CNAP
Centre for Novel Agricultural Products

Molecular Breeding of Industrial Hemp as a Dual Purpose Break Crop For UK Agriculture

Ian Graham,
Centre for Novel Agricultural Products
University of York

New, highly stable seed oil varieties have been developed in the Graham laboratory

CNAP1HOH recently registered in UK

University of York RESEARCH

CNAP
Centre for Novel Agricultural Products

What is industrial hemp?

Cannabis sativa

marijuana/drug-type

- high THC levels
  (up to 28-30% flower DW)

industrial hemp

- low THC

currently allowed levels:
USA/EU: < 0.3% THC
UK: < 0.2% THC

- grown for seed or fibre

University of York RESEARCH

CNAP
Centre for Novel Agricultural Products

Fibre

Speciality paper

Composite materials

Insulation

Fibre variety Oil variety (Finola)

Photo: J. Callaway

Seed/Seed oil

30 - 35% oil

25% protein

27% carbohydrates

dietary fiber

vitamins

minerals

- Food
- Cosmetics
- Paint/varnishes

University of York RESEARCH

CNAP
Centre for Novel Agricultural Products

Canadian hemp cultivation – vast majority for grain

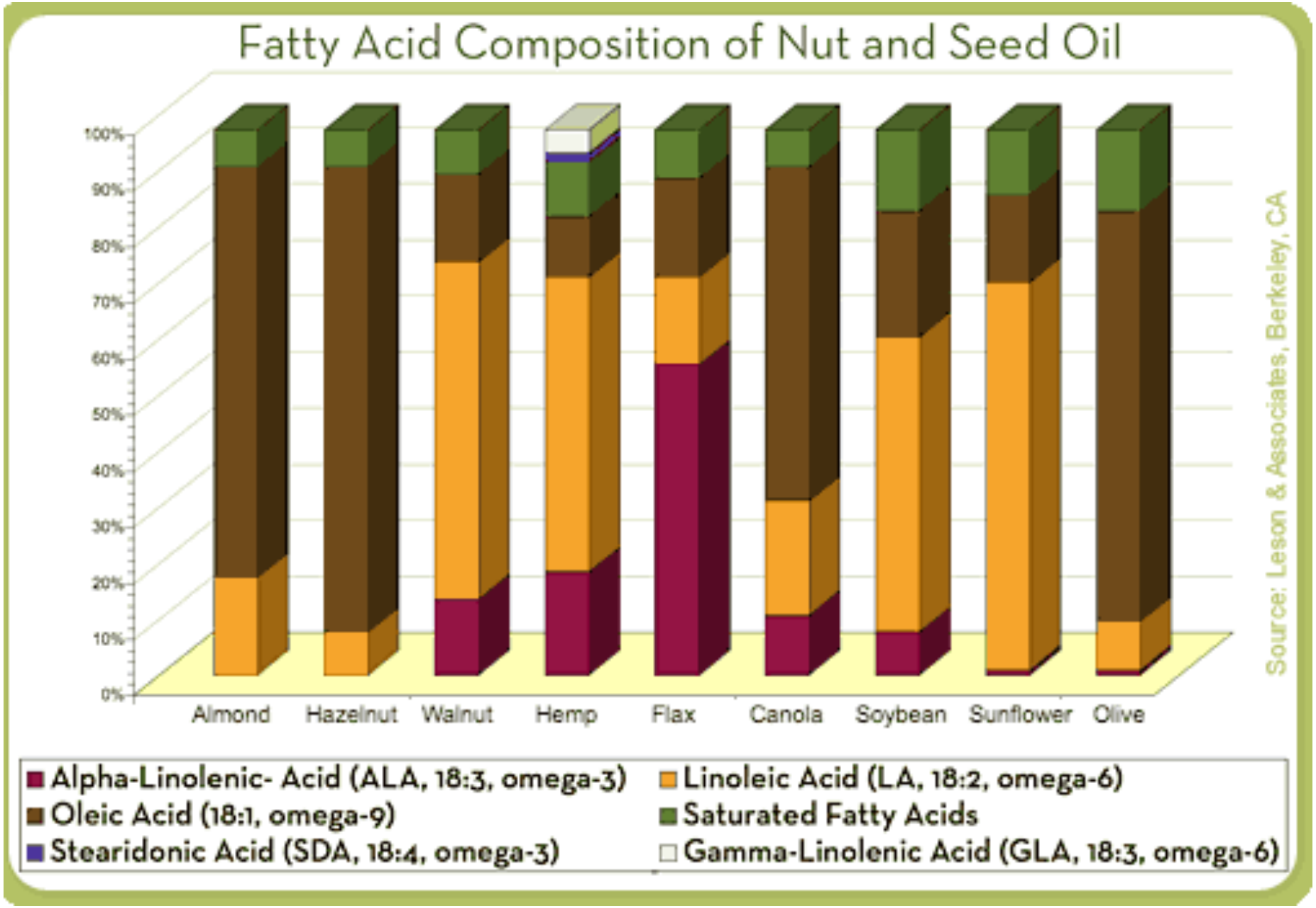
Finola the most widely grown variety – 40% of total in 2023
(Data from Health Canada).

Table 2: Hectarage for Cultivation of Industrial Hemp by Cultivar by Province

	Hectares													
Cultivar	AB	BC	MB	NB	NL	NS	NT	NU	ON	PEI	QC	SK	YT	TOTAL
Finola	2913.34	0.00	655.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1123.05	0.00	**4691.57**
CNAP1HOH	0.00	0.00	24.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**24.69**
TOTAL	**5595.70**	**60.35**	**2770.42**	**2.70**	**0.00**	**133.55**	**0.00**	**0.00**	**124.25**	**31.57**	**921.36**	**2221.57**	**0.00**	**11861.45**

University of York RESEARCH

CNAP
Centre for Novel Agricultural Products



University of York
RESEARCH

CNAP
Centre for Novel
Agricultural Products

Finola variety

- diecious
- short
- frost resistant
- early maturing
- well adapted to northern climates

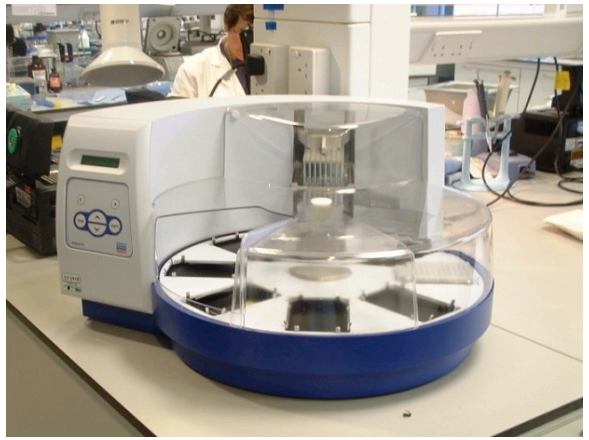
EMS (G:C→A:T)

mutagenised
M1 seed

mutagenised M1 female plants out-crossed
with wild type male plants

M2 seed lines

M2 seedlings (heterozygous)
4 per line



Robotically –assisted DNA extraction

Reverse genetic screening for mutations in candidate genes using TILLING

UNIVERSITY of York
RESEARCH

CNAP
Centre for Novel
Agricultural Products

Targets for molecular breeding of seed oil fatty acid composition

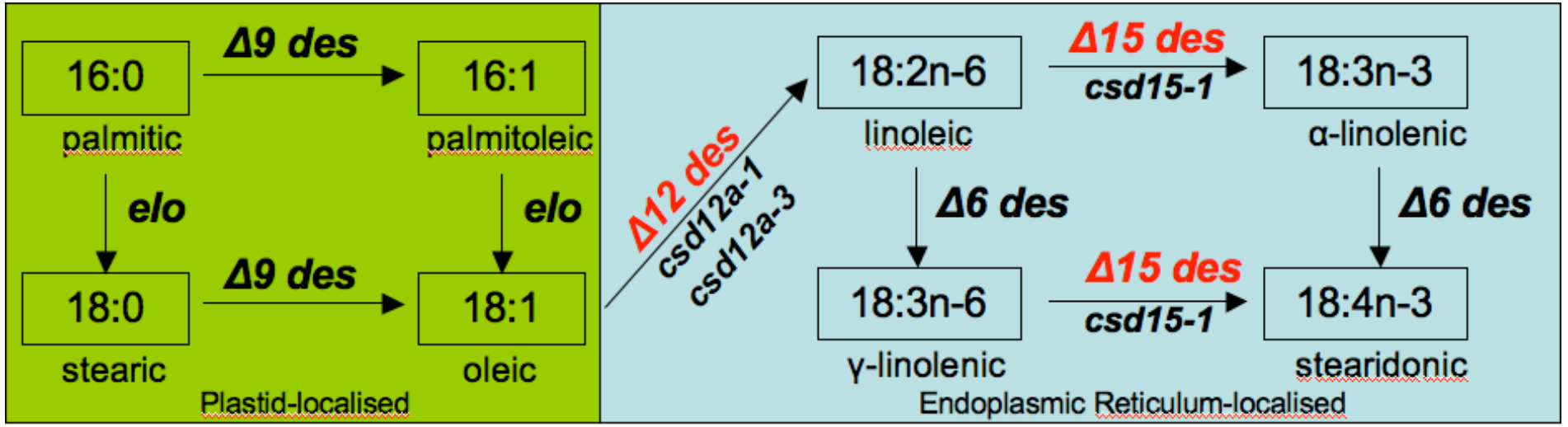


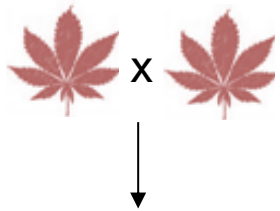
Figure 1: Summary of PUFA synthesis in hemp seed. (elo = elongase; des = desaturase). The location of the three desaturase mutants to be used in the breeding programme are shown.

University of York
RESEARCH

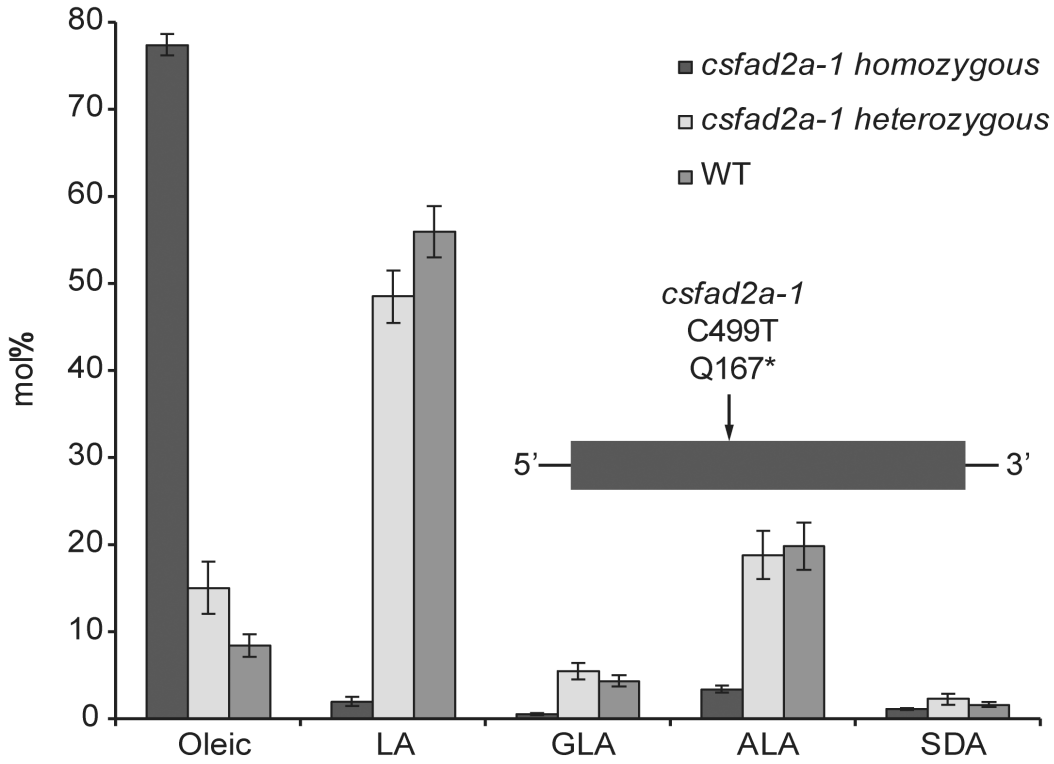
CNAP
Centre for Novel Agricultural Products

High oleic acid content (>75 molar %) confirms that CSFAD2 constitutes the major Δ12 desaturase activity in hemp embryos

Heterozygous mutant M2 siblings



homs 25% : hets 50% : Wild type 25%

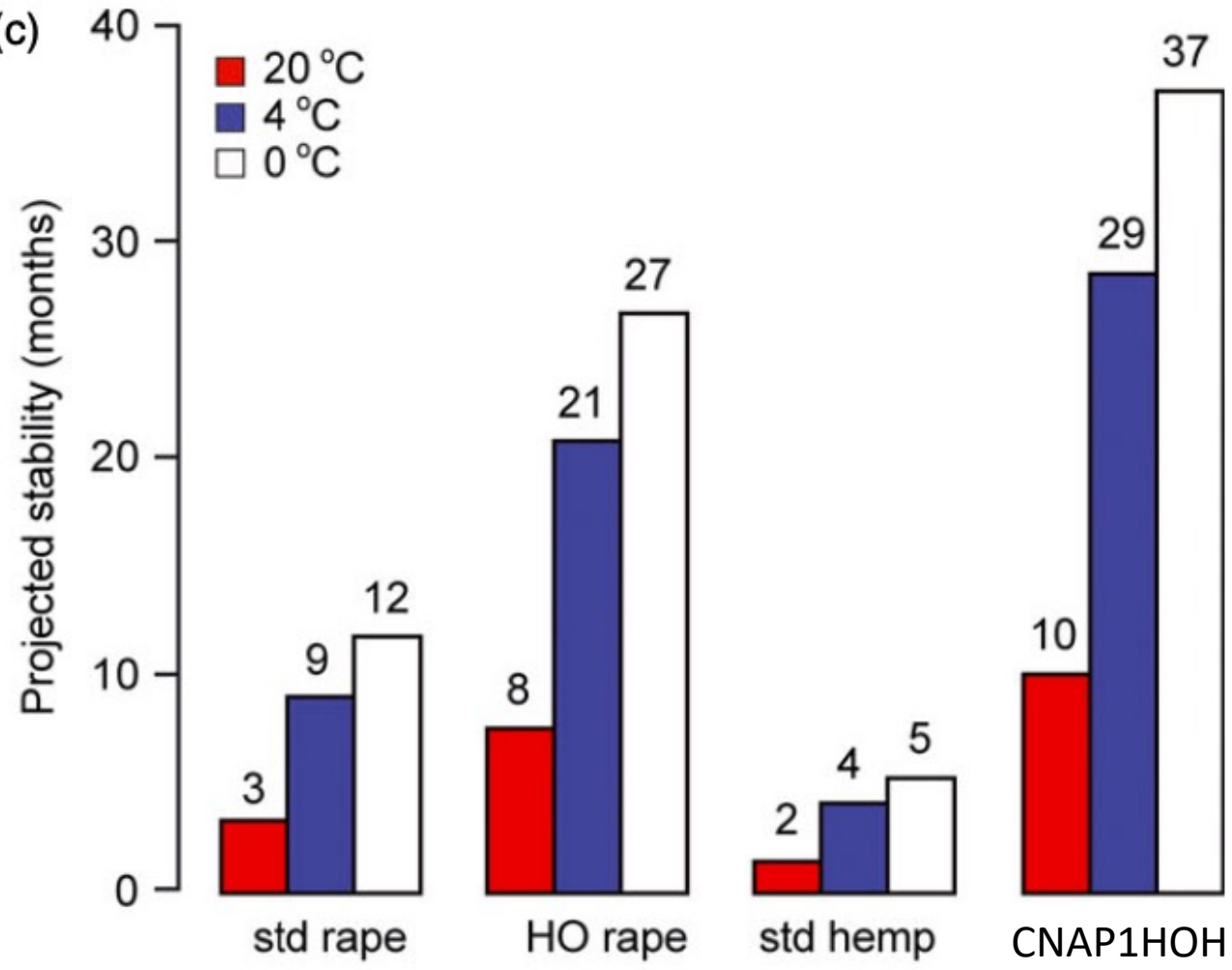


Registration of new UK variety CNAP1HOH awarded in 2021

University of York RESEARCH

CNAP
Centre for Novel Agricultural Products

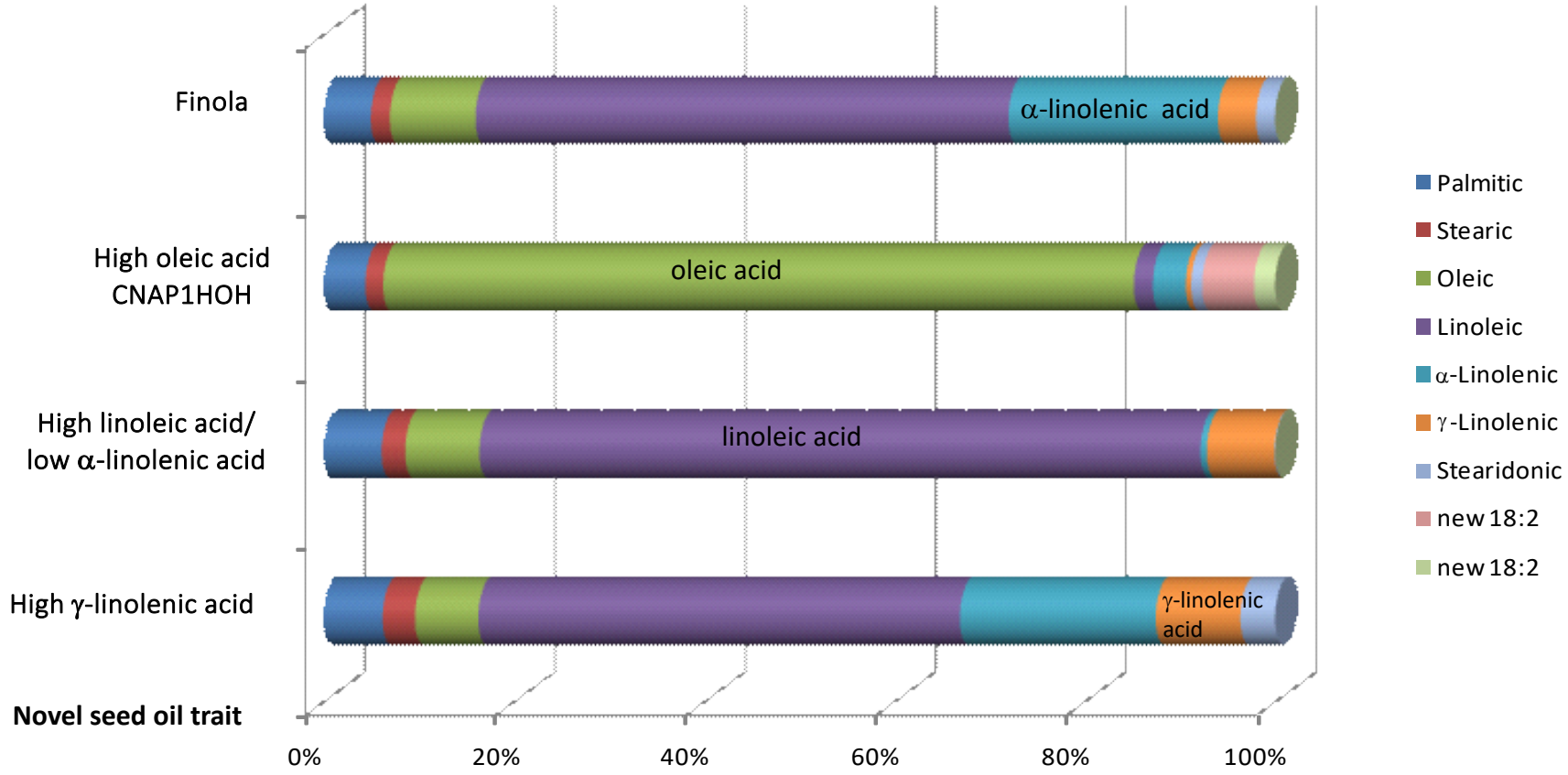
CNAP1HOH seed oil is much more stable than standard seed oil



University of York RESEARCH

CNAP
Centre for Novel Agricultural Products

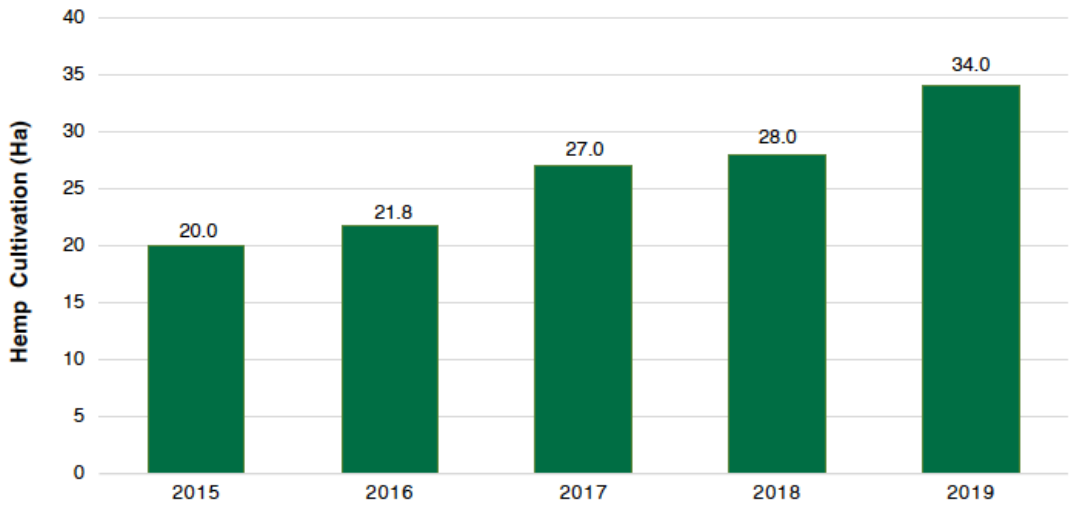
Successful mutation breeding of industrial hemp seed oil fatty acid composition



UNIVERSITY of York
RESEARCH

CNAP
Centre for Novel
Agricultural Products

EU Land Area for hemp cultivation (2015 – 2019) Ha x1000



At present, only about 20 farmers in the UK grow hemp on a total of 800 hectares.

Data from all Party Parliamentary Group for cbd products
(Co-Chairs: Crispin Blunt MP, Baroness Manzoor CBE)
Plan for a Legal and Regulated UK Hemp and Cannabis Sector
Published July 2022

Most global hemp producers regulate the crop as an agricultural commodity, not a controlled substance, and place the industry under the regulatory remit of an agricultural department. To put the UK on a competitive footing with other hemp-producing countries, the licencing of industrial hemp cultivation should be moved to DEFRA, in line with the majority of Europe.

Country	Licensing Body
Austria	No Licence Required
Belgium	Regional Governments
Bulgaria	Ministry of Agriculture, Food and Forestry
Croatia	Registry of Industrial Hemp Growers (Ministry of Agriculture)
Cyprus	Department of Agriculture
Czech Republic	No Licence Required
Denmark	Agency for Agriculture
Estonia	Chamber of Agriculture and Commerce
France	National Agency for the Safety of Medicines and Health Products (ANSM)
Germany	Federal Ministry of Food and Agriculture (BMEL)
Greece	The Department of Rural Development and Control (TAAE)
Ireland	Agriculture and Food Development Authority (TEAGASC)
Italy	Ministry of Agricultural, Food, Forestry and Tourism Policies (MIPAAFT)
Lithuania	Ministry of Agriculture
The Netherlands	Ministry of Agriculture, Nature and Food Quality
Poland	National Agricultural Support Centre (KOWR)
Portugal	Ministry of Agriculture
Romania	County Directorate for Agriculture
Slovakia	Ministry of Health
Slovenia	Ministry of Agriculture, Forestry and Food
Spain	No Licence Required
Sweden	Board of Agriculture
UK	**Home Office - Drugs and Firearms Licensing**

Biorenewables Development Centre

University of York

HEMP-30

LUCID INSIGHT

Kepier & Company Limited
Business and Management Consultants

Catalysing a step change in the production and utilisation of industrial hemp as a biorefinery crop in the UK

INDUSTRIAL HEMP IN 2020 UK

800 HECTARES OF INDUSTRIAL HEMP GROWN IN THE UK

NICHE CROP WITH SMALL HEMP-BASED PRODUCTS INDUSTRY

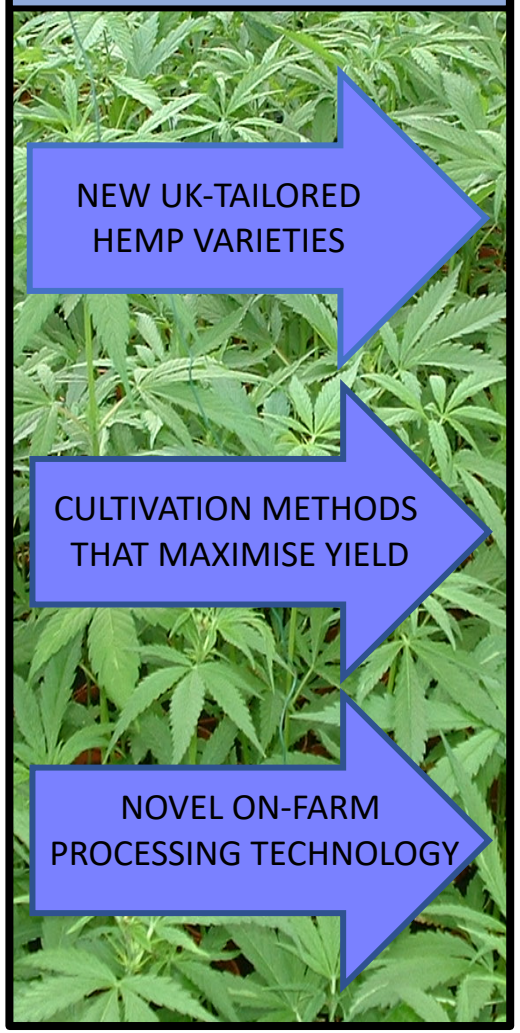
INDUSTRIAL HEMP OPPORTUNITY

- CAPTURES c22 TONNES OF CO_2 PER HECTARE
- NEEDS LOW INPUTS DRIVING BIODIVERSITY
- BREAK CROP ALTERNATIVE TO OIL SEED RAPE
- WIDE RANGE OF POSSIBLE PRODUCTS

HEMP-30 PHASE 1 ANALYSIS AND PLANNING

- DETAILED 2021 LANDSCAPE REVIEW
- SUPPLY CHAIN STAKEHOLDER INTERVIEWS
- 10-YEAR UK HEMP ROADMAP

HEMP-30 PHASE 2 INNOVATIONS



- NEW UK-TAILORED HEMP VARIETIES
- CULTIVATION METHODS THAT MAXIMISE YIELD
- NOVEL ON-FARM PROCESSING TECHNOLOGY

INDUSTRIAL HEMP IN 2030 UK

- CONSTRUCTION
- BIOENERGY
- BIOGAS
- BIOFUEL

80,000 HECTARES OF INDUSTRIAL HEMP GROWN IN THE UK REDUCING GHG AND CREATING GREEN JOBS

- OILS + PROTEINS
- AUTOMOTIVE
- TEXTILES
- CBD + MEDICINES

Capturing carbon

Reducing greenhouse gas emissions, and improving resilience to extreme weather, are global challenges for farming and land management. Input-efficient crops that can increase carbon capture will help farming and associated industries address climate change, but there must be confidence in achieving profitable and sustainable outcomes.

Working towards Net Zero

The Centre for High Carbon Capture Cropping (CHCx3) is a four-year, multi-partner project, led by NIAB. The research aims to help UK farmers and growers target Net Zero and build farming resilience through diversifying their arable and forage cropping. It will enable new revenue sources through a carbon marketplace and support enhanced value chains for industries such as textiles and construction.

Diversifying cropping options

The project is focusing on four cropping options: cover crops; annual fibre crops (industrial hemp, flax); perennial food, feed, and forage cropping (including cereals and herbal leys); and perennial biomass crops (miscanthus, willow/poplar). Field trials and demonstrations will examine the effect of cultivation systems and agronomy on economic returns and environmental outcomes, with practical outputs including crop guides, web tools and apps.

CNAP
Centre for Novel Agricultural Products

Acknowledgements

Thilo Winzer

Monika Bielecka
Filip Kaminski

David Harvey
Tony Larson

Yi Li

Judith Mitchell

Elsoms Seeds

Funding Sources

- former UK Technology Strategy Board
- EU 7th Framework Programme ‘MultiHemp’
- BEIS – Hemp30 Roadmap
- UoY
- Defra/Innovate UK - CHCx3

University of York RESEARCH