Agronomic evaluation of Guayule cultivation in two Mediterranean areas (Spain and France)

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Objective of this study

- Determine the viability of guayule cultivation in the Mediterranean regions of Southern Europe for a possible development of large-scale production.
Temperature and water resources are the major climate factors that govern the distribution of crops, both in space and time.

Guayule is native to the Mexican desert, where:

- average annual rainfall is 300 to 600 mm;
- average annual temperatures is 16 to 25 °C.

These conditions can be found in the Mediterranean region.
We used a GIS to combine the two maps, and generate a potential land suitability map for guayule.

The final result is a map showing six potential yield categories, with better notation where optimal conditions exist.
But, the rainfall patterns are different in the region of origin and in the Mediterranean region.

**Tucson  
(Arizona, USA)**
9 dry months ($P_{mm}/T_{°C} < 2$)
Annual rainfall = 280 mm

**Cartagena  
(Murcia, Spain )**
7 dry months ($P_{mm}/T_{°C} < 2$)
Annual rainfall = 300mm

Thus, the need for field trials in Europe
Site selection

Two sites were selected for field trials:

- France, Montpellier
  Agropolis research station

- Spain, Cartagena
  El Molinar farm
Montpellier Climatic data

- Average temperature in Winter = 5 - 7 °C; in Summer = 21 - 24 °C
- Total annual rainfall = 776 mm, with 3 dry months ($P_{mm}/T_{°C} < 2$).
Cartagena climatic data

• Average temperature in Winter = 10 - 12 °C, in Summer = 22 - 28 °C
• Total annual rainfall = 300 mm, with 7 dry months ($P_{mm}/T_°C < 2$)
Two trials in the two sites

• **Germplasm:**
  - Which cultivars for which region.
  - Produce the seeds of the locally selected cultivars.

• **Irrigation + Fertilization :**
  - Study the influence of these two major farming practices.
Germplasm trial
Materials

The seeds were provided by the University of Arizona, USDA, and Yulex. The cultivars were of:

- Mexican origin (Coahuila, Zacatecas),
- U.S. origin (Arizona, California, and Texas).

During the 1st year of the EU-Pearls project (2008), we planted:

- 40 cultivars in France,
- 24 cultivars in Spain.
Germplasm trial
Materials and Methods

• Planting design:
  – Elementary plots = 1 line / cultivar
    ➢ 2 border lines and 2 border plants.

Observations:
Germination rate,
Height,
Weight of plant parts
  (stems, leaves, and roots),
Plant uniformity,
Winter tolerance (for Montpellier),
Rubber & resin contents in October and March, each year.
Germplasm evaluation
Results (*Montpellier*)

- Dry Matter: stems and roots (at 12 months)

Cultivar origins: **USA** (red) **Mexico** (green)

*(Planting density = 50,000 plants/ha → 3 cvs > 5 tons stems/ha)*
Rubber content in stems of some varieties,
in %

Rubber content in stems:
average = 3.98 %

(12 months old)
Montpellier Climatic data

The 2009-2010 winter was much colder and rainier than average with 53 days below 0°C. The lowest temperature was $-8.1$ °C (on Dec. 16th).

- Average temperature in Winter = $5 - 7$ °C; in Summer = $21 - 24$ °C
- Total annual Rainfall = 776 mm, with 3 dry months ($P_{mm}/T_{°C} < 2$).
Germplasm evaluation
Results (*Montpellier*)

Survival rates after 1 year and after 2 years

In **2009**: 100% of lines survived with No plants/line = 25% to 100%

In **2010**: 76% of lines survived with No plants/line = 5% to 88%
Influence of climate on 2 particular cultivars: The case of winter in Montpellier
Germplasm evaluation
Results (Cartagena)

Dry matter yields: significant variations were observed at 12 months after planting

Cultivar origins: USA (red); Mexico (green)

(Planting density = 50,000 plants/ha → 12 cvrs > 10 tons stems/ha)
Germplasm evaluation
Results (Cartagena)

Rubber content in stems of some varieties,
in %
in g/plant

Rubber content in Stems:
average = 6.89 %

Rubber Yields:
% rubber × Kg dry matter

(Planting density = 50,000 plants/ha → 3 Cvs > 1,600 kg latex / ha)
Germplasm: Conclusions

– The best available subsets of guayule lines from U.S. and Mexico have been selected in two different situations.
– Growing and overwintering of the different lines of the germplasm need to be continued in **Montpellier**.
– Seeds harvested in 2009 could be used to plant further trials (→ fertilization & irrigation).
Material & Methods

• Statistical design:
  – 1 variety: AZ 2.
  – Irrigation:
    3 levels (100%, 66%, 33%) at 100% fertilization.
  – Fertilization:
    3 levels (100g, 50g, 0) of NPK at 100% irrigation.

• Observations:
  – Height and weight (biomass) of plant parts;
  – Soil fertility and humidity;
  – Number of plants after summer and winter (in Montpellier);
  – Rubber & resin contents (October and March).

• Two sites: Montpellier & Cartagena
Fertilization & irrigation trial results (Montpellier)

• Average Stems dry biomass and % rubber.

- Less irrigated plots had better yields.
- Less fertilized plots had better yields.
- % rubber was not statistically different between treatments (average = 5 %).
Fertilization & irrigation trial results (Montpellier)

• Surviving plants after cold winter

In Montpellier:
- Less irrigation produced significantly better survival rates.
- Less fertilization did not produce statistically different survival rates.

Planted: April 2009
Fertilization & irrigation trial results (Cartagena)

• No significant effect of NPK at this stage.
• Irrigated plots had significantly higher yields.

The average % rubber was 6.5% (with no statistical differences between treatments).

Yields are computed from 5 plants / treatment, in a field density of 50,000 plants/ha (with AZ 2)
Conclusions

Montpellier

• Guayule is **not yet** adapted for commercial cultivation:
  – Some winters can be too cold and rainy.
  – Irrigation was not necessary because rainfall is already high.

• **Results were:**
  – Poor growth (< 8 tons total dry biomass / ha / year);
  – High mortality;
  – Low rubber content (< 4 % of stems DM).

\[< 450 \text{ kg latex / ha / year}\]
Conclusions

Cartagena

- Guayule is **well adapted** to the climatic conditions:
  - The dry climate can be compensated by irrigation.
  - Fertilization is not yet recommended.

- **Resulting in** plants perfectly adapted:
  - Good yields (up to 25 tons total dry biomass / ha / year);
  - No mortality;
  - Good rubber content (> 9 % of stems DM)

  *up to 1,600 kg latex / ha / year*
Thank you for your attention