

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

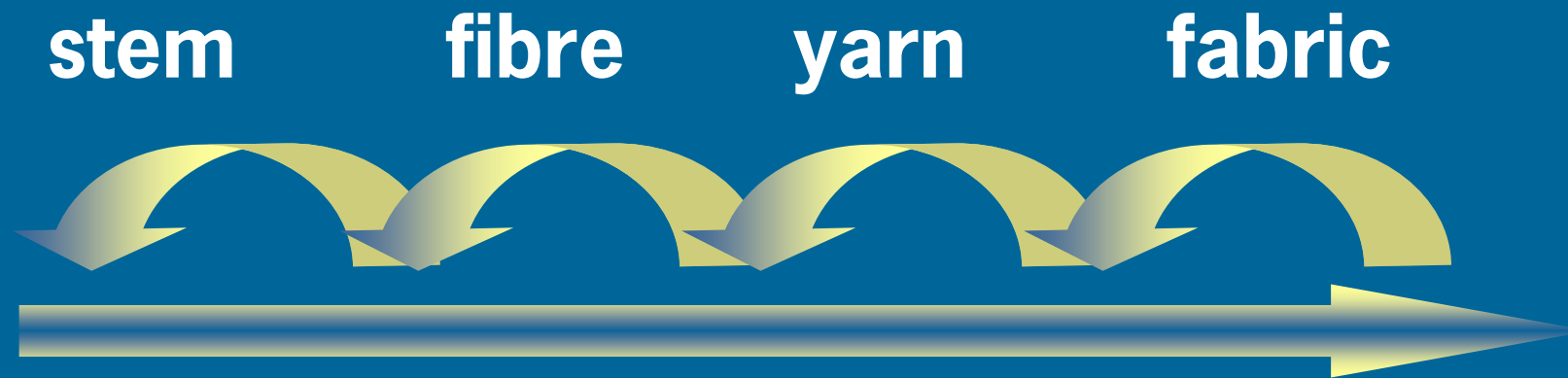
2nd International Conference of the
European Industrial Hemp Association

18-19 / 11 / 2004



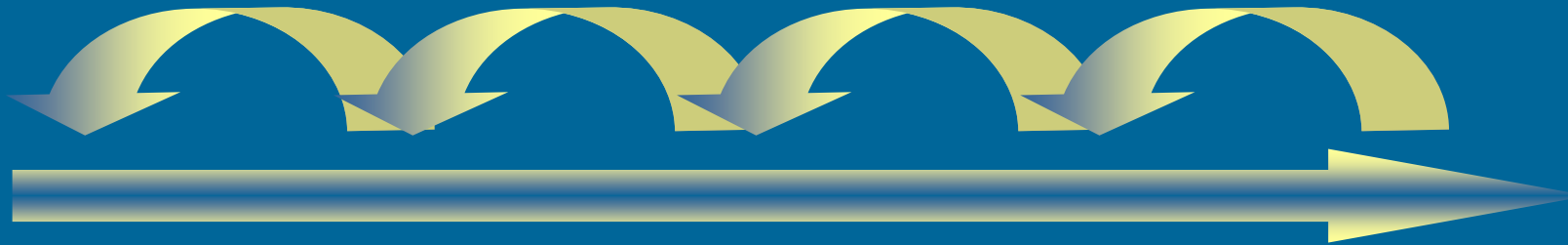
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Integrated production and quality system for hemp textile production chain



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



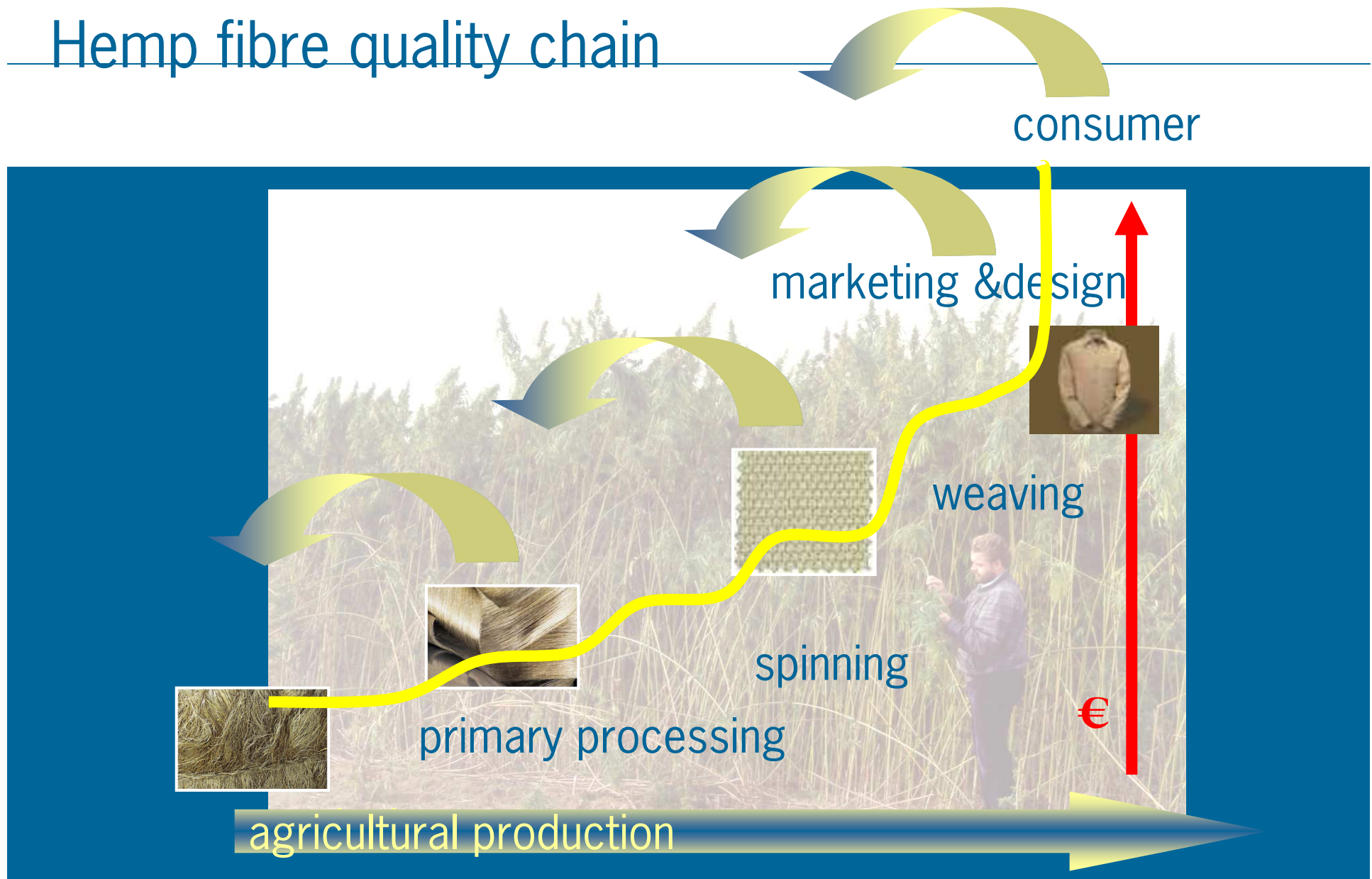
Objective and Methods

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
 - INRA, Rennes
- Gruppo Fibranova srl Finland
- Agro-Hemp Ltd France
- Linificio Spa Italy
- GT Design Hungary
- Fibre, Bremen Italy
- 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



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

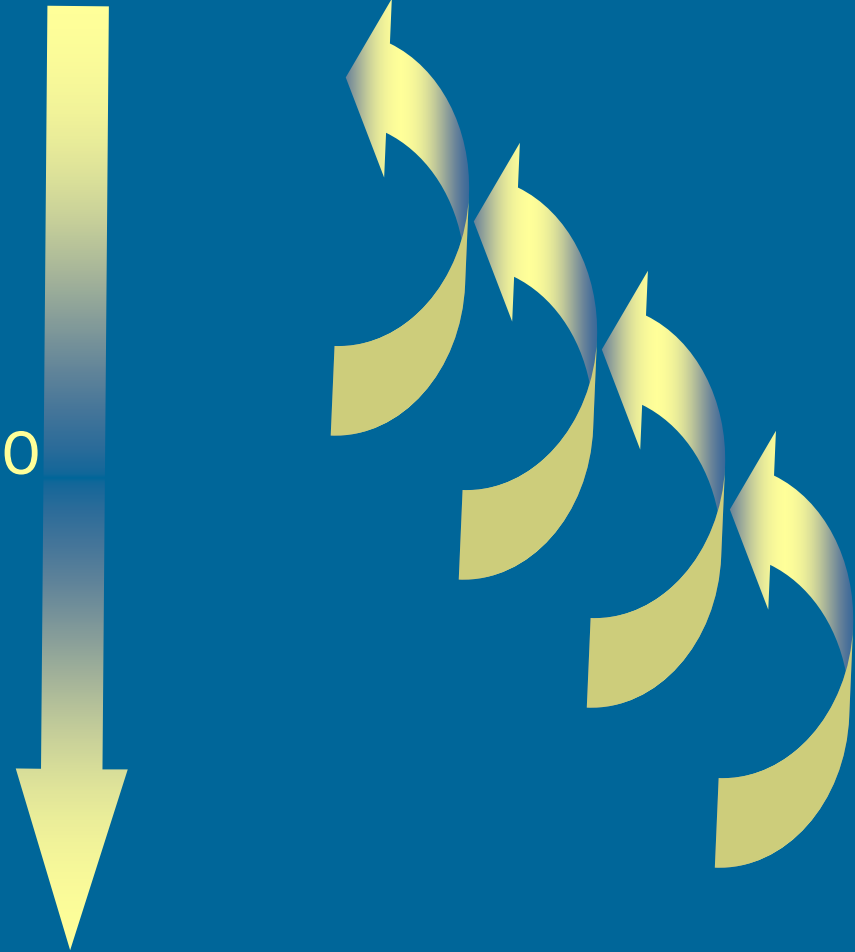
raw and processed fibre

yarns and fabrics



Hemp fibre quality (1)

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



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



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

Design and consumer perception



“tribal fibre”



“dash hemp”



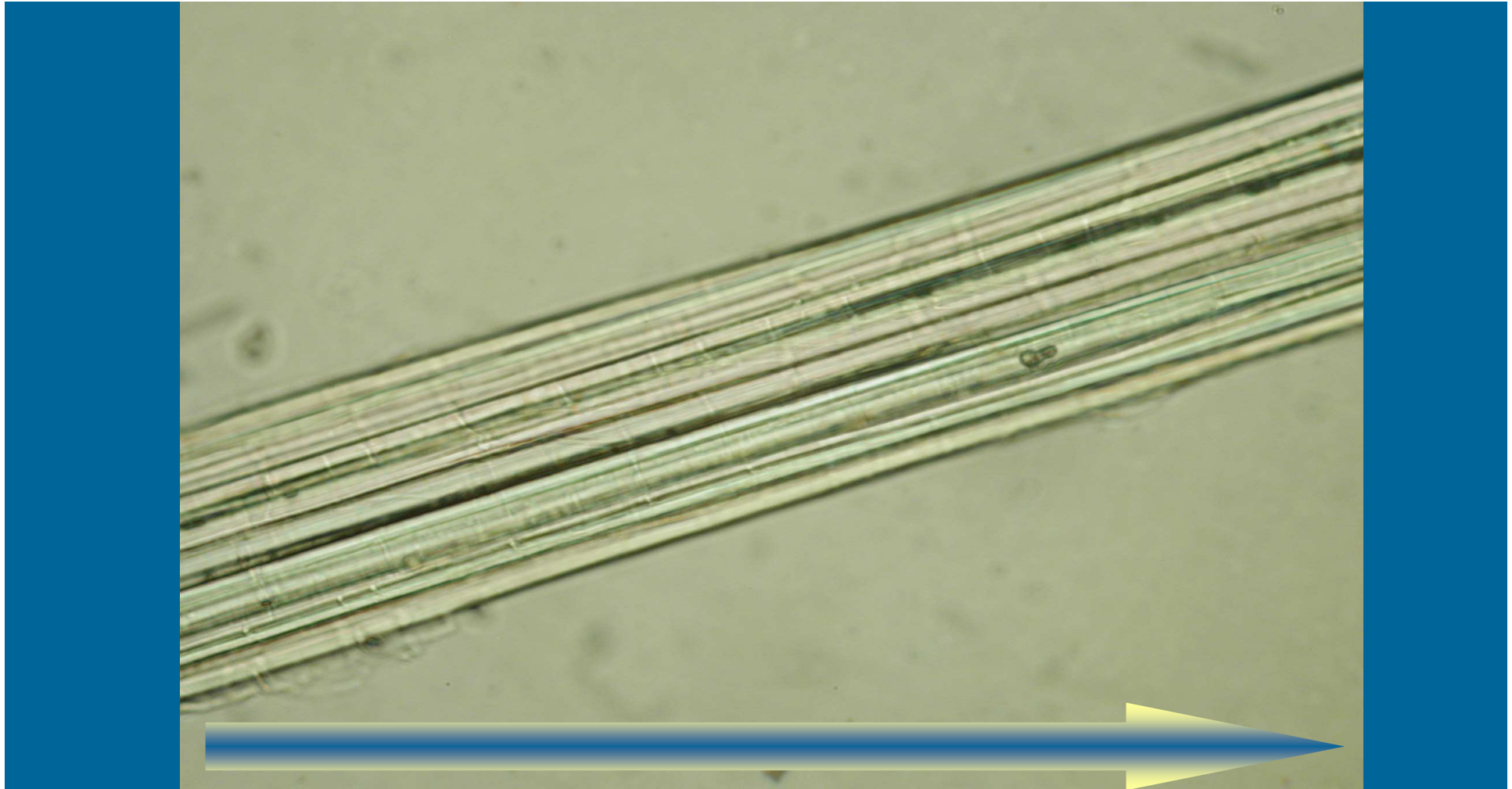
“sweet grass”



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 m²



Multiple Sowing dates




Density trial



Stem properties and quality assessment

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

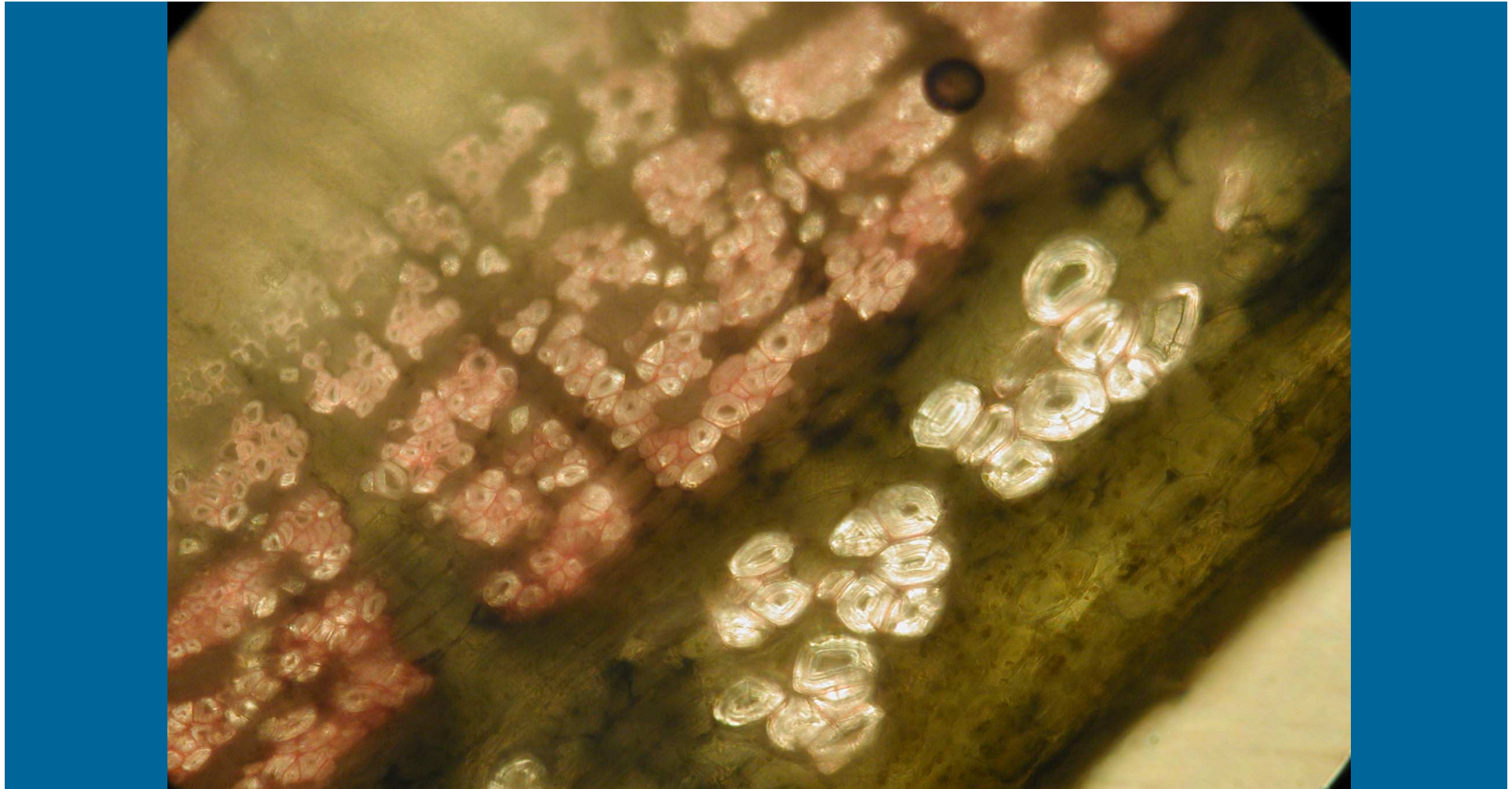


Study of fibre formation in Hemp

- 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

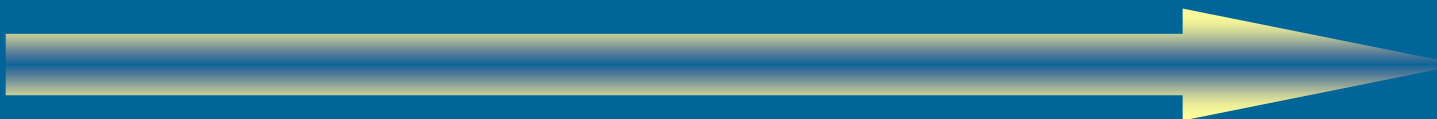


Primary and Secondary Fibres



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 |

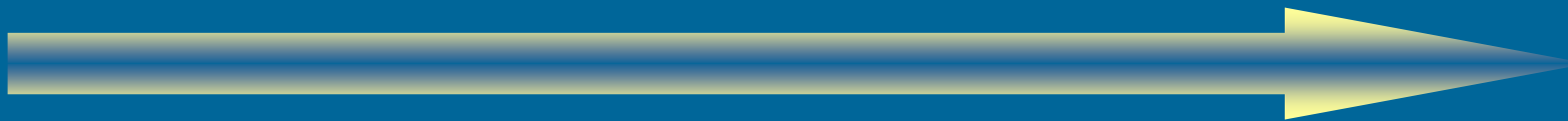
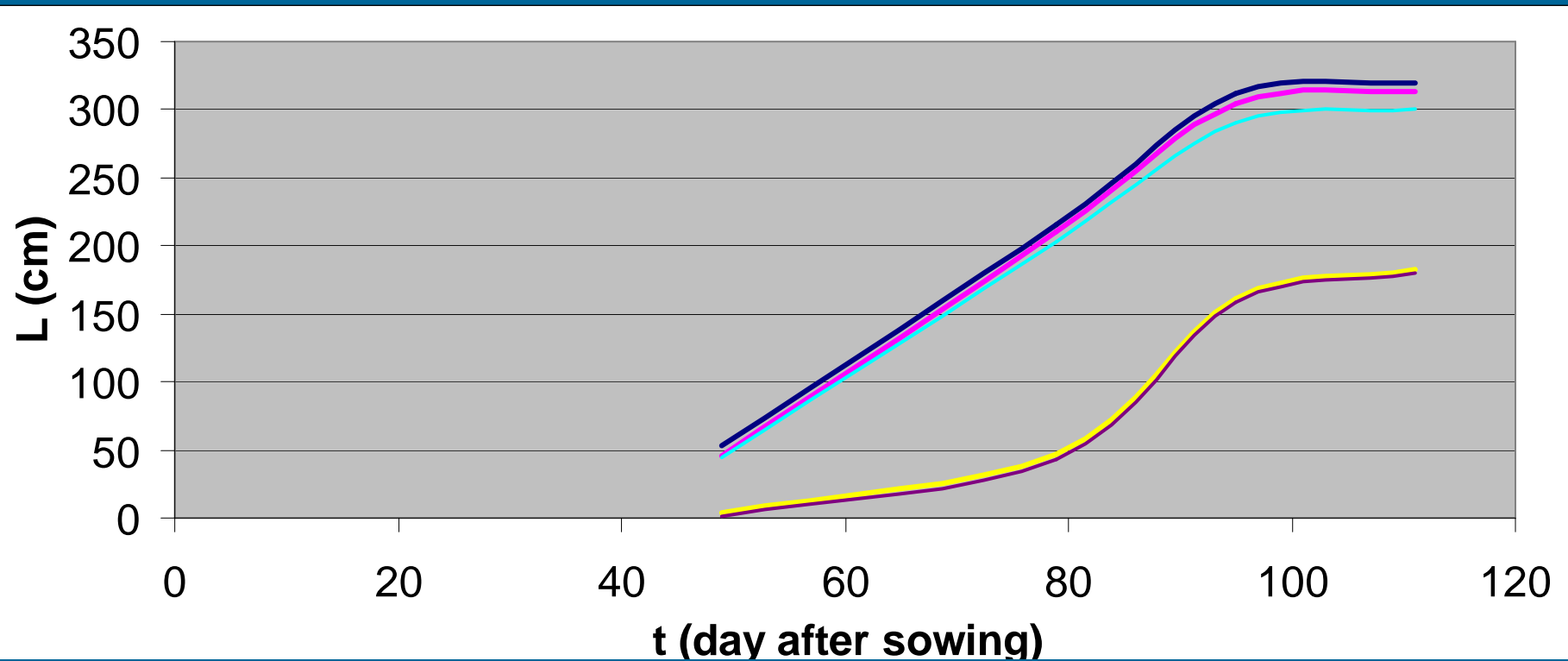


Observations on fibre formation

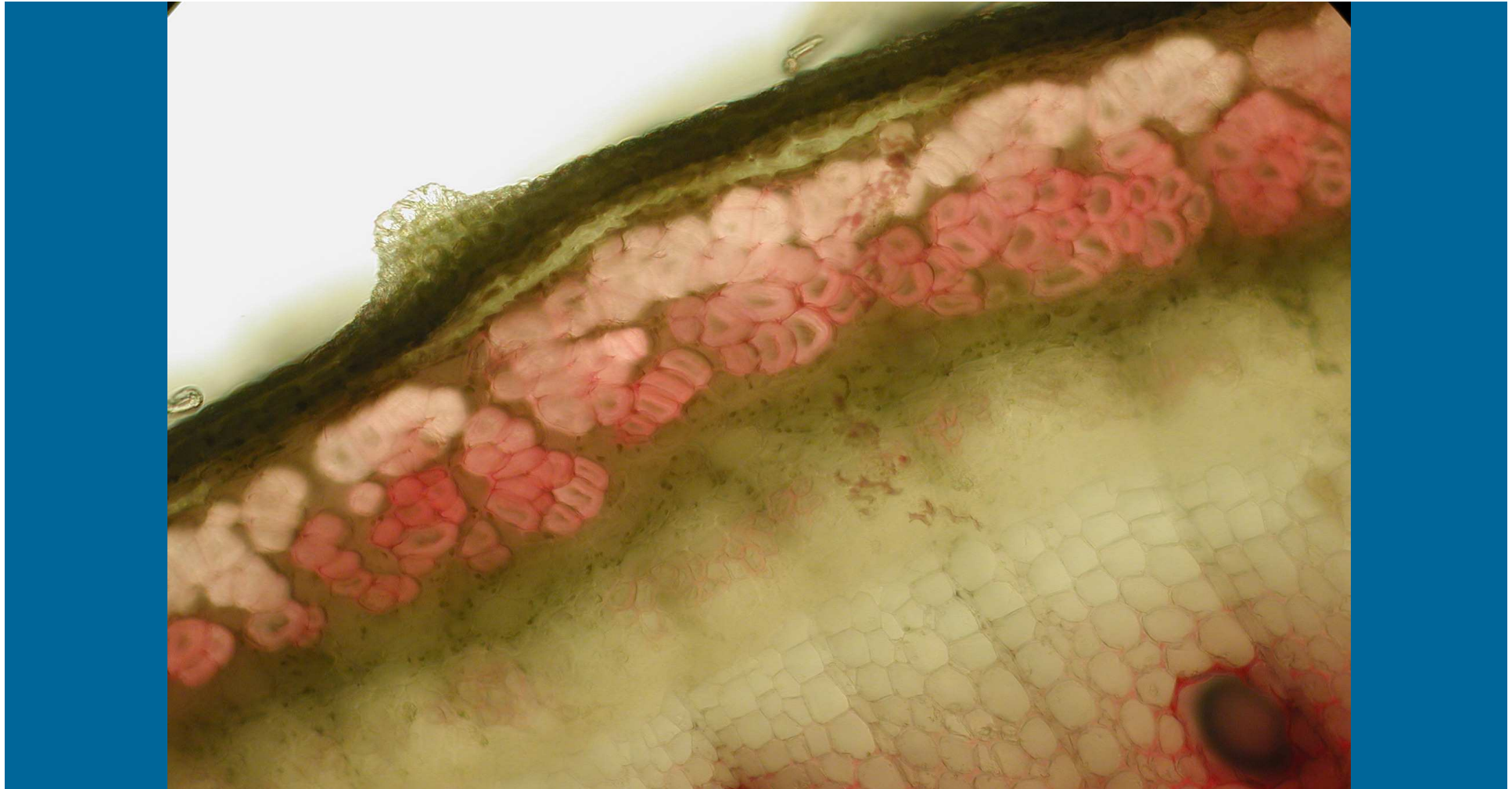
- **Primary fibres** run from bottom to top
 - cell wall thickening proceeds from outer to inner layers
- **Secondary fibres** do not occur above 2nd or 3rd internode when:
 - hemp not taller than about 2.5 m
 - diameter (at the bottom of the stem) < 1 cm
 - hemp has not started to flower



Primary and Secondary Fibres



Cell wall thickening of fibres



Fibre properties and quality assessment

strength

tensile

stetometer
instron

length

image analysis

fineness

image analysis

air flow
ISO 2370
ASTM D1448

fibrillation

micronaire

image analysis

cleanness

image analysis

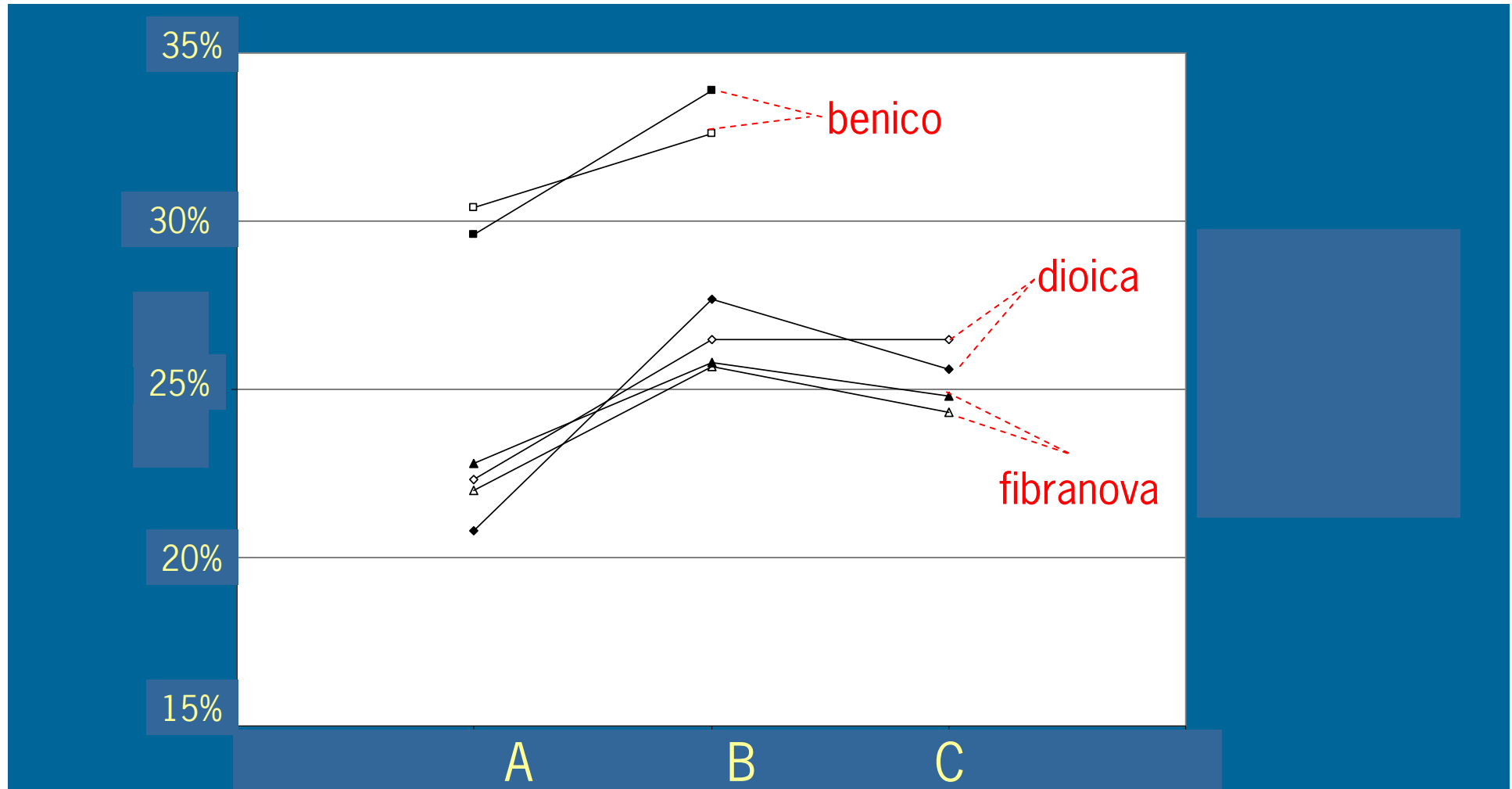
NIR

colour

colorimeter



Fibre yield hemp retting



Preliminary quality data of hemp samples

| | | tensile | | airflow |
|------------------|--------|-------------------|---------------|-------------------|
| | | strength (MPa) | strain (%) | 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 |

Extractives and phenolic content hemp bast fibre

| | EtOH/ Toluene | H ₂ O | 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 |



Polysaccharide content hemp bast fibre

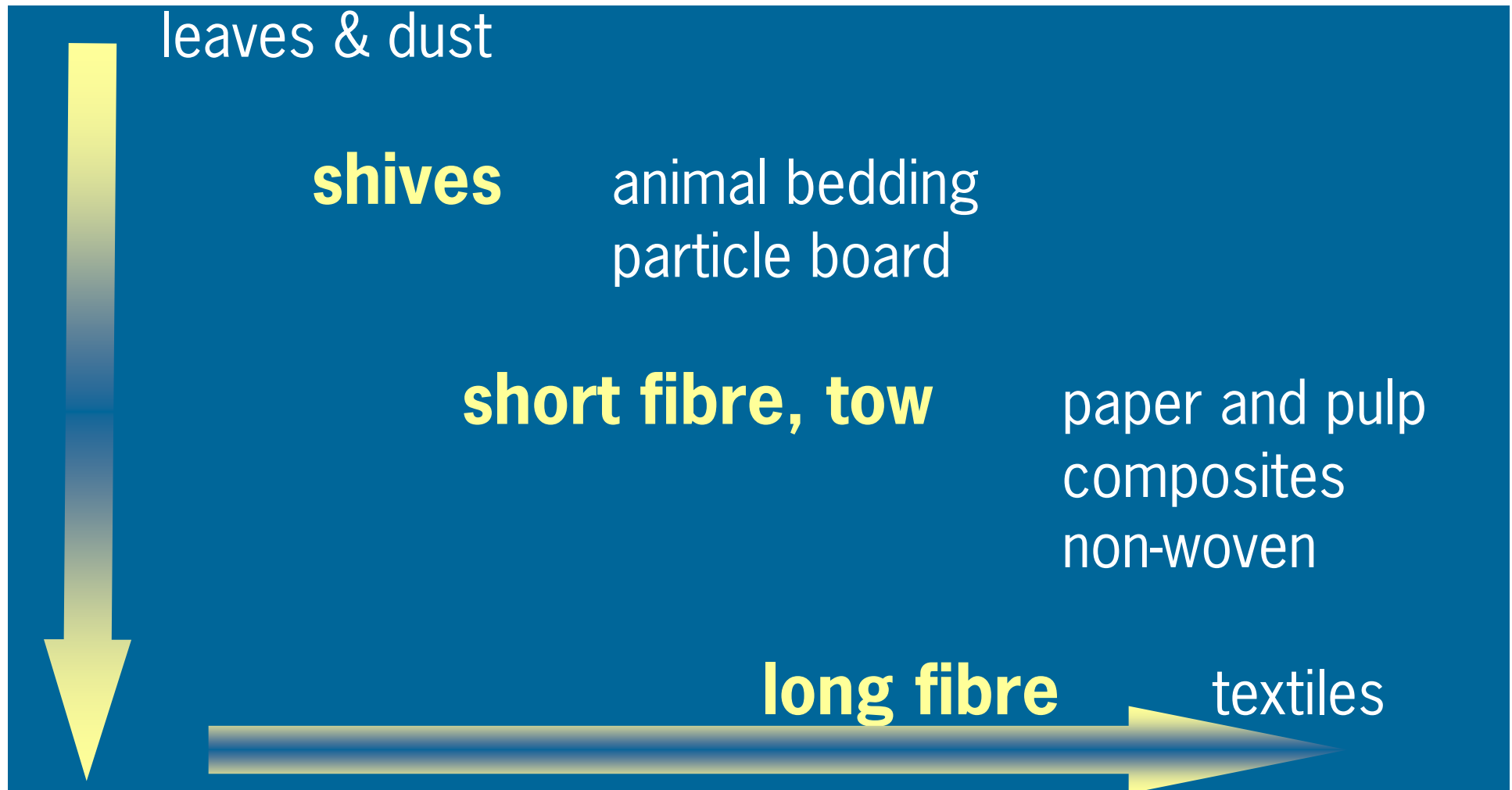
| | Rha % | Ara | Xyl | Man | Gal | Glc | UA |
|----------------|----------|-----|-----|-----|-----|------|-----|
| green top | 0.5 | 1.1 | 2.0 | 2.6 | 2.1 | 62.1 | 6.3 |
| middle | 0.4 | 0.8 | 1.9 | 3.2 | 1.7 | 69.6 | 4.4 |
| bottom | 0.4 | 0.8 | 1.8 | 3.7 | 1.7 | 72.0 | 3.8 |
| ww retting top | 0.0 | 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 |



Fibre properties and quality demands

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

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 (paper pulp, composites, building materials.etc.) requires coordination of supplies

Quality control is essential in the whole production chain



Hemp bast fibre bundle



**Thank you
for your
attention**

