much better than the local varieties, and the agronomic data was comparable to that from the Philippines, the Pilot Project in Luwu Timur was started.

The following activities were undertaken at Luwu Timur:

A. Plantation Establishment

i. Land clearing

- R & D cum Training Center Area: 5 hectares were cleared of vegetations, and purposed for planting of the HYV sweet sorghum.
- Bio-ethanol Plantation: 31 hectares were prepared for the Bio-ethanol Feedstock Plantation of the 4 high yield varieties.

ii. Planting of the Four High Yield Varieties

- R & D Training Center Area: 5 hectares was planted to the 4 HYV sweet sorghum, and ratoon crops are growing 2 ratoons on April and June planting.
- Bio-ethanol Plantation: 31 hectares planted and providing the stalk feedstock for the village type model of Bio-ethanol processing was in operation.

iii. Harvesting seeds and the plants

- Panicles were harvested manually and grains were separated using a rice thresher.
- Grains were dried by sun drying, before storage.
- Bagasse component of the stalk after juice is extracted was used as fuel for boiler in processing the juice to bio-ethanol.

B. Sweet Sorghum Juice Processing

i. Construction of the Bio-ethanol Plant

- A village type of extracting sweet sorghum juice cooking and fermentation-distillation with capacity of 100-110 liters per day was erected and made operational.
- Extracting the juice from stalk

  A small two roller sugar cane crusher was used initally to extract the juice from the sweet sorghum stalk. First press of the stalk through the roller extract 25 to 30% juice from the stalk. It requires to have second pass of the bagasse through the roller to achieve 40% extraction rate.
- Juice clarification

  The juice was filtered to remove foreign material using a fine wire mesh. The juice was further clarified by skimming the impurities during boiling, and allowing the juice to settle for at least 2 hours after boiling the juice to 65^{o}C. The precipitateat the bottom of the tank was discarded.
- Juice concentraction

  Juice was concentrated to 65 Brix before dilluting it to 20 Brixfor fermentation. An open-pan evaporation method was used to concentrate the juice. Wood and dried bagasse was used as fuel.
- Fermentation

  A simple village type fermentation method was employed to prepare the concentrated for distillation. A batch type fermentation using the common bakery powder yeast (*Saccharomyces cerevisiae*) at the rate of 80 gr per 100 liters of 20 Brix juice solution fermentation duration was 3 days.

- Distillation

  A village distillation process was used, using a single rectifier distillation column, and simple boiler for evaporation. The distillation capacity was 5 to 6 liters alcohol per hour. The bioethanol were collected were collected in plastic gerrycans and stored.

  The effluent was collected in drums and applied as fertilizer to the sweet sorghum plantation.

ii. Development of Input and Output Parameters for Indicative Feasibility Study of the Total SINDOKA Project area of 3,500 hectares

- Production Parameters. The following production parameters if High Yield Sweet Sorghum Varieties has been established from the pilot project, applicable to commercial scale production.
- Based on the pilot project data input and output parameters were established the serve as baseline info for the Indicative Feasibility of a commercial scale sweet sorghum – based Bio-ethanol 100 to 120 KLPD Bio-ethanol Plant.

4. Results of the project

A. Variety Trial

Growth dan Yield Performance

i. Plant height

The four introduced varieties ICSR93034, SPV422, and NTJ2 had average plant height of 216 to 250 cm while ICSV700 260 cm during initial variety trial lanting. Subsequent plantings done in the following year had taller plants in all these varieties with ICSV 700 having plants up to 300 cm. Measurement was done at flowering stage of the plant.

ii. Whole plant (stalk and leaves) yield

Whole plant (above ground biomass) yields were on all the four intriduced varieties had 114 to 160 tons per hectare. Measurement was taken at full maturity stage 82 to 132 days after planting of the 1 hectare trial planting.

No.	Variety	Grain Yield (kg/Ha)	Stalk Yield (kg/Ha)	Brix (%)
1	ICSR-93034	4,528.65	82,460.00	15.00
2	SPV-422	4,834.55	127,015.00	16.00
3	ICSV-700	1,708.00	132,202.00	15.00
4	NTJ-2	4,475.45	99,218.00	14.00
5	BIMA HITAM	2,413.95	33,516.00	13.00
6	BIMA PUTIH	4,036.55	19,950.00	15.00

In plantings done the following year with an area 6 hectares, variety the stalk yield of ICSR93034, SPV422, and NTJ2 was 50 to 60 tons per hectare, while ICSV700 had 70 to 80 tonnes per hectare.

iii. Grain yield

Grain yield of the ICSR-93034, SPV-422, and NTJ-2 was 4.4 to 4.8 tons per hectare, while ICSV-700was only 1.7 tons per hectare.

iv. Sugar content (Brix)

Sugar content measured in Brix were taken at flowering and full maturity stage from stalk of the varieties:

Tabel 1. Average Sugar content of four varieties at flowering and maturity stage

Varieties	Brix at flowering	Brix at full maturity
ICSR-93034	9.0	15.0
SPV-422	9.2	16.0
ICSV-700	13.0	15.0
NTJ-2	11.0	13.0

The sugar content of the four varieties at full maturity is comparable to that of sugar cane. In some samples Brix were 18% to 20%.

v. Juice yield from fresh stalk

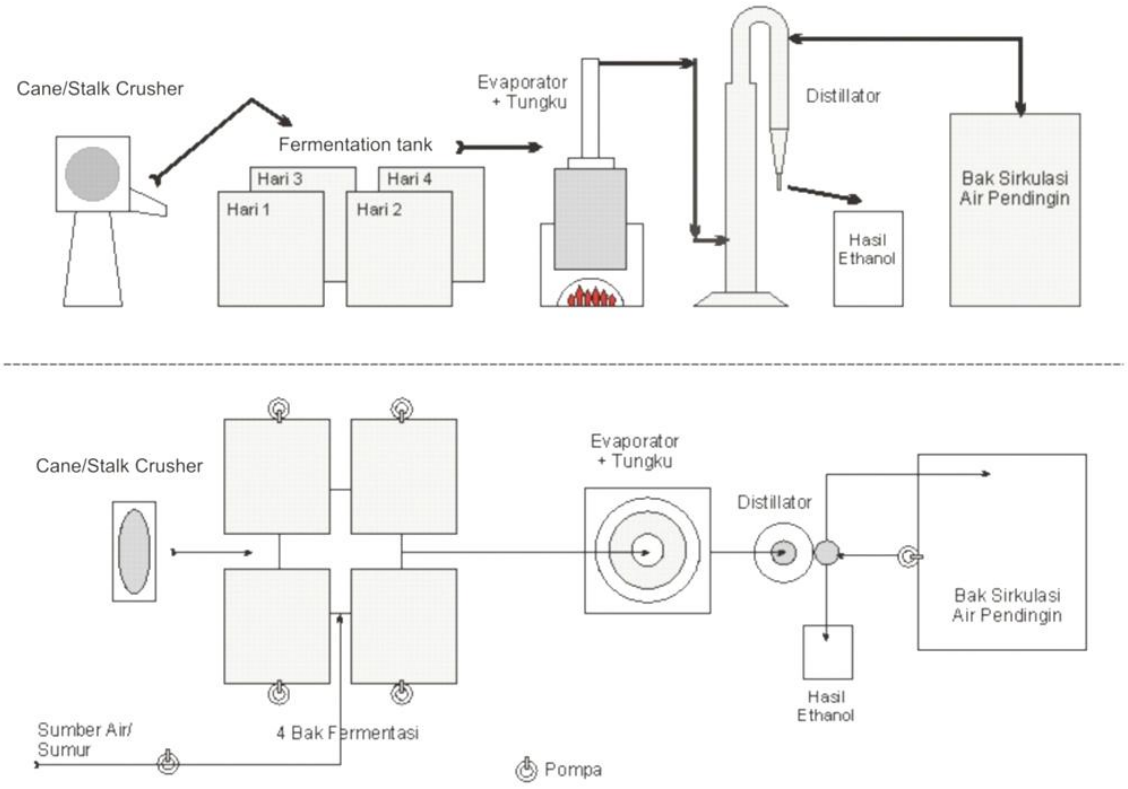
All the four varieties have almost similar juice content in the stalk. One ton of stalk when crushed to extract juice (milling process) will produce 600 kg of juice using a cane crusher machine (3-roller mill) at 60% extraction rate.

vi. Bioethanol yield

Village Type

Alcohol distillation equipment (Figure 1.)

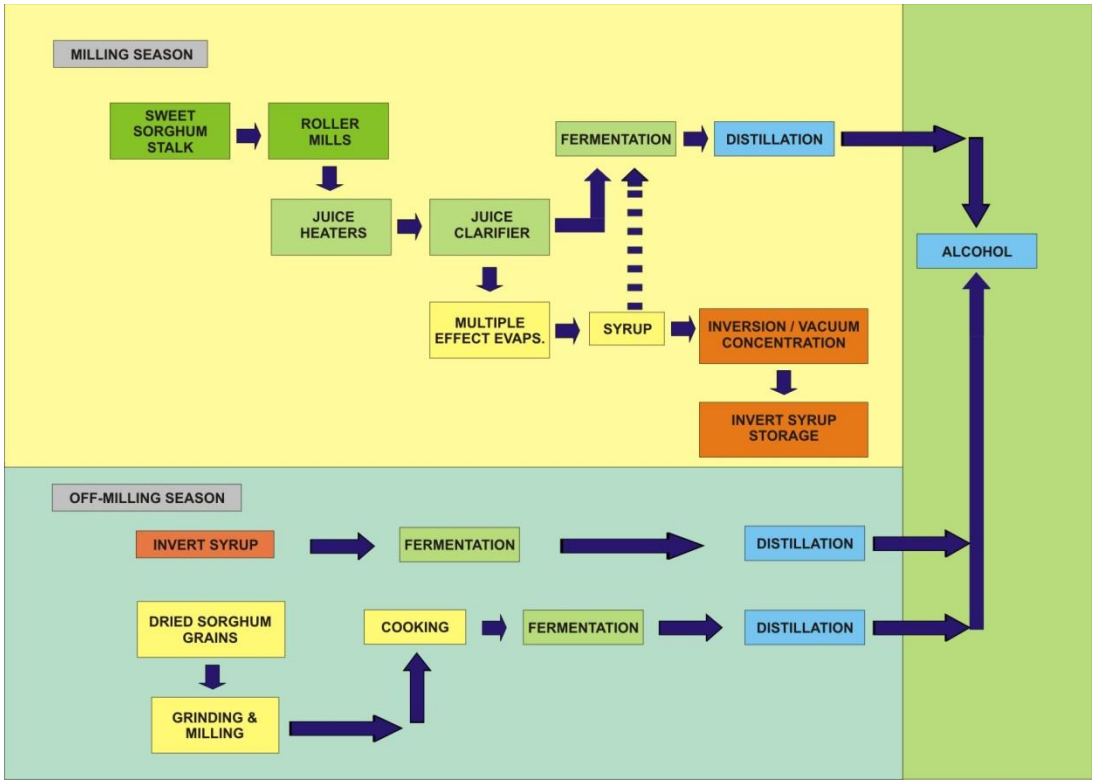
Figure 1: Bio-ethanol Process from Sweet Sorghum (village type model)



The fresh juice when concentrated to 65 Brix by open-pan evaporation re-diluted to 20 Brix and fermented using yeast in plastic drums with gas emmision valve yielded 35 to 40 liters of alcohol after distillation, using a single rectifier distillation and drum boiler.

It is expected that the bio-ethanol yield will be 50 to 55 liters per ton in a commercial bio-ethanol processing plant (Figure 2.)

Figure 2: Bio-ethanol Processing Flow Diagram Commercial



B. From the activities and result of the project, a Training Manual entitle A Primer on Sweet Sorghum Growing and Utilization in Indonesia were produced in English and Bahasa Indonesia version.

The manual contains procedures on growing sweet sorghum up to processing to different juice and grain products. The basic contents are:

- Sweet Sorghum Morphology and Growth Stages
- Soil and Climatic Requirement
- Cultural Management
  - Land clearing
  - Fertilizer application
  - Seed sowing and thinning of seedling
  - Weed control
- Plant and Disease Control
- Harvesting, Handling, Transport
- Ratooning and Crop Management

- Utilization of Sweet Sorghum
  - Juice processing to Bio-ethanol and syrup
  - Grain processing

C. Full project operation involves establishment of 3,000 Ha Plantation (gross area) which will supply 405,000 tons/year of fresh stalk to the bio-ethanol at the rate of 1,500 tons per day. A bio-ethanol plant with rated distillation capacity of 100 KLPD and a mill unit with rated 2,000 TSSD (cane/day).

D. It was clearly demonstrated by the Pilot Project that Sweet Sorghum High Yielding Varieties grow very well under Indonesia Agro-climatic condition and sweet sorghum is offers the best alternative feedstock for bio-ethanol production over the common feedstock cassava, sugar cane, and molasses. The cost producing the feedstock is 40 to 60% lower than cassava, easy and simpler. Full mechanization fro farm operation can be employed which is not possible in cassava. A bio-ethanol yield per hectare per year is more than doubled compared to that of cassava.

Based on activities and result of the pilot project, basic parameters for input output for Indicative Feasibility Study was developed.

Basic Assumptions

Tabel 2. Basic parameters for Indicative Feasibility Study

1.	Total Project Area (Ha)	3,500
2.	Gross area suitable for Sweet Sorghum Plantation (Ha)	3,000
3.	Net Sweet Sorghum Area Plantation (Ha)	2,700
4.	Net Crop Duration, seedling to harvest	90 to 100 days
5.	Number of crop harvest year (one seed plus 3 ratoon crops)	4 times
6.	Average stalk yield per harvest	50 tons
7.	Average grain yield per hectare per harvest	3 tons
	Total per year	32,400 tons
8.	Total millable fresh stalk per Ha per year	200 tons
9.	Total Sweet Sorghum Stalk per year	540,000 tons

10.	Average Sweet Sorghum juice Pol Percentage	12.50%
11.	Pol extraction	95%
12.	Total Available Bio-ethanol recoverable 90% alcohol per tonnes stalk	70 liters
13.	Total recoverable 90% alcohol per hectare per year	14,000 liters
14.	Total recoverable 90% alcohol product per year	37.8 million liters
15.	Stalk milling capacity (receiving end mill unit)	
	Rated capacity/day	2,000 tons
	Actual capacity/day	1,687 tons
16.	Distillery Capacity (90% alcohol)	100 to 120 kiloliters per day
17.	Overall distillation efficiency	88%

5. Lesson Learned

a. The pilot project being under the Global Sustainable Biomass Program category should have included data parameters related to climatic change, as part of the activities, such as energy/biomass balance, GHG etc. The project review mission during the last period of implementation was evaluating the project accomplishment based on these parameters.

b. Processing equipment for bio-ethanol was not purchased because the project duration was short relative to the construction period of the processing plant. This should have been considered in project planning.

c. The local government and the community should be actively involved in the project implementation to ensure continuity of promoting sweet sorghum growing as alternative bioethanol feedstock.

6. Follow up the Project

The commercial project expansion to utilize SINDOKA's 3,000 hectares was not realized, but two new projects were developed using the NL-SINDOKA Project result.

a. SHM Project in Majalengka, West Java 50 hectares expand to 500 hectares – Bio-ethanol and cattle fattening.

   The project consist of:

   i. 50 hectares sweet sorghum plantation of the four varieties NJJ-2, SPV-422, ICSR-93034, and ICSV-700.
   ii. Syrup processing plant 15 tons 70% Brix syrup/day; and bio-ethanol distillery with 1000 liters per day capacity.
   iii. Beef cattle fattening 150 heads per 4 months or 450 heads per year, and methane biogas digester.
   iv. Grain processing to animal feed 2 tons per day.

   The project is complete with a Base Camp building infrastructure, Factory infrastructure and Processing Unit with about $ 500,000 initial investment cost at its initial stage. Sample products of syrup has been sold to sweet soy sauce manufacture, and sweet sorghum poultry and cattle feed has been sold to livestock producers.

b. KGM sweet sorghum syrup and bio-ethanol in Blitar, East Java. 15 hectares pilot to 1,500 hectares commercial.

   The project focus on sweet sorghum syrup and bio-ethanol production. A 15 hectares sweet sorghum plantation establishment has started, and simultaneously syrup processing plant is now being constructed with mill unit extraction capacity of 1500 kg per hour. Subsequently, a bio-ethanol distillery with a 1000 liters capacity will be erected. It is expected that the pilot project of 15 Ha is a precursor to a 1000 hectares sorghum for bio-ethanol project, which will be a part of a sugar cane factory project with 6000 TCD capacity.

Colophon

Date :
Status : Final Report
Project number : DBM01004
Contact person Ag NL : J.P. van Aken

This study was carried out in the framework of the Global Sustainable Biomass Fund, with financial support from the Ministry of Foreign Affairs.

Name organization : Widjajatunggal Sejahtera
Contact person : Johnny Widjaja
Address : Menara Duta Building 3rd floor
Jl. HR Rasuna Said Kav. B-9, Kuningan
Jakarta 12910. Indonesia
Website for more info :