KENAF:
A NON-FOOD CROP FOR SOUTHERN EUROPE

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Abstract: The Biokenaf project will contribute to the implementation of three main EU policies, the ***Common Agricultural Policy***, the ***Agenda 2000*** and the ***White Paper.*** In this view of these policies, the financial feasibility of the non-food crops production will increase, while the diversification of land use and sustainability of farm incomes should be ensured. Although kenaf has been accepted (from 1993) by EU a high yielding "non-food crop" for fiber production the research on kenaf has been focused strictly on its use for the paper/pulp industry, while the yielding potential of the crop is not defined. Hardly any research has been directed towards the other industrial uses of the crop as well as the energy exploitation of it, in spite of the favorable characteristics of kenaf feedstock and its high biomass yields. This project with its integrated approach aims at the sustainable yielding potential, the alternative industrial bio-products as well as the energy exploitation of kenaf. A dynamic crop-growth simulation model will be developed and will be a useful tool for yields prediction. Following an environmental and economic assessment will provide insight in the feasibility of kenaf for industrial and energy applications.

Introduction

Kenaf is an annual fiber crop of great interest for both the production of industrial raw materials and as bio-fuel under the pedoclimatic conditions of south Europe. It has been cultivated long, as early as 4000 BC in western Africa. The area of its cultivation is estimated to about 200,000 ha (FAO) and the main producers are Thailand, China, India and Mexico.

The main reasons for considering kenaf as a high productivity multi-purpose non-food of increasing importance for Europe are listed below:

- *It is a multi-purpose crop and can provide raw material for industrial and energy applications.* The 30-40% of the stem (bark) can be used for several high value fibre applications (Robinson, 1998), while the 60-70% of the stem (core) among several industrial applications (Goford, 1994; Kulger, 1996) can be used for thermochemical process (combustion pyrolysis and gasification).
- *The high biomass potential and the low inputs of the crop.* Dry matter yields came up to 26 has been reported (Alexopoulou et al. 1999 & 2000; Kipriotis et al. 1998; Robinson, 1998). Under the semi-arid conditions such as prevailing in Mediterranean areas, it requires 250-400 mm of water, which is much lower than in conventional land use types (including maize, sugarbeets, alfa-alfa, etc.) largely reassembly cotton in water requirements. On the other hand, considering the low N requirements (50-100 kg N/ha), this crop is believed comprising an important ***alternative land use*** in lands with poor and moderate water availability.

- ➔ *It offers alternative land use and can be used in a crop rotation.* Kenaf can be cultivated in rotation system. This is very important in areas devoted to monocultures (cotton, cereals) and although are supplementary irrigated performing very low yields, which are unsustainable without the EU policies.
- ➔ *It is an annual non-food crop.* As an annual crop, it is quite similar to other conventional field crops with respect to cultivation and harvest. The production and management systems are being developed for agricultural annual non-food crops such is kenaf, bringing thus costs of delivery down to commercially accepted levels. As an annual crop can be used where *crop rotation is indispensable due to local crop disease, weed competition or soil fertility degradation.*
- ➔ *High farmer's perception.* Being an annual crop, kenaf does not require a long-term commitment in land use and moreover has similar management with other conventional crops.

Although kenaf is being cultivated worldwide mainly for fiber production, in Europe there is no much data concerning the adaptability, growth and biomass yields of the crop. There are only few references regarding the agronomic aspects of the crop at European pedoclimatic conditions. In these research activities the adaptability and biomass productivity of few kenaf varieties have been tested in southern Europe and high biomass yields, up to 26 t/ha (Alexopoulou et al. 1999 & 2000; Kipriotis et al. 1998, Manbelli and Grandi, 1995; Manzanares et al., 1993; Petrini et al. 1994; Quaranta et al. 1998), have been reported and are comparable to the ones have been reported in similar works worldwide.

In April 2003 a European Network was started entitled "Biokenaf-Biomass Production Chain and a Growth Simulation Model" aiming at addressing the sustainable yielding potential, the alternative industrial bio-products as well as the fuel quality of kenaf as a non-food crop, under certain cultivation techniques, in south Europe. The consortium of the project is presented in Table 1.

Objectives

The *overall objective* of the project is to introduce and evaluate kenaf as a non-food crop through an integrated approach for alternative land use in South EU that will provide diversified opportunities for farmers and biological materials for the "bio-based industries" of the future.

The overall objective will be achieved through the following specific ***objectives***:

- To determine the sustainable yielding potential of kenaf, as a non-food crop in all Southern EU countries.
- To develop a dynamic crop growth simulation model for kenaf yields predictions.
- To evaluate the effect of harvest timing and storage methods on quality of raw material.
- To evaluate the suitability of kenaf both for selected industrial and energy applications.
- To carry out environmental assessment and LCA and make scenarios for alternative land use.
- To conduct an economic evaluation of the whole production chain of the crop for alternative land use.
- To prepare a handbook and a booklet for kenaf.

- To establish links with the American Kenaf Society (AKS).

Methods and materials

Eight workpackages (WPs) have been scheduled in order to fulfill the main and the scientific objectives of this proposed RTD project.
WP1 is a general work package aiming at the coordination of the project and establishment of a link with the American Kenaf Society (AKS).
WP2 aims at the determination of the sustainable yielding potential of kenaf as energy crop at several locations in southern Europe. The sustainable yielding potential of kenaf will be answered by the data that will be collected for the four types kenaf fields of WP2 that will be: a) screening trial, b) effect of sowing dates and plant populations on yields, c) effect of irrigation and fertilization on yields and d) fields trials with size 2 ha. It will be pointed out field trials will be conducted in all south EU countries (Table 2). It should be stressed out that the proposed number of field trials is absolutely needed in order to achieve a more realistic approach to the growth simulation model (WP3).
Furthermore, this work package will provide data to the *WP3*, in which a dynamic growth simulation model will be developed. The model development will be a very useful tool for the yield and energy production prediction of kenaf it can be further used as a core module of any expert system for economic quantitative land evaluation including land uses systems with kenaf. The difficult but very important task of predicting and analyzing possible alternative scenarios in future in medium and long term planning (WP3) will be based on the detailed crop data (WP2) that will include photosynthetic capacity, respiratory losses, phenology, dry matter distribution and data on leaf area.
In WP4 the appropriate harvesting time and methods as well as the appropriate storage methods (indoors and outdoors) will be determined. The selection of the appropriate harvesting time for south EU that will ensure the highest yields with the lowest moisture content will be accomplished through the data that will derived from the conduction of the harvesting trials (WP4), while the needed information for the best storage method that will ensure the minimum losses in the quality and quantity of the feedstock will be derived from the storage trials (WP4).
In *WP5* the suitability of kenaf both for selected industrial (high added value) and for thermochemical energy applications (combustion, gasification and pyrolysis) on the whole crop and the core fiber remaining after removal of the high value bark fiber. Through this evaluation (WP5) the technical specifications of kenaf-based products for selected areas as well the economical characteristics and market perspectives for these product (composites, building materials, nonwovens, paper & board and absorption particles). Furthermore, the quality characteristics and energy potential of kenaf as a biofuels for thermochemical energy applications (combustion, gasification and pyrolysis) will be determined.
Environmental impact assessment for the whole production chain of the crop and Life Cycle Analysis (LCA) taking into account both the industrial and thermochemical energy applications of the crop will be conducted in *WP6*. The goal of this study (environmental impact assessment and LCA) is to assess the ecological sustainability of production and use of kenaf for industrial bio-products and energy generation (WP6). In order to acheive this goal a comparison of kenaf among different southern EU regions as well as a comparison with other crops will be done.

The valuable information that will be collected in the WP2, WP3, WP4, WP5 and WP6 will be used in *WP7* for the cost analysis of kenaf as a "non-food crop" in comparison to other annual traditional crops. The economic analysis of the whole production chain (WP7) will be used not only for comparison of the crop with other conventional crops with similar cultural practices but also for the development of scenarios for alternative land use and diversified opportunities for farmers in order to produce industrial bio-products that will provide the "bio-based industries" of the future.
In WP8, all the above-described work packages will be used as a base for the development of a Handbook and a Booklet for kenaf. In the Handbook and the Booklet apart from the project information, an extensive literature review will be included to define the state-of-the-art of kenaf in Europe. The Handbook and the Booklet will be very useful tools for the dissemination of the project's results as well as will be used as a point of reference for the further exploitation of the projects results.
The distribution of the work among the partners is presented in Figure 1.

Expected results

Adaptability and Productivity Trials (WP2)

1 Evaluation of the adaptability and productivity of several kenaf varieties in South Europe.
2 Selection of the appropriate kenaf varieties in the pedoclimatic conditions of Southern EU.
3 Determination of the appropriate combination of irrigation and fertilization inputs that will result in the maximum biomass yields and under minimum production cost.

Development of the crop growth model (WP3)

1 Energy balance of the crop under different cultivation and harvesting and storage methods, which can lead to management improvement of the crop.
2 The dynamic growth and biomass production model that will be a useful tool for yields and energy production prediction of kenaf.

Harvesting and Storage Trials (WP4)

1 Determination of the appropriate harvesting time to ensure higher yields.
2 Information on the application of various harvesting machines commonly used in the agricultural practice.
3 Information on the application of various storage to ensure minimum losses in quantity and quality of feedstock.

Utilization of kenaf (WP5)

1 Establishment of a market-driven demand for kenaf as alternative source for energy production.
2 Increased demand for annual fibre based renewable and sustainable products.

3 Increased European market potential for kenaf based industrial products.

Environmental impact assessment and LCA (WP6)

1 Environmental impact assessment covering the whole production chain of kenaf.

2 LCA considering the potential of kenaf as a biofuel for thermochemical conversion processes (combustion, gasification, pyrolysis).

3 Scenarios for alternative land use in agriculture regions of south EU.

Economic analysis for the crop production chain (WP7)

1 Cost of kenaf at farm and at plant gate (including harvesting, storage and transportation).

2 Economic comparison of kenaf with other annual conventional crops.

Preparation of Handbook and Booklet for kenaf (WP8)

1 Evaluation of the collected data of the project as well as of all the relevant bibliography that will be recorded in the Handbook and the Booklet.

2 Handbook can be used as a pilot for the future development of the crop

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Table 1. Consortium

Partners	**Country**	**Main involvement**
CRES	Greece	Coordinator, Crop production, harvesting and storage, Handbook and booklet for kenaf
University of Catania	Italy	Crop production
University of Thessaly	Greece	Crop production and Model development
BTG	The Netherlands	Thermo chemical energy applications
CETA	Italy	Crop production, harvesting and storage,
INIA	Spain	Crop production
University of Lisbon	Portugal	Crop production and environmental impact assessment and LCA
ATO	The Netherlands	Utilization for industrial uses
UNIBO	Italy	Crop production
INRA	France	Crop production and environmental impact assessment and LCA
ADAS	UK	Economic analysis

Table 2. Detailed description of the kenaf trials.

Experimental field trials	**Countries**	**Factors under study**	**Experimental design**	**Plot size**
Screening trial	Greece	Six kenaf varieties	Randomized complete block design in three replications	3m *x* 4m ($12m^2$)
Sowing times and plant population trial	Greece, Italy, Spain, Portugal and France	▪ 2 varieties ▪ 2 sowing times ▪ 2 plant populations	A factorial 2^3 in three blocks	6m *x* 8m ($48m^2$)
Irrigation and nitrogen fertilization trial	Greece, Italy, Spain, Portugal and France	▪ 3 nitrogen levels ▪ 4 irrigation levels	A split-split plot design in four blocks	6m *x* 8m ($48m^2$)
Kenaf field trial with size 2 ha	Greece, Italy	The best-performed variety will be sown under the best plant population and will be irrigated and fertilized according to the results of the previous trials.		2 ha