# BIOKENAF

## *BIOMASS PRODUCTION CHAIN AND GROWTH SIMULATION MODEL FOR KENAF*

## QLK5 CT2002 01729

**Bologna - May 9th, 2006**

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## BIOMASS PRODUCTION CHAIN AND GROWTH SIMULATION MODEL FOR KENAF

## QLK5 CT2002 01729


# CETA

*Centro di Ecologia Teorica ed Applicata*

*Gorizia - ITALY*

**Scientific Team**

- Dott. Roberto Jodice
- Dott. Massimo Vecchiet
- Dott. Denis Picco
- Dott. Piero Venturi*

*University of Bologna - UNIBO

# **CETA,** Italy **(5)**

## WP 2: Adaptability and Productivity Field Trials

- Task 2.4: Kenaf Field Trials with Size 2 ha

## WP 4: Harvesting and Storage Trials

- Task 4.1: Harvesting Trial
- Task 4.2: Storage Trial

## WorkPackage 4: Harvesting and Storage Trials

**OBJECTIVES**

- To determine the appropriate harvesting time and methods and the storage techniques.

- To conduct techno-economic evaluation of storage methods for the feedstock (indoors and outdoors).

WP 4: Harvesting and Storage Trials

- *Task 4.1: HARVESTING TRIAL*

The appropriate harvesting time will be the one that will ensure the higher biomass yields with the lower moisture content.

It is usually appointed by the first killing frost that usually causes defoliation of the stems.

WP 4: Harvesting and Storage Trials

- *Task 4.2: STORAGE TRIAL*

Different storage conditions (uncovered, covered with plastics and storage in buildings) was studied for a period.

During storage the heaps was periodically sampled at different levels to determine variations in:

- Biomass humidity

- Heating values

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## KENAF FIELD TRIALS

2003: WP2 and WP4 (harvest and storage)

2004: WP2 and WP4 (harvest, storage and yield transformation)

2005: WP2 (biomass sowing down)


**Cervignano del Friuli (UD)**
North East Italy

- Latitude: 45° 51’ N
- Longitude: 13° 20’ E
- Altitude: 8 m a.s.l.

- Soil texture: fine silty-clayey soil

# BIOKENAF

## *2003 – First Year*

| ***SOWING PARAMETERS*** | *FIRST SOWING* | *SECOND SOWING* |
|---|---|---|
| *KENAF VARIETY* | EVERGLADES 41 | |
| *DATA* | 28/05/2003 | 21/06/2003 |
| *FIELD SIZE* | 1,00 ha | 0,45 ha |
| *PLANT POPULATION* | 221.000 plants/ha<br>(to obtain 200.000 plants/ha) | |
| *SPACE BETWEEN PLANTS* | 10 cm X 45 cm | |
| *SOWING DEPTH* | 3 – 4 cm | |

Sowing, May

Kenaf development, July

Kenaf development, August

# KENAF DEVELOPMENT

## December Survey

| | *FIRST SOWING* | *SECOND SOWING* |
|---|---|---|
| *PLANT HEIGHT (cm)* | 201,1 | 140,8 |
| *BASAL STEM DIAMETER (mm)* | 17,0 | 13,7 |
| *STEM HUMIDITY (%)* | 58,7 | 62,2 |

- **MANUAL HARVESTING**
- **WHOLE STEMS**
- **SHELTERED STORAGE**

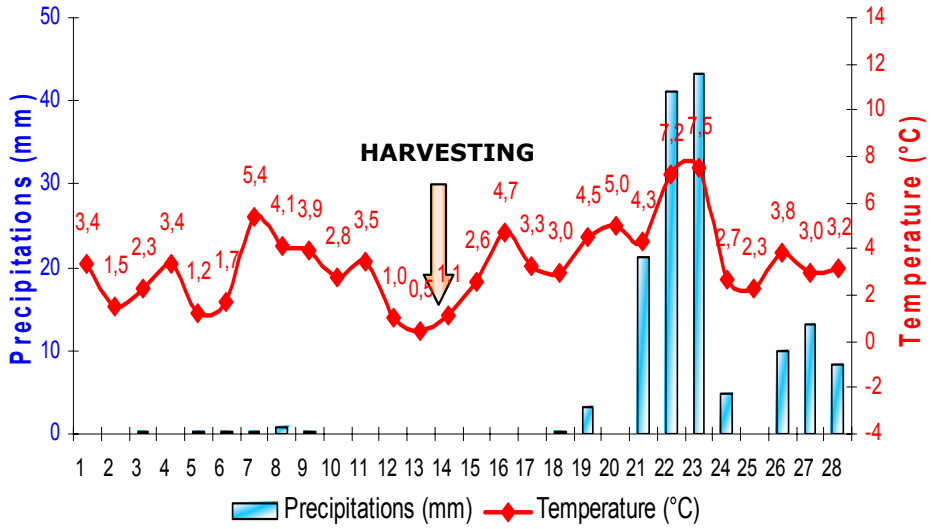
# HARVESTING TRIALS

Harvesting operations have been carried out on 14th of February.

Winter 2003-2004 planned activities were including:

- mowing-chopping harvesting with sheltered storage of the product
- mowing-windrowing-baling

Because of unfavourable weather conditions only the first harvesting chain has been performed in February.



# KENAF HARVEST IN FEBRUARY

**CHOPPER MACHINE**

**CHOPPER HEADER**

Machine used to mow and chop the material:

## JAGUAR 870 (CLAAS)

THIS CHOPPER IS COMMONLY USED IN THIS AREA TO HARVEST MAIZE DURING SEPTEMBER-OCTOBER.

# KENAF HARVEST IN FEBRUARY

- Field size 1.45 ha
- Average kenaf characteristics:
  - ✓Stem diameter 1.7 cm
  - ✓Stem height 200 cm
  - ✓Moisture content 22.5%

- JAGUAR 870 (CLAAS)
- Forward speed machine: 8,5 km/h
- Theoretical work capacity: 3,8 ha/h
- **Really work capacity: 1,6 ha/h**

- ***KENAF YIELD EVALUATION (dry matter)*** ***11.0 t/ha***

# KENAF HARVEST IN FEBRUARY

Trailer volume: 9,6 $m^3$.

(small trailer used in the farm for other tasks)

It can be considered that only 30% of the working time has been allocated to chopping while the rest for transport-unload operations (even if the storage place was closed to the field).

In order improve the speed of whole operation it is useful to increase the number of trailers and their capacity.

# DIFFERENT SIZE CHOPPED KENAF

Length: 10 mm

Length: 34 mm

BULK DENSITIES

- 10 mm chopped kenaf: 41,9 kg/m$^3$
- 34 mm chopped kenaf: 28,6 kg/m$^3$

***LOW BULK DENSITY!!***

# CHOPPED KENAF STORAGE

*Beds arrangement*

It was spent a lot of time for the unloading (*manual labour*) of the trailer due to the characteristics of the biomass.

# TREND MOISTURE CONTENT IN CHOPPED KENAF

The heaps were sampled at different levels to check:

- variations of biomass humidity
- heating values of biomass

| | 14/02/2004 | 01/03/2004 | 12/03/2004 | 19/03/2004 | 06/04/2004 | 26/04/2004 |
|---|---|---|---|---|---|---|
| **KENAF 10 mm** | 17,0% | 16,9% | 16,8% | 16,1% | 15,7% | 12,8% |
| **KENAF 34 mm** | 17,0% | 17,2% | 16,8% | 16,5% | 17,3% | 11,4% |

**Low content of moisture** in the pile.

No changes in temperatures in the pile.


⇒ ***NO FERMENTATION PROCESS*** inside the biomass was started.

# KENAF FIELD DURING HARVESTING TRIAL

CHOPPER MACHINE CUT EIGHT
(*about 20 cm*)


The difference between chopped kenaf moisture (17,0%) and whole stem moisture (22,5%) in February was due to the *different cut height*

# OBSERVATIONS (Task 4.1)

- This kind of harvesting chain has been working very efficiently. The machine is well-known and used also on other crops and kenaf harvesting could give the opportunity to depreciate the chopper using it during November or the following spring.

- The weak point of the chain is represented by the low bulk density that doesn't make long transport economically convenient. Next step of the research could be a study on possible densification systems.

- A solution could be the cut of the integral stem and the bale with the common machines used for the harvest of straw and hay.

# OBSERVATIONS (Task 4.2)

- The low chopped kenaf bulk density involve the necessity of a large volume buildings for the storage. With the aim to reduce the storage cost it would be better to compact the chopped kenaf.

- No fermentation process inside the pile was started during the storage.

- As there was a different harvest time, some plants in December and other in February, after the winter, the fibre quality of kenaf stems was examined in order to valuate if there is a significant difference.

# BIOKENAF

## *2004 – Second Year*

### *SOWING PARAMETERS*

| KENAF VARIETY | EVERGLADES 41 |
|---|---|
| DATA | **19/05/2004** (ten days before last year first sowing) |
| FIELD SIZE | **1,50 ha** |
| PLANT POPULATION | **440.000 plants/ha** (to obtain **400.000** plants/ha) |
| SPACE BETWEEN PLANTS | **5 cm X 45 cm** |
| SOWING DEPTH | **3 – 4 cm** |

| | | |
|---|---|---|
| **STEM HEIGHT (cm)** | **160** | 110 --- 240 (high variability) |
| **BASAL STEM DIAMETER (mm)** | **12** | 8 --- 20 (high variability) |
| **PLANT POPULATION (plants/ha)** | **335.000** | 400.000 (plant population attended) |
| **KENAF YIELD (t/ha)** | **8,0** | Fresh Weight (Stems) |
| **KENAF MOISTURE (%)** | **40%** | Stems |

**SITUATION January, 12th 2005**

# KENAF MOISTURE TREND

***Kenaf moisture content at the end of its cycle***

***(stems cut at the height of 20 cm)***

| | 20/01/2005 | 28/01/2005 | 04/02/2005 | 02/03/2005 |
|---|---|---|---|---|
| **Kenaf Moisture (%)** | **31.4%** | **17.2%** | **15.5%** | **12.2%*** |

* chopped kenaf

# KENAF HARVEST STUDY

THE IDEA WAS TO HARVEST THE KENAF STEMS ACCORDING WITH THE QUALITY PARAMETERS REQUIRED BY A NATURAL FIBRE TRANSFORMATION FACTORY.

1st STEP

- SEARCH OF NATURAL FIBRE TRASFORMATION FACTORY

IT WAS FOUND THREE FACTORIES WHICH WORK WITH NATURAL FIBRES:

- ***HEMPFLAX*** - Holland
- ***K.E.F.I.*** – North Italy
- ***AGRIKENAF VOLTURNO*** – South Italy

# KENAF HARVEST STUDY

2nd STEP

CONTACT THE TRANSFORMATION FACTORY WITH THE AIM TO KNOW THEIR NEED

According to ATO the necessary arrangements were made in the harvesting yard with a view to conveying the material to the Dutch firm.

The Hempflax transformation line needs a material with specific characteristics. The stems must be cut at an height from **30** to **60** cm and baled in big rectangular bales.

# KENAF HARVEST STUDY

Problems:

- Impossibility to find a machine which could cut the stems at the desired length.
- Difficulty to find a conventional baler for big rectangular bales. In these areas the fleet of baling machines is usually made up of round balers.

A solution for both problems was found in the old conventional balers for small rectangular bales.

# FIRST HARVEST TRIAL

Gaspardo FBR 175 reciprocating a knife and teeth mower

Harvesting trial operations were carried out on 14th February, 2005.

The planned activities for this test included mowing the stems, with a mowing bar, and baling some bales

| STEMS CHARACTERISTICS | |
|---|---|
| Average basal stem diameter (mm) | 12 |
| Average height (cm) | 160 |
| Average moisture content | 15% |

AMA model 153 conventional baler

# FIRST HARVEST TRIAL

## THE TRIAL FAILED

The main problems usually pointed out in other experiences were associated to the material picking up and the machine flooding, owing to the fibrous kenaf structure.

The cut material analyses showed that most stems were cut at the desired length, which means that the principle was right but, probably, a more powerful machine was needed.

# KENAF HARVEST STUDY

2nd STEP

CONTACT THE TRASFORMATION FACTORY WITH THE AIM TO KNOW THEIR NEED

Due to the impossibility to deliver the kenaf stems with the requested characteristics to Hempflax, a contact was made with an Italian factory processing natural fibres, the **K.E.F.I.**, in the Po Valley.

The K.E.F.I. transformation line needs a material with specific characteristics.

The stems must be chopped (size between 25 and 50 mm), moisture content about 15%, unbaled.

# KENAF HARVEST

3td STEP

KENAF HARVEST


Jaguar 870 (Claas)

2nd March, 2005

**Harvesting operations**

The stems were cut in a single size (34 mm), according to K.E.F.I. demands.

The bulk density was about 32 kg/m$^3$, while the chopped kenaf moisture content was 12.2%.

# KENAF HARVEST STUDY

4th STEP

CHOPPED KENAF STORAGE

The chopped kenaf was piled up and compact near the field border.

Afterwards the pile was covered with a plastic sheet, normally used to cover the ensiled maize, with the purpose to prevent the chopped kenaf from becoming damp from rainfall or snow.

# KENAF HARVEST STUDY

## 5th STEP - KENAF TRANSPORT TO K.E.F.I.


8th March, 2005


For the chopped kenaf transports to K.E.F.I. firm (about 300 km), a trailer model "walking floor" was used.

The load operation was carried out with a machine normally used, in the past, to load the sugar beet in the field.

# K.E.F.I. VISIT and KENAF PROCESSING

6th STEP - KENAF FIBER PROCESSING

12th April, 2005

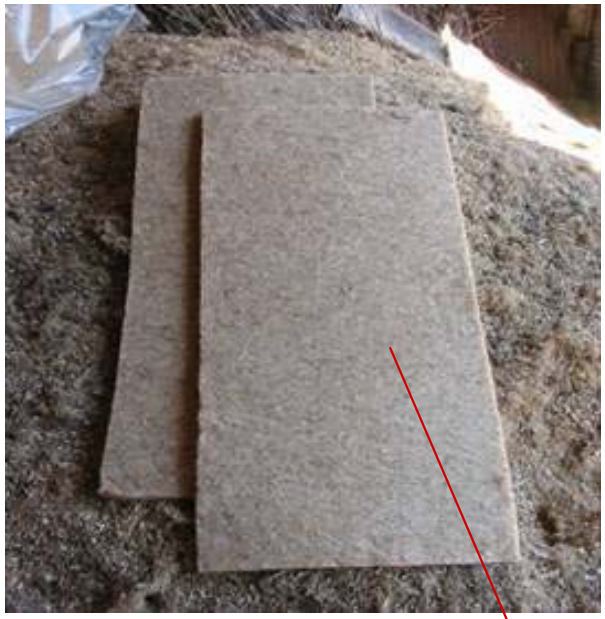
Partners: CRES, UNIBO, ATO, C.E.T.A.

K.E.F.I. PLANT

- SEPARATION PLANT, in which the fiber is separated from the core
- FIBRE PROCESSING PLANT, in which the fiber is added to with polyester fiber and processing to obtain panels

# BIOKENAF PROJECT PRODUCTION

Pack
25 panels



Single panels

Polyester backing fibers

Impurities
(*Sorghum halepense*)

# BIOKENAF

***Thank you for the attention!***


## C.E.T.A.

**Via Alviano, 18**
**Gorizia – Italy**

**Tel. +39 0481 537159**
**Fax +39 0481 599268**

**www.ceta.go.it**
**laboratorio@ceta.go.it**