Oil crops production and delivery for biorefineries

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Contents of the presentation

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- Advantages and Constraints
- Planting
- Harvesting
- Storage - Pretreatment
Oil crops

- Castor seed (*Ricinus communis* L.),
- Crambe (*Crambe abyssinica*),
- Cuphea (*Cuphea spp.*),
- Lunaria (*Lunaria biennis*),
- Lesquerella (*Lesquerella fendleri*),
- Safflower (*Carthamus tinctorius*)
Markets

Biosolvents

Biolubricants

Biosurfactants

Biopolymers

Biocides & innifuges

Cosmetics

GMP dedicated technology
Main uses for castor oils
EuroBioRef will bridge the gap between agriculture and chemical industry by integrating the whole biomass chain in a Multi-feedstock (non-edible), Multi-process (chemical, biochemical, thermochemical), Multi-products (aviation fuels and chemicals) commercially viable and adaptable approach for a sustainable bio-economy in Europe.
Concept

Flexibility, Adaptability, and Multidimensionnal Integration of the EuroBioRef Project

Variety of Pretreated Biomass
- Cellulosic and Hemi-cellulosic Residual Materials
- Sustainable Non-edible Oils
- Lignin, Solid Residues

MULTI PROCESS
- Original Biochemical Conversion Processes
- Innovative Catalytic Conversion Processes
- Advanced Thermo-Chemical Conversion Processes
- Integrated Modular and Flexible Process Design

Integrated Modular Bio-Refinery Pilot Plants
- Scenarios for Biorefinery Concepts under Specific Regional Conditions
- Contribution to New Process and Biomass Product Standards

Integrated Demonstration of Building Blocks of High Value Added Bioproducts

High Value Added Chemicals, Polymers and Aviation Fuels, with Optimised Costs and Zero Waste Required by the Market

MULTI PRODUCTS
Castor seed (*Ricinus communis* L.)

**General information**

**Area of Origin:**
Indigenous to the S. Mediterranean, E.Africa and India. Widespread in tropical regions. Commercially grown in India, China and Brasil. The world production of castor seed is around 1200000 tons.

**Plant nature:**
Annual, rare perennial

**Environmental requirements**
Well adapted to temperate climatic zones

**Production-Yield**
- Seed yields: 1500-3500 kg/ha (hybrids with >4000 kg/ha)
- Oil yield: 600 – 2000 kg/ha
- Oil content: 40-55% (85-95% ricinoleic acid)
Advantages and Constraints

**Advantages**

- Highly productive and fast-growing crop in temperate climates
- Existing markets (lubricants, pharmaceuticals and lately biopolymers)
- Mechanized production (planting/harvesting equipment)
- No competition with food crops as it is non-edible

**Constraints**

- Frost sensitive. It needs high temperatures (opt. 20-25°C over 4.5-6 months)
- Seeds contain ricin, a toxic protein, thus has to be separated from food crops
- Allergenic compounds found on the plant surface can cause nerve damages at harvest
- Yields have to increase to be economically attractive
- Harvesting has to improve to avoid seed loses and crop damage
Planting

- **Planting date**: sown in March-April (as spring crop) and harvested in October
- **Planting depth**: 13-25 mm,
- **Seed quantities**: 12-16 kg/ha
- **Population planting**: 20000 to 30000 plants/ha (in rows 100cmX90cm, or 100cmx50cm).
- **Basic fertilization**: 30-60 kg P
- **Irrigation**: 600 mm
- **Fertilization**: 30-60kg depending on the soil fertility
- **Planting equipment**: Castor beans have high oil content and are easily broken, therefore they can block the planting machinery. Maize planters with air metering plates are suitable. They usually require plates with proper cell size.
Castor seed (*Ricinus communis* L.)

**Harvesting**

- **Crop specific characteristics:**
  - Castor seed forms uniform plantations with crops of uniform heights and maturation times.
  - Seeds do not shatter but can be easily broken during harvest.

- **Harvesting time:**
  When all the capsules are dry and the leaves have fallen, in October. If harvesting cannot be operated before winter, a chemical defoliant may be applied 10 to 15 days before the desired harvest date.

- **Harvesting equipment:**
  Combine corn harvesters properly adjusted to prevent from seed breaking are suitable, with an efficiency of 85%. Prototypes with higher efficiencies are being produced.
After harvest, the remaining stalks and other materials like the seed hulls should be incorporated into the soil in order to increase its organic matter.

The moisture content during storage should be at 6%.

During grading the seeds should be cleaned from broken beans, hulls and other particles.
Crambe (Crambe abyssinica L.)

General information

**Area of Origin:**
Mediterranean region, tropical & subtropical Africa, Near East, Central-West Asia (Turko-Iranian area), Europe, USA and South America.

**Plant nature:**
Annual spring crop

**Environmental requirements**
Widely adapted, cool season crop, grown in Northern Europe as spring crop

**Production-Yield**
- Seed yields: 1200 – 2000 kg/ha (could reach 2500 kg/ha)
- Oil yield: 400 kg/ha
- Oil content: 35-38% (53-66% erucic acid)
Advantages and Constraints

**Advantages**
- Tolerant to lodging and late season drought (depending on the variety)
- Grows on a variety of soil types (better on sandy loams) and climates
- Not cross pollinated thus can be grown alongside with rapeseed

**Constraints**
- Damage by birds during ripening
- Highly sensitive to low temperatures at sowing and at flowering
- Low genetic variability
- Very low investments in research - some industrial production in USA
- Low seed germination
- Competition with high erucic rapeseed but lower oil yields

Crambe (*Crambe abyssinica* L.)
Planting

- **Planting date:** Oct-Dec (winter crop), March/April (spring crop)
- **Planting depth:** 5-25 mm
- **Seed quantities:** 10 – 15 kg/ha
- **Population planting:** in rows 12-50 cm, about 1,000,000 plants/ha
- **Basic fertilization:** 80 - 150 kg N/ha
- **Fertilization:** 0-200 kg N/ha tested (75kgN/ha in most references)
- **Planting equipment:** Crambe is of the same family as rapeseed and rapeseed/corn planters are also suitable.
- **Machinery for tillage, planting, spraying and harvesting** are similar to small grains so farmers do not need to purchase additional equipment.

Crambe *(Crambe abyssinica L.)*
Crambe (*Crambe abyssinica* L.)

**Harvesting**

- **Crop specific characteristics:**
  - Crambe is suitable for harvesting 90-100 days after planting - when all leaves have fallen, the seed pods, small branches and the top of the main stems get the color of the straw.
  - Crambe is susceptible to seed shatter if harvesting delays
  - Extensive branching is a disadvantage for mechanical harvesting

- **Harvesting time:**
  June-July

- **Harvesting equipment:**
  Crambe is of the same family as rapeseed and rapeseed combine harvesters with adjustable sieves are suitable. The plants should be cut at 12-18 in above ground.

Source: Claas SE GmbH
Storage - Pretreatment

The moisture content before storage should be at 10%.

After harvest, the remaining stalks should be incorporated into the soil in order to increase its organic matter.

During storage the seeds should be cleaned from remaining green parts, weeds, insects etc. To prevent any heating of the stored material, aeration in the storage facilities should be assured.
Cuphea (Cuphea spp L.)

General information

**Area of Origin:**
American origin. Best cropping results in Mediterranean countries. Experimental in NL

**Plant nature:**
Low-growing herbaceous or annual plants. Over 45 species. Plant height: 20cm-400cm

**Environmental requirements**
Lack of frost tolerance thus unlikely to be suitable for culture in many parts of Europe.

**Production-Yield**
- Seed yields: 350 – 1000 kg/ha
- Oil yield: 24 – 300 kg/ha
- Oil content: 25-35%
Advantages and Constraints

Advantages

• Oil resembles to coconut and palm oils, rich in medium-chain triglycerids, the richest natural source in single fatty acid. The industrial oils made from these acids could replace others made from imported palm kernel and coconut oil.

Constraints

● Only a few years from the wild and still has the characteristics of a wild plant:
  ● tendency to seed shatter,
  ● indeterminate flowering, sequential maturation and release of oil seeds from the seed pods, precluding mechanised harvesting
  ● overall stickiness
● Not grown in large-scale so far. Harvested by hand
● Slow germination in central Europe (14-20 days) even in late May, but that is compensated by a quick growth and early seed ripening.
Planting

- **Planting date:** early May - June
- **Planting depth:** 13-25 mm
- **Seed quantities:** 21 kg/ha
- **Population planting:** in rows 40-60 cm apart, 400,000-600,000 plants/ha
- **Basic fertilization:** 90 kg N/ha
- **Fertilization:** 90 kg N/ha
- **Irrigation:** 300- 400 mm
- **Planting equipment:** Drill seeding as shallow as possible, cone type seeder planters (in experimental plots in USA)

- Existing row-crop machinery is suitable.
Harvesting

- **Crop specific characteristics:**
  - It has an indeterminate flowering, up to 2 months and is prone to shatter
  - To avoid shattering chemical treatment may also be applied

- **Harvesting time:**
  - July – August (80-90 days after sowing) or late September to early October

- **Harvesting equipment:**
  Combine harvesters have shown good results in field trials in USA (by Gesch at al)

Source: Claas SE GmbH
Storage - Pretreatment

The moisture content at harvest – either after a killing frost or chemical desiccation in the field is at 30-40\%. Therefore additional drying is required.

A commercial batch-dryer designed for small seeded crops had been successfully used in field trials in Minnesota (by Gesch at al)
Lesquerella (Lesquerella fendleri L.)

General information

**Area of Origin:**
From the dry areas of south west USA where it is grown as a winter annual

**Plant nature:**
70 species, 30% of which are annual. L. fendleri is the only one currently being domesticated. Plants grow up to 45 cm height.

**Environmental requirements**
Best suited in areas 600-1800 m above sea level, annual rainfall of 250-400mm, adapted to temperatures < -18°C

**Production-Yield**
- Seed yields: 440kg/ha (in UK) - 1,390kg/ha (NL), 950-1120kg/ha (USA) but only 800-900kg/ha in large scale
- Oil yield: 220-380 kg/ha (22.5-25% oil content)
- Oil content: 22% (UK) - 36% (NL), 21% (USA)
Advantages and Constraints

**Advantages**

- Tolerant to medium salinity with low sodium water.
- Desertic crop
- High content of oils in lesquerolic acid, which is compositional similar to ricinoleic acid produced from castor. In some ways oil from lesquerella are superior to castor oil.

**Constraints**

- Plant establishment is a major constraint because seeds have a tendency for dormancy and weak seedling vigor.
- Indeterminate growth habit
- Low seeds yields
- No commercial data is yet available but trials are going on across Europe, like Belgium, Italy, Netherlands and UK. From these trials it has been established that L. fendleri is not well adapted to temperate western European climate, the crop showed very poor establishment and germination.
Planting

- **Planting date:** October
- **Planting depth:** 25 - 35 mm
- **Seed quantities:** 5-11 kg/ha (9 kg/ha in most references)
- **Population planting:** in rows 33 cm apart, 750,000-1,000,000 plants/ha recommended in Arizona
- **Basic fertilization:** 60-80 kg N/ha and 40-70 kg P/ha
- **Fertilization:** 0-120 kgN/ha tested
- **Irrigation:** 300- 400 mm
- **Planting equipment:** Seeders
Lesquerella (*Lesquerella fendleri* L.)

Harvesting – Storage - Pretreatment

**Crop specific characteristics:**

- Flowering and seed production in indeterminate. However, ripe capsules tend to remain closed until the entire plant is mature and dry.

- High competition with weeds due to slow growth and poor establishment

**Harvesting time:**

June-July

**Harvesting equipment:** Combines

**Pretreatment:**

Oil recovery is difficult due to the small size of seeds. Pretreatment may lead to percolation of solvants. Oil extraction however is not commercially viable so far.

Source: Claas SE GmbH
**General information**

**Area of Origin:**
Native of SE Europe and western Asia. Now naturalised in many temperate countries of Europe and North America as ornamental and as a garden escape on waste land. Oil plant in Germany, UK and NL.

**Plant nature:**
Biennial plant, 30-100 cm high

**Environmental requirements**
Native of Europe. Well adapted to temperate climates

**Production-Yield**
- Seed yields: 2,000 – 2,500 kg/ha (mean 900 kg/ha), 900 -1,500 kg/ha (in USA, able to reach 1,900 – 2,900 kg/ha
- Oil yield: 600-1000 kg/ha
- Oil content: 30-40% oil content (24 -34% in USA). high proportion of erucic and nervonic acids.
Advantages and Constraints

**Advantages**
- Shatter resistance
- Has potential interest for the oil processing industry because of the high content of long-chain fatty acids in its oil.

**Constraints**
- The plant is still at the developmental stage
- The biennial nature of the plant and its high vernalisation requirement. The development of a late winter or spring sown annual type is a primary requirement.
- The production potential and agronomy of the crop requires investigation. Honesty often does not thrive in large open fields.
- Mechanical harvesting and cleaning of the seeds may be a problem
Planting

- **Planting date:** June – Aug (UK)
- **Planting depth:** 25 -35 mm,
- **Seed quantities:** 15 -20 kg/ha
- **Population planting:** in rows 50 cm apart, 200,000 -250,000 plants/ha
- **Basic fertilization:** 75 kg N/ha, 50 Kg P/ha and 50 kg K/ha
- **Fertilization:** 75 kg N/ha
- **Irrigation:** 300- 400 mm
- **Planting equipment:**
Crop specific characteristics:

- It requires a cold vernalisation period of at least 20 weeks at 5°C to induce max flower production

Harvesting time:

Oct - Feb (or July of the following year)

Harvesting equipment:

So far is grown only as ornamental
**Safflower** (*Carthamus tinctorius* L.)

### General information

**Area of Origin:**
One of the humanity’s oldest crops but still a minor crop. It is distributed in India, US, Ethiopia, China.

**Plant nature:**
- Annual winter/spring crop,
- There are linoleic and oleic varieties

**Environmental requirements**
- Mostly suited to hot dry climates. In North Europe, maturity delays to late autumn

**Production-Yield**
- Seed yields: 2600 – 5000 kg/ha
- Oil yield: 560 – 1000 kg/ha
- Oil content: 21-22%
Advantages and Constraints

**Advantages**

- High quality edible oil.

**Constraints**

- Frost sensitiviness.
- In North Europe temperatures may be not suitable and rainfall excessive during flowering and maturity period so yields are likely to be poor.

**Crop rotation possibilities**

- In the US usually grown in rotation with small grains or fallow. Safflower can be severely injured by soil residues of broadleaf herbicides that were used on small grains earlier in the rotation. Caution must be used when growing safflower after small grains.
- Safflower should not follow safflower in rotation or in close rotation with crops susceptible to Sclerotinia head rot (white mold), such as sunflower, mustard, canola (oilseed rape), or dry bean.
**Safflower** (*Carthamus tinctorius* L.)

# Planting

- **Planting date:** late April or early May. It may not mature if planted after mid-May. In Germany 31 Mar-5 Apr. In Greece and Turkey Oct-Dec (winter crop) and March/April (spring crop)
- **Planting depth:** 25 -35 mm,
- **Seed quantities:** 20 kg/ha
- **Population planting:** in rows 50 cm apart, 400,000-1,500,000 plants/ha
- **Basic fertilization:** 60-80 kg N/ha and 40-70 kg P/ha
- **Fertilization:** 0-200 kg N/ha tested (75kgN/ha in most references)
- **Irrigation:** 600 - 700 mm
- **Planting equipment:** Seeders
Safflower (*Carthamus tinctorius* L.)

Harvesting – Storage - Pretreatment

- **Crop specific characteristics:**
  - Hull proportion and very thin hulls may cause problems to mechanical harvesting
  - Does not shatter

- **Harvesting time:**
  - September - October

- **Harvesting equipment:** Combines

- **Pretreatment:**
  - Quality safflower should have a white seed coat, no trash materials, no sprouting/heated seeds.
  - Moisture content of safflower seeds should not exceed 8% for safe and long term storage.

Source: Claas SE GmbH
<table>
<thead>
<tr>
<th></th>
<th>Castor seed</th>
<th>Crambe</th>
<th>Cuphea</th>
<th>Lesquerella</th>
<th>Lunaria</th>
<th>Safflower</th>
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</thead>
<tbody>
<tr>
<td><strong>Planting date</strong></td>
<td>March-April</td>
<td>Oct-Dec</td>
<td>Early May-June</td>
<td>October</td>
<td>June-August (UK)</td>
<td>Oct-Dec (winter crop) March-Apr (spring crop)</td>
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<td>March-Apr (spring crop)</td>
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<td><strong>Basic fertil.</strong></td>
<td>30-60kg P/ha</td>
<td>90 kg N/ha</td>
<td>90 kg N/ha</td>
<td>60-80 kgN/ha</td>
<td>75 kg N/ha, 50 Kg P/ha</td>
<td>60-80 kg N/ha 40-70 kg P/ha</td>
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<td><strong>Nitrogen</strong></td>
<td>30-60kg</td>
<td>75 kg/ha</td>
<td>90 kg/ha</td>
<td>0-120 kg/ha</td>
<td>75 kg/ha</td>
<td>0-200 kg/ha</td>
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<td><strong>Irrigation</strong></td>
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<td><strong>Harvesting date</strong></td>
<td>October</td>
<td>June - July</td>
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<td>Oct-Feb/ July nextyear</td>
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<td><strong>Harvesting</strong></td>
<td>Maize harvester</td>
<td>Combines</td>
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<td><strong>Seed yields (kg/ha)</strong></td>
<td>1500 - 3500</td>
<td>350-1000 (900)</td>
<td>2300–3200</td>
<td>950-1100</td>
<td>2000 – 2500</td>
<td>2600-4000</td>
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<tr>
<td><strong>Oil content (%)</strong></td>
<td>40-55</td>
<td>27-35</td>
<td>32-37</td>
<td>21 - 25</td>
<td>30-40</td>
<td>21-22</td>
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<td><strong>Oil yields (kg/ha)</strong></td>
<td>600 - 2000</td>
<td>240-300</td>
<td>730-1100</td>
<td>200 – 280</td>
<td>600-1000</td>
<td>560-1,000</td>
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</table>
Thank you for your attention!

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  - 4FCROPS ([www.4fcrops.eu](http://www.4fcrops.eu))
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  - EUROBIOREF ([www.eurobioref.org](http://www.eurobioref.org))

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