EU-PEARLS
EU-based Production and Exploitation of Alternative Rubber and Latex Sources

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RRB5, Gent, June 10-12, 2009
Natural rubber = cis-1,4-polyisoprene

- Monoculture of *Hevea brasiliensis*
- Over 8 million Ha, mainly in Southeast Asia
- Over 10 million labourers
- 7 years growth to first tapping
- Rubber yield: 1-2 tonnes / ha . year
The market share of natural rubber increases
because NR latex is superior to synthetic products.

- Latex applications: gloves, tubing, contraceptives
  - Thin, flexible films, good dexterity
  - Good physical properties
  - Low cost
  - Environmental benefits
and because NR is superior to synthetic rubber..

- Dry rubber applications: heavy duty tires for airplanes, trucks, agricultural equipment, side-wall of car-tires
  - Heat-tolerance, low heat-buildup
  - Resistance to break
  - Resistance to shrinkage
  - High tear and tensile strength
  - Long shelf life

- In many of it's most significant applications, NR cannot be replaced by synthetic rubber!
The day that haunts the rubber industry will dawn like any other. As tappers fan out among the plantings, the sea wind picks up, scattering foliage that falls unnaturally from the branches. The leaves are withered and dry, blackened with lesions. The dark eruptions mean only one thing: The South American leaf blight, a fungal pestilence so virulent as to have thwarted all efforts to cultivate rubber in its native Amazonian homeland, has reached the shores of Asia.

On the scattered family farms, source of 80% of the production, the disease proves impossible to control.

So fearful have Malaysian officials been of this potential calamity that they have never permitted a commercial airline to fly directly to their country from any South American nation known to harbor the fungus.

The outcome: the end of the natural-rubber industry as we know it.

(Wade Davis, Fortune Magazine, 1997)
Why work on natural rubber in Europe?

- **Strategic issues**
  - Emergency crop should be available

- **Scientific issues**
  - Neglected compared to other biopolymers
  - Identity of rubber polymerase (*cis*-prenyl transferase) not certain
  - Links between genes and functions not established
Enzymes / proteins involved in synthesis?
Modification of rubber synthesis?
Why work on natural rubber in Europe (II)?

- Commercial opportunities

  - Life-threatening, IgE-mediated *Hevea* latex allergy
  - Alternative sources providing added value through new functions (hypoallergenic latex, high MW polymer)
  - New “marginal” supply under tight market conditions
  - Peak-oil: threat to synthetic rubber
Why work on natural rubber in Europe (III)?

- Social / environmental issues
  - Rubber tree tapping is laborious, poorly paid, and often involves child labor
  - Competition for land by palm oil plantations
  - *Hevea* plantations replace natural forests
**EU-PEARLS: project details**

- Call FP7-KBBE-2007-1 in Food, Agriculture and Fisheries, and Biotechnology
- 12 Partners: industry, SMEs, academia, research institutes
- 8 Countries, 8 M€ - ~6M€ subsidy, 2008-2012
- Disciplines/activities: Entire chain from new varieties, molecular breeding, agronomy, by-products, extraction, modification, applications
- Objective: Establishment of new production and application chains for latex and rubber in Europe
EU-PEARLS: partners / coordinator

- Wageningen UR Biobased Products (WUR, Coordinator: Hans Mooibroek)
- Plant Research International B.V. (PRI, NL)
- Keygene (NL)
- Yulex Co. (USA)
- Vredestein (VRB, NL)
- Westfälische Wilhelms-Universität Münster (WWUM, DE)
- Université de Lausanne (UNIL, CH)
- Czech Academy of Sciences, Institute of Botany (CAS-IBOT, CZ)
- Basque Institute for Agrarian Research and Development (NEIKER, ES)
- Establishment Center Ecological Reconstruction (ECER, Kazakhstan)
- Centre de coopération internationale en recherché agronomique pour le développement (CIRAD, FR)
- Extraction Unit Designer (Stramproy)
Target species for Europe

*Partenium argentatum* Gray, Guayule, Chihuahuan Desert (“wa-you-lee”)

*Taraxacum koksaghyz* Rodin, Russian dandelion, Kazakhstan
Taraxacum kok-saghyz Rodin (TKS)

- Occurs in central Asia
- Superior rubber (high MW), up to 15% of dry weight
- Latex in laticifers
- Fast breeding: sexual diploids, several generations per year
- (Bi)-annual crop for temperate regions
TKS bottlenecks

- No systematic breeding
- Limited germplasm available
- Critical properties
  - Vigor
  - Root size and morphology
  - Reliable rubber content

TKS  T. officinale
TKS bottlenecks

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  - Vigor
  - Root size and morphology
  - Reliable rubber content
TKS bottlenecks

- Agronomics
  - Vulnerable seedlings
  - Competition with other dandelions
  - Plant diseases
  - Rabbits!

- Processing technology
  - Limited information

- By-products
  - Butanol-acetone
  - Inulin (35% DW)
  - Leaf and root fractions for feed, ethanol or biogas
1 ton of rubber per ha from improved TKS

German rubber imports: 212000 tons in 2010, FAO

Areas used for sugar beet and potato cultivation in Germany in 2007: 403 000 and 275 000 ha, respectively

Cultivation costs similar to chicory
*Parthenium argentatum* (Guayule)

- Occurs in Mexico, Southern USA
- Commercial in early 20th century
- “Manhattan project” type effort during WWII
- Partially domesticated
- Under development for high-value hypoallergenic latex
- Can be grown in Southern Europe, drought resistant
Guayule bottlenecks

- **Germplasm**
  - Suitable for Europe?
  - More breeding necessary

- **Agronomics**
  - Direct seeding is difficult, and seedling production is expensive
  - Harvest: various methods

- **Difficult processing**
  - Rubber in parenchyma cells: extraction is difficult and costly

- **Marginal by-products**
  - Resins (sesquiterpenes)
  - Low-MW rubber
  - Biomass energy
Guayule future

- Large scale cultivation in Southern Europe
- Rubber reserve *in planta*
- Processing facilities linked to cultivation (locked supply chain, similar to sugar beet)
- Initial market: high-value medical applications
Project flow scheme

Extraction, processing and material production technologies

Cultivation y1
Cultivation y2
Cultivation y3
Extraction y1
Extraction y2
Extraction y3
Application Research y2
Application Research y3
Application Research y4

Enabling knowledge, breeding of elite material

Germplasm of Russian dandelion & other dandelions
Guayule Germplasm

Fundamental res.
Hybridization
Genetic maps
QTLs
Rubber metabolism
Induced mutations
Field trials

Molecular breeding for improved:
- Rubber yield
- Rubber quality
- Vigor
- Agronomy

1st gen. improved dandelion
2nd gen. improved Guayule

1st gen. improved Guayule

Germplasm of Russian dandelion

Guayule Germplasm

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2nd gen. improved Guayule
Economics (situation in 2007)

- Increasing market share for natural rubber
- Rapidly increasing demand from China and India
- Palm oil competition for land
- Great prospects!
Current context

- **Commodity**
  - Natural rubber: -18% demand, -50% price
  - Oil: -5%? demand, -65% price
  - Petrochemicals: -10% demand, -35-60% price
  - Synthetic rubber: -20% demand, -70% (SBR, BR) price
  - Tires: -20% demand
  - Gloves: +10% demand
  - Price: up? (flu, regulations)

- **Peak oil**: declining production soon
  - Less road and air transport, fewer and smaller tires

- **Climate change**: 80% CO₂ emissions necessary
  - Less road and air transport, fewer and smaller tires
Long term vision

- SALB or other pests may decimate production
  - Strategic issue for the EU!

- Hypoallergenic gloves, medical rubber and latex products required
  - Commercial opportunity

- Climate change and peak oil
  - Land transport electrification, lighter vehicles, less road transport, fewer and smaller tires
  - Less competition from synthetic rubber
  - Plants as sole source of carbon: chemicals, materials, fibers, plastics, rubber: opportunity for all sources of natural rubber
Conclusions

- *Hevea* rubber production is low-tech and cheap (about 70% of production costs for labor)

- Guayule and TKS as strategic backup crops

- Guayule rubber is suitable for high-value applications (hypoallergenic products)

- TKS in case of “Emergencies” (plant disease, shortage, and for hypoallergenic products)

- Farmer income (compared with e.g. chicory) highly acceptable
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Thanks
Danke
Merci
Dzienki

Спасибо
Děkuji
Gracias
Dank