UNIVERSITY OF BOLOGNA

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BIOKENAF EU project
"BIOmass Production Chain and Growth Simulation Model for KENAF"

Present and future of kenaf as multipurpose crop for industry and energy applications

– Agricultural Faculty. Bologna May 9th 2006 –

Agronomic comparison between KENAF and HEMP

N. Di Virgilio, A. Zatta, G. Venturi

Hemp-sys EU project

QLK5-2001-01363

HEMP SYS: Design, Development and Up-Scaling of a Sustainable Production System for HEMP Textiles: an Integrated Quality SYStems Approach

www.hempsys.net

Start date: 01.November.2002
End date: 30.April.2006

University of Bologna:
- ***Coordination***
- ***Field trials***

BIOKENAF EU project

QLK5-CT2001-01729

BIOMASS PRODUCTION CHAIN AND GROWTH SIMULATION MODEL FOR KENAF

www.cres.gr/biokenaf

Start date: 1April 2003
End date: 31 August 2006

University of Bologna:
- ***Field trials***

Draft

Complete bibliography will be published

Importance of fibre crop

- 2 million hectares of non-food crops in UE, 650 000 hectares of fibre crops (2002, FAO)
- Europe is a great importer of vegetal fibre

Italy: 300 000 t, 450 million of dollar

- Cotton is the prevalent fibre crop both for quantity and market importance
- Italy: cotton represents 95% of the fibre market in quantity and 90% in value
- Italy: 900 hectares of Hemp and 700 hectares of Kenaf (2002, FAO)

Increasing of non-food/energy crop (20-40 million hectares for 2020) may erase the importance of fibre crop

Increasing demand of fibre for industry and textile uses

Why to grow fibre crop

- Possibility for an alternative land use
- Introduction of a different crop in the traditional crop rotation
- Revaluation of vegetal fibre against synthetic
- Relieve the pressure of the paper industry on remaining natural forests
- Replace cotton by less polluting alternative crops
- Possibility of added financial aid related to the environmental friendly management of fibre crops like Hemp and Kenaf
- Can provide material for several industrial and energy applications (multi-purpose crops)
- Possibility to decrease the risks related to fluctuation of market and climatic conditions

***Hemp** and **Kenaf** (with flax and fibre sorghum):*

- *easily adaptable to pedoclimatic conditions of Italy*
- *easily to insert in the crop rotation of Italy*
- *high farmer perception being annual crops*

GENERAL COMPARITION

	Hemp *(Cannabis sativa L.)*	Kenaf *(Hibiscus cannabinus L.)*
Family	**Cannabinaceae**	**Malvaceae**
Stem	**Round, from tiny to large, tendentially single unbranded stem**  	
Leaves	**Palmately 7-9 leaflets** 	**Palmately or entire leaf** 
Flowers	Monoecious and **Dioecious**  	**Monoecious**  
Root	**Tap root system with wide – ranging lateral root**	
Fibre	**Mainly in a thin bark (long fibre), in a woody core (short fibre)**	

Requirements

	Hemp 	Kenaf 
Base emergence temperature (°C)	1	9
Base growing temperature (°C)	1	10
Optimum growing temperature (°C)	10 – 28	15 - 27
Evapotraspiration coefficient (L Kg^{-1})	300 - 500	400 – 500
RUE (g MJ^{-1})	2.2 - 2.3	2.4
Water per growing period (mm)	500 (in 5 months)	500 – 600 (in 5 months)
Soil	Drained sandy-loam soil	Drained sandy-loam soil

Large variability of climate conditions

Sensitive to frost (tropical and subtropical regions)

Base temperatures of hemp are lower than kenaf

Radiation-use efficiency and Evapotraspiration coefficient are similar

For temperate climate with a long period of low spring temperatures Hemp may be sowed early and canopy establishment will be rapid

Seedbed preparation

- Typical soil tillage of spring crops: Deep cross-ploughing and dragging
- Ploughing at good depth is favourable for the tap root vertical development
- Deep tillage often increases biomass yield
- Fine bed and contact of soil with seed are necessary for good an uniform germination
- Kenaf requires higher ground temperature (15°C) than Hemp
- Soil moisture is also more important for Kenaf than Hemp

Improperly prepared bed and a moisture deficiency during the early stages of growth both tend to produce irregular growth, short and tall plants, and stems that are not uniform in diameter

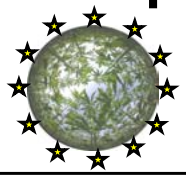
Varieties

Hemp	Kenaf
	
Breeding programs to improve yields, bast fibre %, low content in THC, quality fibres (fineness)	Breeding programs to improve yields, bast fibre %, anthracnose resistance, lodging resistance, root-knot nematode and fungi
30 varieties in EU (reg. CE n. 206/2004 art. 7 bis)	240 varieties in USA (10 commercially grown)
Fibranova, Carmagnola, Dioica 88, Cs (late variety, good fibre production) Chamaeleon, Epsilon 68, Fibrimon 24, Futura 75 (medium variety) Fedora 17, Felina 32, Uso 31, Juso 14, Ferimon (early variety)	Everglades41, Tainung2 *(late variety, good fibre production)* G4 *(photo-insensitive and short maturity cycle)* Gregg *(long growing period)* Dowling, Everglades71, Cuba2032, ect.
Dry stem (t ha^{-1}): 5-6 (Early V.); 8-10 (medium); 16 (Late V.)	Dry stem (t ha^{-1}): 8 (Early V.); 18 (Late V.)

Sowing

	Hemp	Kenaf
Seed (kg ha^{-1})	35 – 60	20 – 30
Seed cost (euro kg^{-1})	4 - 5	4 – 5
Sowing depth (cm)	2 – 4	1 – 4
Sowing time	from late March to middle April	from late April to late May
Plant population (plants m^{-2})	100 – 400 (baby hemp)	30 – 50
Dist. between the row (cm)	12 – 20	25 – 50
Dist. within the row (cm)	1 – 5	5 – 10
Time of emergence (days)	5 – 7 	4 – 5 

Fertilization and irrigation

Nutrient removal	Hemp 	Kenaf 
N (*Kg t^{-1} DM*)	10 - 15	2 – 3
P_2O_5 (*Kg t^{-1} DM*)	3 - 5	1 – 2
K_2O (*Kg t^{-1} DM*)	15 - 17	3 – 4
CaO (*Kg t^{-1} DM*)	15	4 – 5
MgO (*Kg t^{-1} DM*)	2 – 3	-
Irrigation (*m^3 ha^{-1}*)	1500 – 3000 (South)	2500 – 3000

- N (60 kg ha^{-1}) supply before sowing may be enough to reach valuable yields for both the crops in Bologna pedoclimatic conditions
- Field trials did not show effect of increasing N level on Biomass yields
- Irrigation may be necessary for Hemp in South Italy
- Water supply significantly increases biomass yield mainly for Kenaf
- Water stress is not always injurious

… low input principle

Weed control and diseases

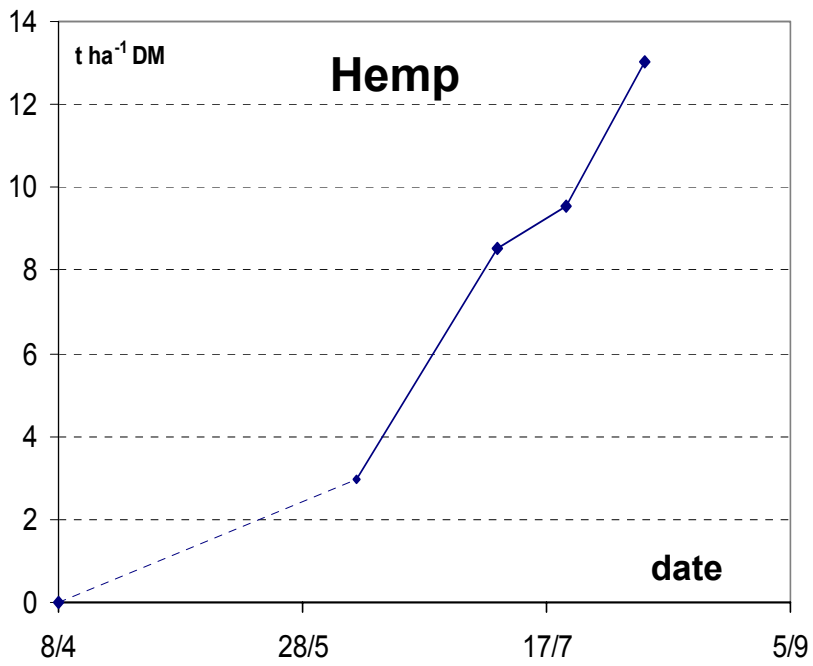
Hemp	Kenaf
	
Problem in the early phase	
3 - 5 weeks to cover the row space under good conditions	**5 weeks to cover the row space under good conditions**
-	**Pre or post emergence herbicide**
-	**Single/twice hoeing after emergence**
-	**Mechanized hoeing with 50 cm row spacing**
Used narrow-row spacing avoids weed problems after emergence	**Reducing row spacing may reduce n° of intervents**
Orobanche ramosa	**Root knot nematodes, anthracnose, *Rhizoctonia solany,* Botrytis sp., *Aphids***

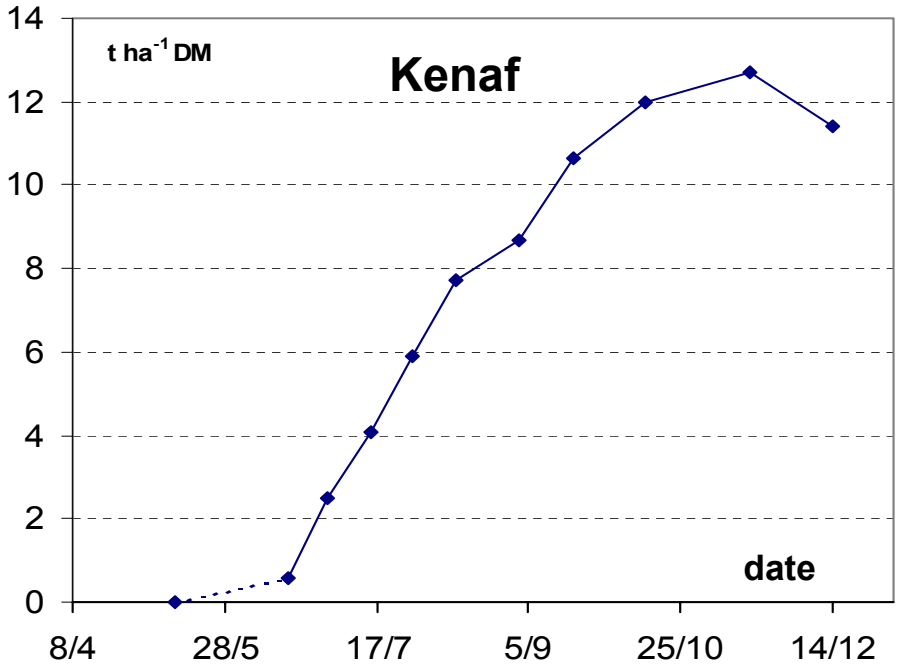
Cultural practices like timely planting, narrow row spacing, optimum fertilization and plant population may be used to avoid herbicides

Growth

	Hemp	Kenaf
Cycle length (d)	80 - 170	75 – 105 (early) 105 – 120 (semi-early) 120 – 140 (late)

Grow course in 2004





Flowering

Flowering is mainly under photoperiodic control for Hemp and Kenaf (strongly for late kenaf v.)

Hemp 	Kenaf 
Short-day plant	Vegetative until daylight higher than 12.5 hours
Early maturity cultivar (june/July)	Early maturity cultivar (July/August)
Late maturity cultivars (August/September)	Late maturity cultivars (September/October)
-	Two weeks of very cloudy days may initiate flowering
Duration may be 3 to 4 weeks	
Flower blooms for many days	Flower blooms for 1 day
Anemophily	Self-pollinate crop (moderate cross-pollination)

Harvest

- Highest fibre quality when plants are harvested at flowering period
- Harvest is strongly related to the destination
- Harvest has to meet the processing needs
- Kenaf: After killing frost the moisture content of stems is low.
- The defogliation in Kenaf and Hemp returns to the soil significant quantities of N, Ca, Mg, P, K
- Kenaf: Late harvest leads to a bark degradation by fungus and yields losses

Hemp	Kenaf
Harvest is carried at flowering for textile Hemp or later for technical fibre	At flowering or after a killing frost
from middle July to middle August	from October to late winter

Proposed textile chain in Hemp-Sys

Harvesting and cutting stem



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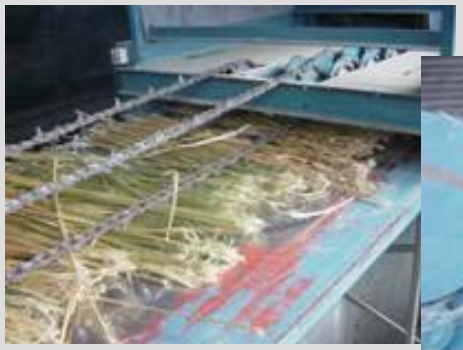
Green scutching – separation of bark from core (flax line)



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Bio-degumming and drying



Standard industrial process

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Hackling and spinning

Cutting and bailing

Scutching

Chopping

Separation of bark from core

BIOMASS YIELDS

	Hemp 	Kenaf 
Fresh Biomass (t ha^{-1})	30 – 50	20 - 40
Dry Biomass (t ha^{-1})	12 – 15	8 - 12
Fresh Stems (t ha^{-1})	25 – 40	20 – 30
Dry Stems (t ha^{-1})	10 – 12	8 – 12
Dry Fibre (t ha^{-1})	1 – 2	1 – 2.5
Moisture content (%)	50 – 60	70 – 80
Plant Height (cm)	150 – 400	150 – 350
Base Stem Diameter (mm)	1 – 7	10 – 15

- In Northern Italian conditions, Hemp show higher yield than Kenaf
- The moisture content in Hemp is lowest than Kenaf
- The “pit” in Kenaf cause the problem in the drying
- The plant height and diameter are strictly correlated to plant population
- Dry biomass potential makes this crops feasible for energy applications

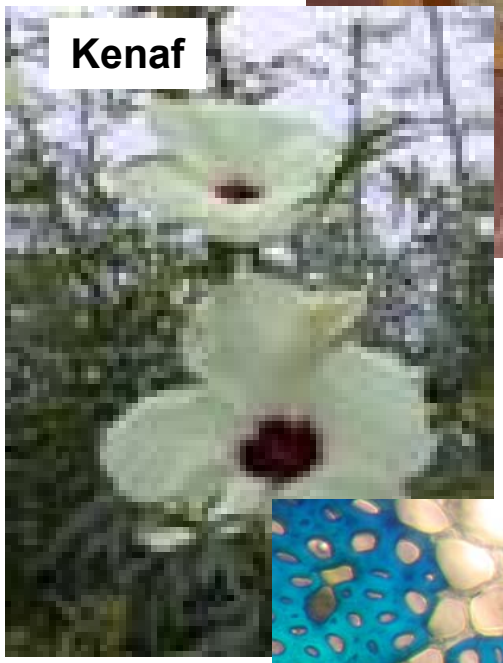
FIBRE YIELDS

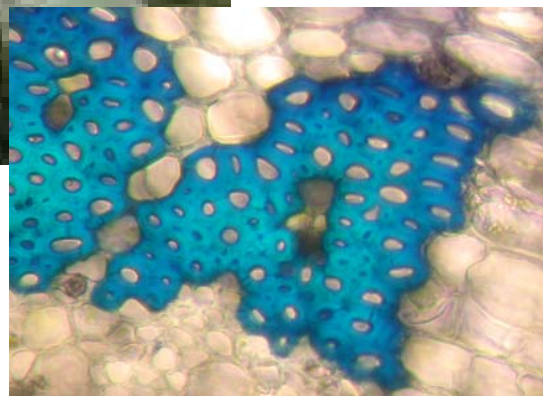
Similar fibre yield

Higher cellulose content in Hemp

Low lignin content and long fibre of Hemp makes it more feasible for textile uses

	Hemp	Kenaf
Dry Fibre (t ha^{-1})	1 – 2	1 – 2.5
Fibre content in stem (% DM)	15 – 30	1 – 15
Cellulose (% DM)	60 – 70	30 – 35
Emicellulose + pectin (% DM)	5 – 15	22 – 33
Lignin (% DM)	3 – 14	8 – 19
Fibre fineness (μm)	25 – 45	20 – 35
Fibre length (mm)	16 – 40	8 – 18





Product applications

Textile fibre

Bast fibre: yarns, cords, fabrics, yarn manufactures.

Technical fibre

Paper pulp:
Newsprint, bond, coating raw stock and surfaced size.

Manufactures, as substitute of synthetic and fibreglass.
Bio-composites.

Particleboards, insulation panels.

Core uses

Paper pulp, oil absorbent, orticultural mixes, bedding materials.

Thermochemical processes: pyrolysis, gasification and combustion.
Pellettization.

Young Kenaf plant as animal feeding material (high protein content and good digestibility)

CONCLUSION

	Hemp	Kenaf
Agronomic Knowledge	XXX	XX
Thermal requirements	X	XXX
Water requirements	X	XXX
Nutrient requirements	X	X
Seedbed preparation	XX	XX
Weed control	X	XX
Seed Availability	XX	X
Specific varieties	X	X
Positive effects in crop rotation	XXX	XX
Sensibility to insects and diseases	X	XXX
Mechanization	XXX	XX
Storage	XXX	X
Textile destination	XXX	XX
Other destinations	XX	XXX

Thank you for the attention!