Hemp-Sys,
Quality control and integrated supply chain of hemp for textile processing

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HEMP-SYS (QLK5-CT-2002-1363)

Integrated production and quality system for hemp textile production chain

stem fibre yarn fabric

HEMP Research at A & F

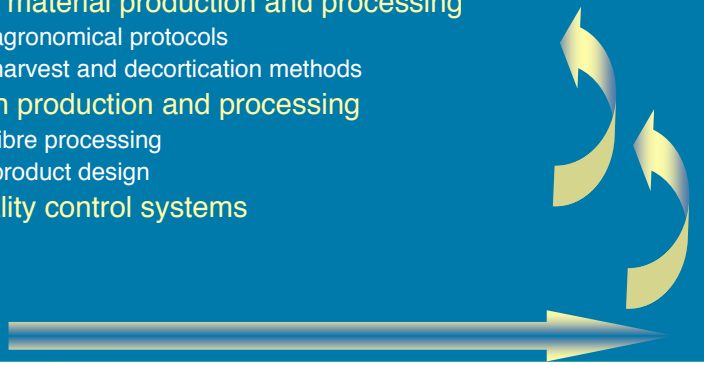
- hemp fibre for paper production
- hemp fibre reinforced composites
- hemp cellulose for non-wovens

- Integrated production and quality system for hemp textile production chain

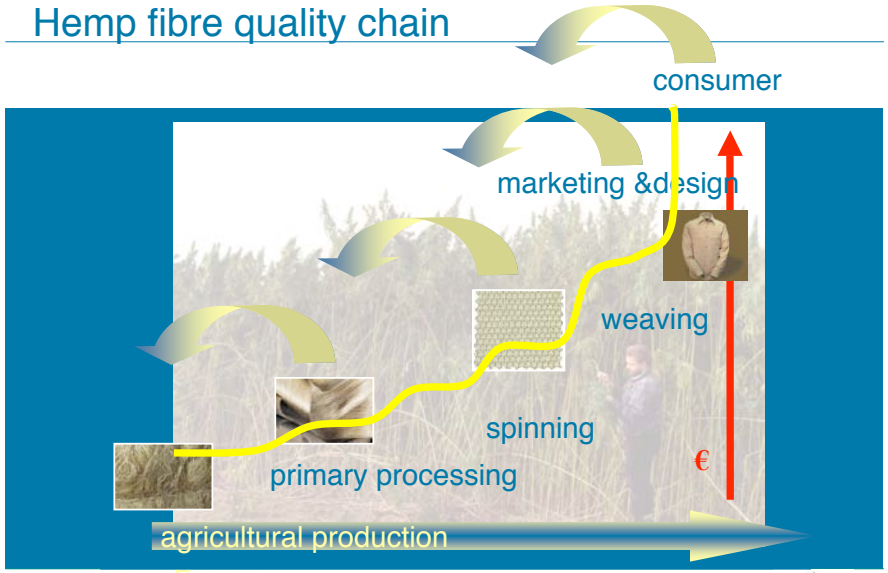
Objective and Methods

Competitive and innovative hemp fibre production chain for textile industry in EU

- raw material production and processing
  - agronomical protocols
  - harvest and decortication methods
- yarn production and processing
  - fibre processing
  - product design
- quality control systems



Hemp fibre quality chain



Qualified production chain

- objective quality assessment
- improved logistic supply chain
- reduced dependency on organoleptic methods
- efficient use of raw materials, with highest added value

Partners HEMP-sys

• DiSTA Univ Bologna,	Italy
• Wageningen UR,	Netherlands
– Crop and Weed ecology	
– Agrotechnology and Food Innovations	
– MTT plant production reseach	Finland
– INRA, Rennes	France
• Gruppo Fibranova srl	Italy
• Agro-Hemp Ltd	Hungary
• Linificio Spa	Italy
• GT Design	Italy
• Fibre, Bremen	Germany

Work package (1)

- Hemp Production - growing conditions for textile use
  - growing conditions
    - soil, water, temperature, photoperiod
  - genotype
  - management
    - density, irrigation, fertilizer, sowing and harvest time
  - decision support system

Work package (2)

- Hemp processing (post harvest handling)
  - from harvest to ribbon preparation
  - decortication, degumming
- Yarn production
  - quality control of hemp fibre raw material
  - spinning performance
- Design
  - yarns and fabric transformation to fashionable end-products

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Work package (3)

- Integrating Quality aspects of the production chain

relationships between
crop growth conditions, genotypes management
fibre extraction techniques

and quality parameters of
stem
raw and processed fibre
yarns and fabrics

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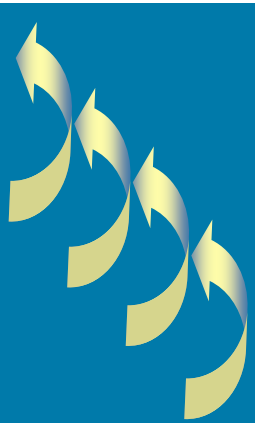
Hemp fibre quality (1)

- Agricultural crop production
- Fibre extraction process
- Fibre cleaning and preparation
- Textile processing & design
- Consumer



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Hemp fibre quality (2)

- Agricultural crop production
  - Plant variety / cultivar --> Breeding
  - growing conditions --> Agronomy
    - seed density
  - harvesting and storage --> Harvesting technique
    - moment of harvest (flowering / seed formation)

stem

yield rather than quality

15 (-up to 25) tons dry matter per ha

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Hemp fibre quality

Hemp fibre quality (3)

- Fibre extraction process
  - retting
    - field retting / water retting / enzyme retting
  - decortication
  - degumming

cleaned bast fibre

Hemp fibre quality (4)

- Fibre cleaning and preparation
  - mechanical, chemical decortication (breaking / scutching)
    - parallel handling of long fibre bundles
  - hackling / combing

sliver
fine and homogeneous
fibres with high strength

Hemp fibre quality (5)

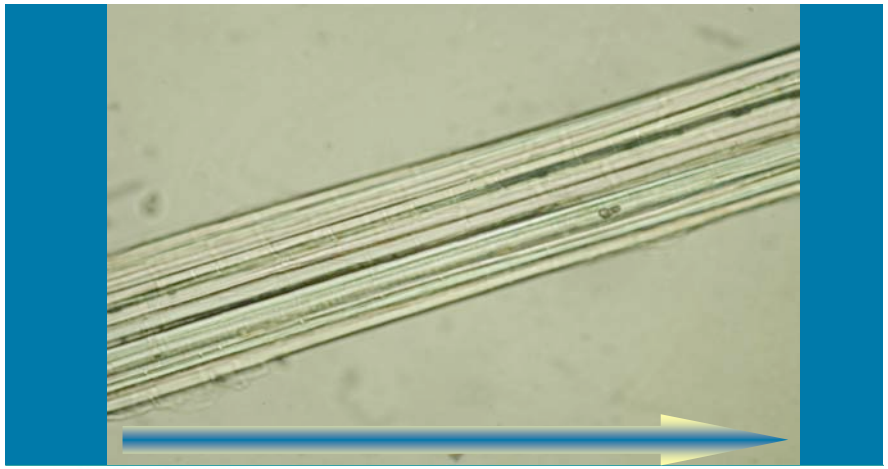
- Textile processing
  - long fibre spinning (wet spinning, dry spinning)
  - fineness
  - strength
  - homogeneity (cleanness)
  - colour, softness

yarn high strength,
fineness (Nm)

Hemp textile products

Harvesting hemp

Bundle of parallel primary fibres



Agronomical trials HEMP-sys project (1)

- 5 locations
  - North and South Italy, Hungary, The Netherlands, Finland
- 12 varieties
  - beniko, bialorzeski, carmagnola, dioica 88, epsilon,
  - fedora 17, felina 34, ferimon, fibranova, futura 75,
  - lovrin, tiborszallasi

Agronomical trials HEMP-sys project (2)

- 7 sowing dates / 4 varieties
  - monoecious: felina 34, futura 75
  - dioecious: fibranova, tiborszallasi
  - two weeks interval
- 3 plant densities
  - 120, 240 and 360 seeds per m^2

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Multiple Sowing dates

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Density trial

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Stem properties and quality assessment

	Seed density	genotype	growth stage
length	+	+	++
thickness	+++	++	++
flowering	+	+++	++
colour	-	-	+
fibre extraction	-	+	++
fibre content	+	++	++
fibre quality	++	++	+++
fibre yield	+	++	+++

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Study of fibre formation in Hemp

- Bast fibre development in the stem
  - stem growth and primary fibre cell elongation
  - cell wall thickening
  - lignification
  - stem thickness growth and secondary fibre cell formation

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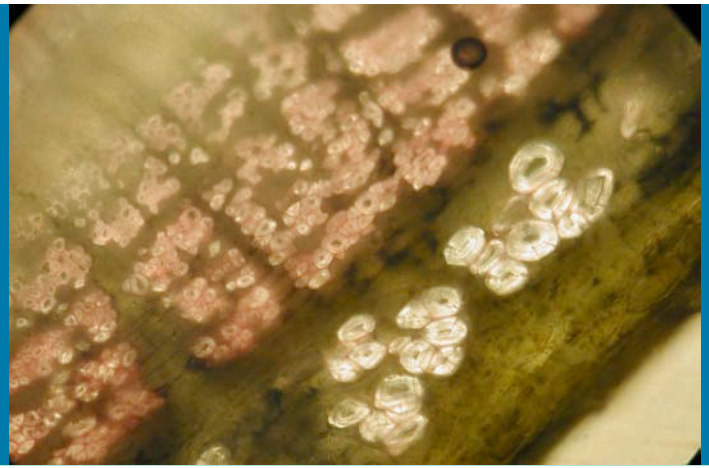
Primary and Secondary Fibres



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Hemp Fibre Dimensions

	Length mm	diameter μm	cell wall thickness μm
primary fibre	10-40	20-40	10-20
secondary fibre	2- 3	5-10	10-20

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Observations on fibre formation

- Primary fibres run from bottom to top
  - cell wall thickening proceeds from outer to inner layers
- Secondary fibres do not occur above 2nd or 3rd internode when:
  - hemp not taller than about 2.5 m
  - diameter (at the bottom of the stem) < 1 cm
  - hemp has not started to flower

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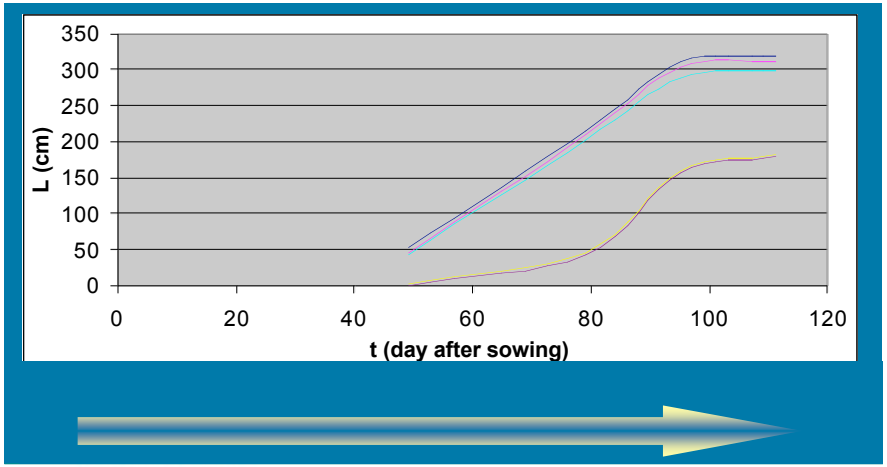
Primary and Secondary Fibres



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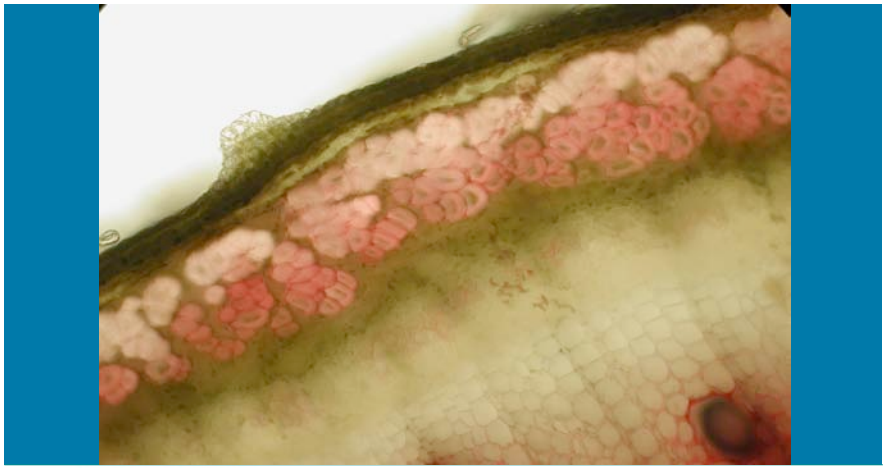
Cell wall thickening of fibres



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Fibre properties and quality assessment

strength	tensile	stelometer instron
length	image analysis	
fineness	image analysis	air flow ISO 2370 ASTM D1448
	micronaire	
fibrillation	image analysis	
cleanness	image analysis	NIR
colour	colorimeter	

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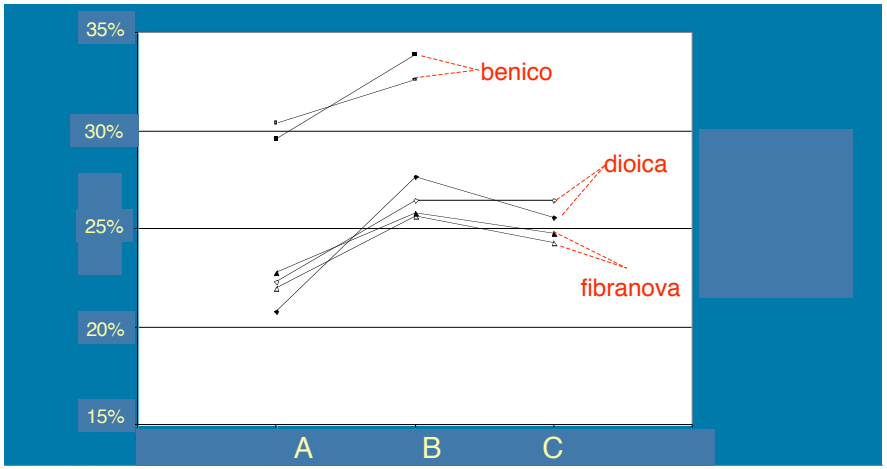
Fibre yield hemp retting



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Preliminary quality data of hemp samples

		tensile strength (MPa)	strain (%)	airflow fineness (1/A)
Benico	top	559	2.3	2,3
	bottom	663	2.5	3.5
Dioica	top	643	3.1	2.1
	middle	724	3.3	4.0
	bottom	642	2.6	2.1
Fibranova	top	822	3.4	2.4
	middle	801	3.5	2.4
	bottom	513	2.3	2.0

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Extractives and phenolic content hemp bast fibre

		EtOH/ Toluene %	H_2O %	AIL %	ASL %
green	top	3.0	9.5	4.7	1.1
	middle	3.6	8.1	3.2	0.8
	bottom	3.2	7.3	3.3	0.7
ww retting	top	1.2	1.8	2.8	0.5
	middle	0.3	2.0	1.9	0.4
	bottom	0.2	2.4	1.9	0.5

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Polysaccharide content hemp bast fibre

		Rha %	Ara	Xyl	Man	Gal	Glc	UA
green	top	0.5	1.1	2.0	2.6	2.1	62.1	6.3
	middle	0.4	0.8	1.9	3.2	1.7	69.6	4.4
	bottom	0.4	0.8	1.8	3.7	1.7	72.0	3.8
ww retting	top	0.0	0.5	1.0	3.8	1.7	78.3	2.0
	middle	0.4	0.4	1.1	4.1	1.4	85.8	2.3
	bottom	0.0	0.5	1.6	4.6	1.4	79.5	1.9

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Fibre properties and quality demands

	cellulose	chemical composition	morphology
strength	+++	++	++
length	++	+	++
fineness	+	+	+++
fibrillation	-	++	++
cleanness	-	+++	+
absorbency	-	++	++

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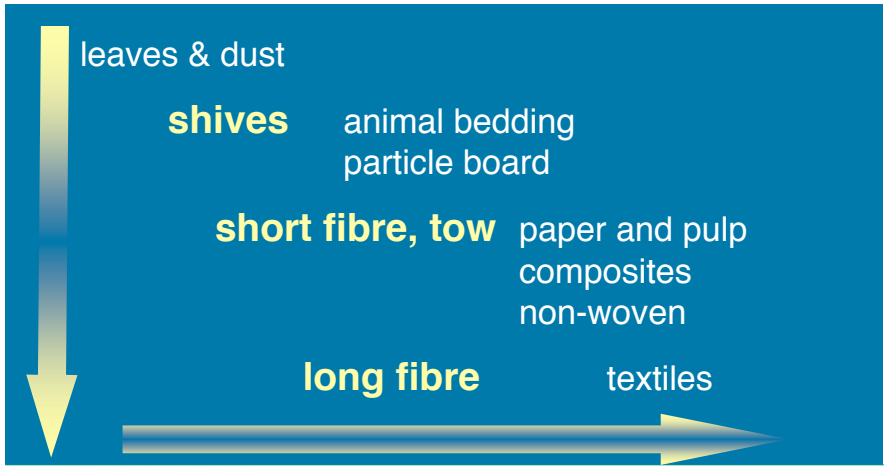
Hemp fibre quality and end-use



Conclusions (1)

Hemp bast fibre formation occurs in two stages:
- primary fibre is formed during fast growth
- secondary fibre is formed during maturing

Agronomical management affects:
(timing of sowing and harvest)
- ease of fibre extraction
- fibre quality
- fibre yield

Conclusions (2)

Hemp fibre quality testing for textile processing :

- standard protocols and data exchange
- correlation of processing conditions and input - output product quality data (yield and performance)
- feedback mechanism in the production chain (tracking and tracing)

Conclusions (3)

Hemp bast fibre could find highest added value in textiles

whole crop utilisation in other end-uses (apper pulp, composites, building materials.etc.) requires coordination of supplies

Quality control is essential in the whole production chain