Life cycle assessment of non-edible oil crops 
(Crambe abyssinica) production

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Energy dependence of EU 28 in 1990, 2000 and 2013 roku (1000 ktoe)

Source: Eurostat 2015
Global warming

CO₂ concentration in the atmosphere - Hawaii’s Mauna Loa observatory

Source: Kerr 2007, ESRL 2012

Loss of 8% of freshwater fish habitat in N. America
- Polar ecosystems increasingly damaged
- Amphibian extinctions increasing on mountains

Temperature change (°C) above preindustrial

Source: Kerr 2007, ESRL 2012
Oil basket price

Source: OPEC 2016
Classical and integrated multiproduct biorefinery approach

Source: EuroBioRef 2014
Crambe abyssinica
Hochst. ex R.E. Fries)

- High content of erucic acid regarded as one of the feedstocks used in modern integrated biorefineries.
- Yield of seeds 1.2-3.2 Mg ha\(^{-1}\).
- Oil content 31-37%, with erucic acid accounting for more than 54% (Kulig and Pisulewska 2000; Laghetti et al. 1995; Lazzeri et al. 1994).
- Production of biodiesel, lubricants, rubber additives, nylon, base for paints and coatings, hydraulic fluids, waxes and other products (Falasca et al. 2010; Wang et al. 2000).
Reason of the study

• The aim of the study was to determine, the impact on the environment of the production process of the crambe, by the life cycle assessment (LCA).
Life Cycle Assessment (LCA)
A tool to assess the environmental impacts of a product, process or activity throughout its life cycle; from the extraction of raw materials through to processing, transport, use and disposal.

- Life Cycle Assessment: How Relevant is it to Australia? M. Demmers and H. Lewis
Methods

Goal and scope

• Simplified, comparative LCA for the production process of the crambe in two variants of production, compared to the cultivation of spring rapeseed.
• Identification of stages with the most negative impact on the environment.

Functional unit

• The impact of the cultivation system on the area (1 ha) was the functional unit adopted in the study.
• However, due to a different yield of seeds, which can be obtained from the same area of cultivation – 1 Mg of seeds of the cultivated plants was adopted as well.
Crambe I:
• No herbicides used
• Desiccant used

Crambe II:
• Herbicides used
• Desiccant used

Spring rape:
• Herbicides used
• Pesticides used
• Desiccant used
Methods

• Calculations were made in the SimaPro 7.3.2 software using CML 2 baseline 2000 method with categories:
  – abiotic depletion,
  – acidification,
  – eutrophication,
  – global warming,
  – ozone layer depletion,
  – human toxicity,
  – freshwater aquatic ecotoxicity,
  – marine aquatic ecotoxicity,
  – terrestrial ecotoxicity,
  – photochemical oxidation.
Results of the characterisation of the *Crambe* I cultivation system

1-abiotic depletion, 2-acidification, 3-eutrophication, 4-global warming (GWP 100), 5-ozone layer depletion (ODP), 6-human toxicity, 7-freshwater aquatic ecotoxicity, 8-marine aquatic ecotoxicity, 9-terrestrial ecotoxicity, 10-photochemical oxidation.
Results of the characterisation of the *Crambe II* cultivation system

1-abiotic depletion, 2-acidification, 3-eutrophication, 4-global warming (GWP 100), 5-ozone layer depletion (ODP), 6-human toxicity, 7-freshwater aquatic ecotoxicity, 8-marine aquatic ecotoxicity, 9-terrestrial ecotoxicity, 10-photochemical oxidation.
Results of the characterisation of the Spring rape cultivation system

1-abiotic depletion, 2-acidification, 3-eutrophication, 4-global warming (GWP 100), 5-ozone layer depletion (ODP), 6-human toxicity, 7-freshwater aquatic ecotoxicity, 8-marine aquatic ecotoxicity, 9-terrestrial ecotoxicity, 10-photochemical oxidation.
Characterisation results for the three cultivation systems under study. Functional unit, area of 1ha.

1-abiatic depletion, 2-acidification, 3-eutrophication, 4-global warming (GWP 100), 5-ozone layer depletion (ODP), 6-human toxicity, 7-freshwater aquatic ecotoxicity, 8-marine aquatic ecotoxicity, 9-terrestrial ecotoxicity, 10-photochemical oxidation.
Characterisation results for the three cultivation systems under study. Functional unit, 1 Mg of seeds.

1-abiotic depletion, 2-acidification, 3-eutrophication, 4-global warming (GWP 100), 5-ozone layer depletion (ODP), 6-human toxicity, 7-freshwater aquatic ecotoxicity, 8-marine aquatic ecotoxicity, 9-terrestrial ecotoxicity, 10-photochemical oxidation.
GHG emission (kg CO$_2$ eq.)

- **Crambe I**
  - **Ploughing**: 5%
  - **Fertilisation PK**: 6%
  - **Fertilisation N**: 74%
  - **Harrowing**: 2%
  - **Sowing**: 4%
  - **Harvest**: 5%
  - Total: 2096 kg/ha, 1839 kg/Mg

- **Crambe II**
  - **Ploughing**: 5%
  - **Fertilisation PK**: 6%
  - **Fertilisation N**: 72%
  - **Sowing**: 4%
  - **Harvest**: 5%
  - **Ploughing**: 5%
  - Total: 2148 kg/ha, 1705 kg/Mg

- **Rapeseed**
  - **Ploughing 2**: 5%
  - **Fertilisation PK**: 8%
  - **Fertilisation N**: 67%
  - **Discing**: 3%
  - **Pestycide 2**: 4%
  - **Sowing**: 4%
  - **Harvest**: 4%
  - Total: 2334 kg/ha, 1297 kg/Mg
Conclusions

• The highest environmental impact in most impact categories was connected with fertilisation (6-7 out of 10 categories).
• Seed production had a considerable impact on the fresh water aquatic ecotoxicity and terrestrial ecotoxicity.
• A comparative LCA with the 1 hectare FU showed that spring rape had the most negative environmental impact in 9 out of 10 categories.
• When 1 Mg of seeds was used as FU spring rape - impact was lower in 9 out of 10 categories comparing to crambe.
• Crambe GHG emission per 1 ha is 9-11% lower comparing to rapeseed but 30-40% higher if FU was changed to 1 Mg of seeds.
• Crambe could be an attractive crop for biorefineries because it provides desirable erucic acid and does not cross-pollinate with 00 rapeseed. However, the environmental impact of the “weak links” in the crambe production: mineral fertilisation and a low yield, should be minimised.
Thank you!

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