FGU Project Genetic Engineering and the Environment

The application of NGTs in *Brassicaceae*: environmental risk assessment scenarios

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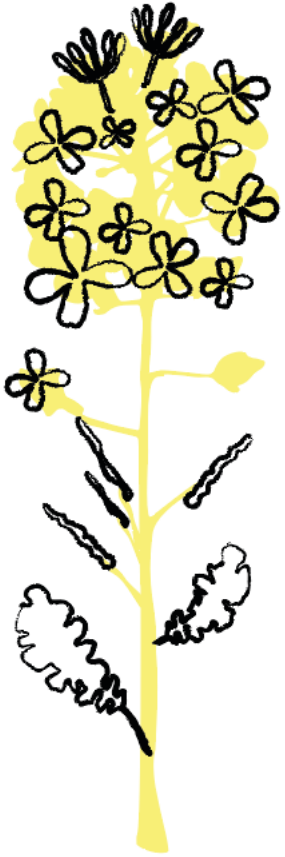
Brassicaceae - biology



Native to Euroasia

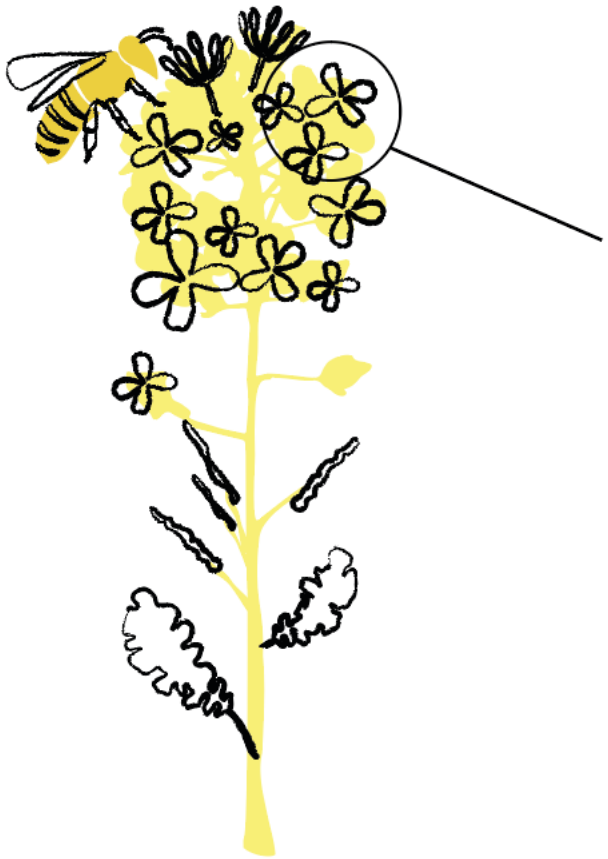
Plant family including different domesticated as well as wild (and feral) plants

Partially cross-compatible

Large-scale cultivation in EU (especially oilseed rape): source of nutrients and vegetable oil, but also for biofuels, industrial compounds

Brassicaceae - interactions

Example of oilseed rape



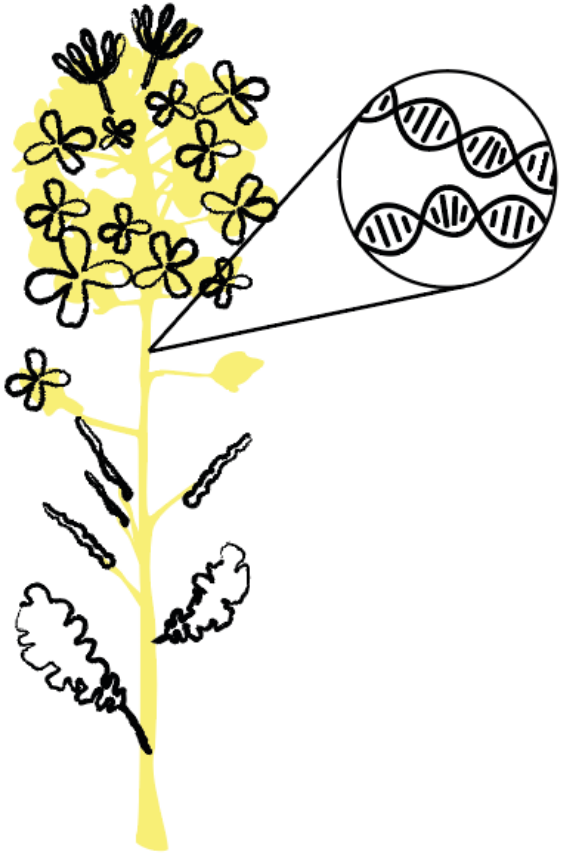
Easily accessible and highly abundant floral resources

Attractive for pollinators such as honey bees

Sticky pollen: source of proteins, lipids, vitamins, and minerals

Significant yield increase by insect pollination

Brassicaceae - genome and breeding



Partially complex polyploid genome
(e.g. oilseed rape 4x, camelina 6x)

Gene copies and duplicated genes

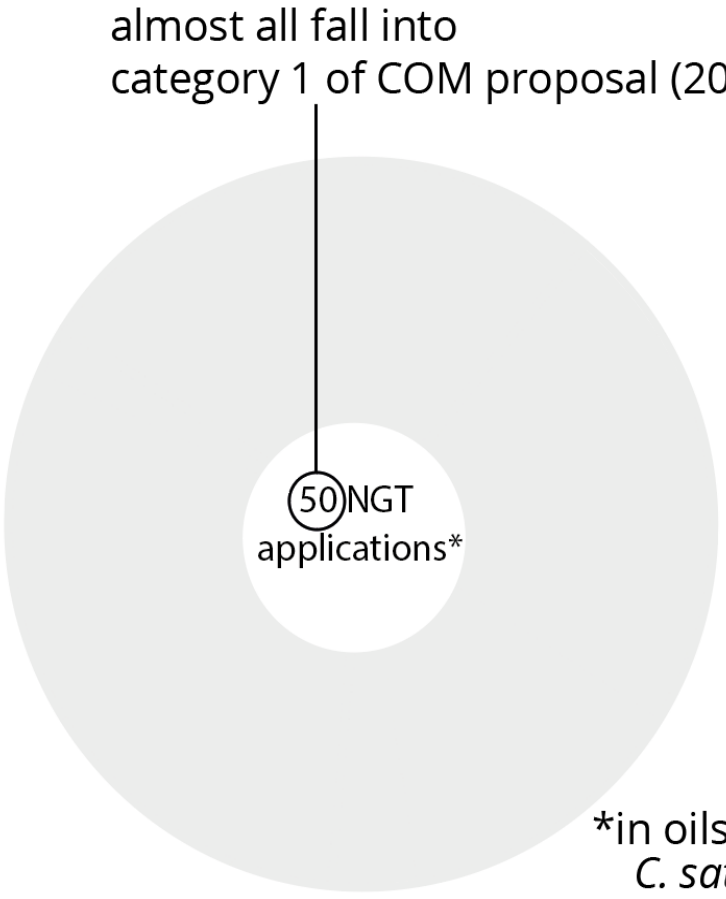
Restrictions for conventional breeding
can be overcome by NGTs

Unintended effects on the plant and the environment

Analysis of current NGT applications in *Brassicaceae* oil seed crops*

*database research

Current NGT applications in *Brassicaceae*



*in oilseed crops *B. napus (39)*,
C. sativa (9) & *T. arvense (2)*

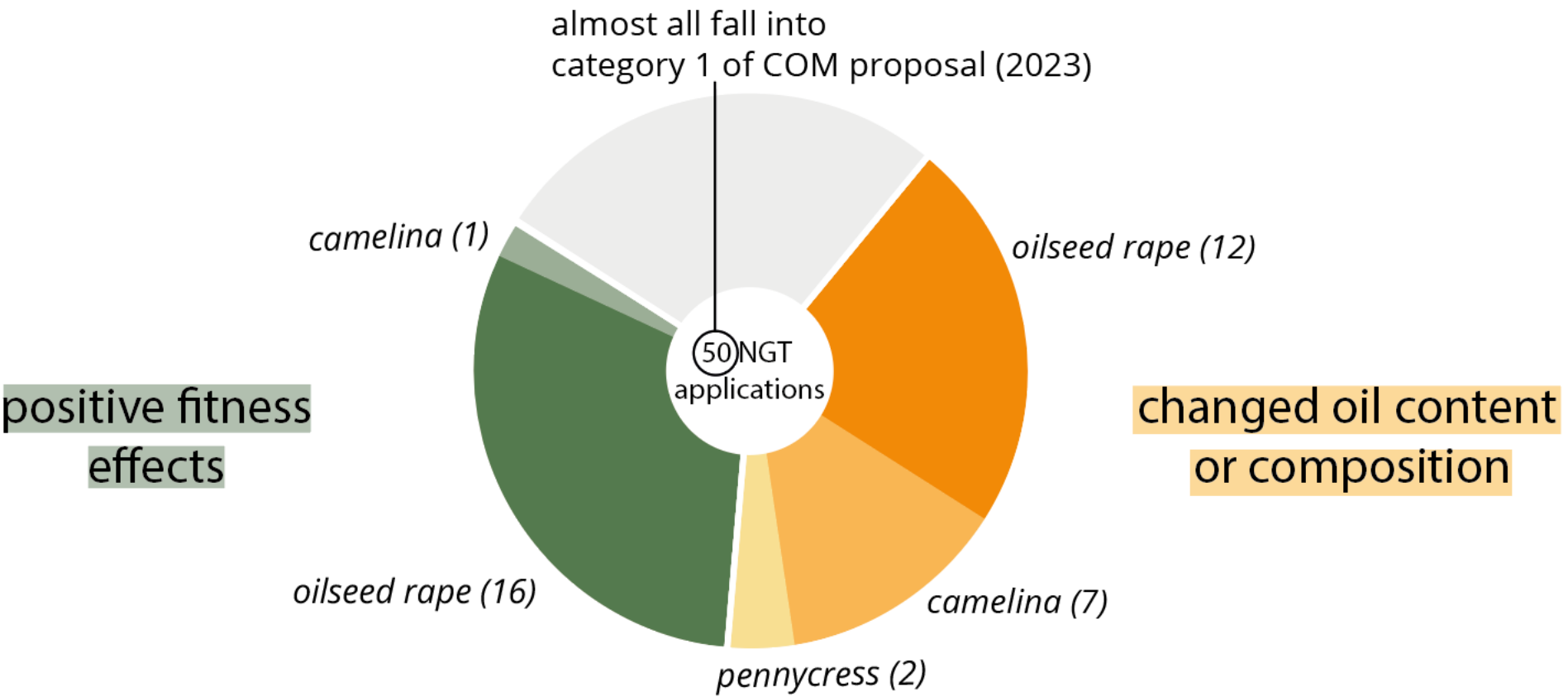
<u>category 1</u>:

Changes in 20 genomic regions

E. g. insertions of 20 nucleotides at each target region or deletions in various size

→ Exemption NGT plants of category 1 from risk assessment and monitoring

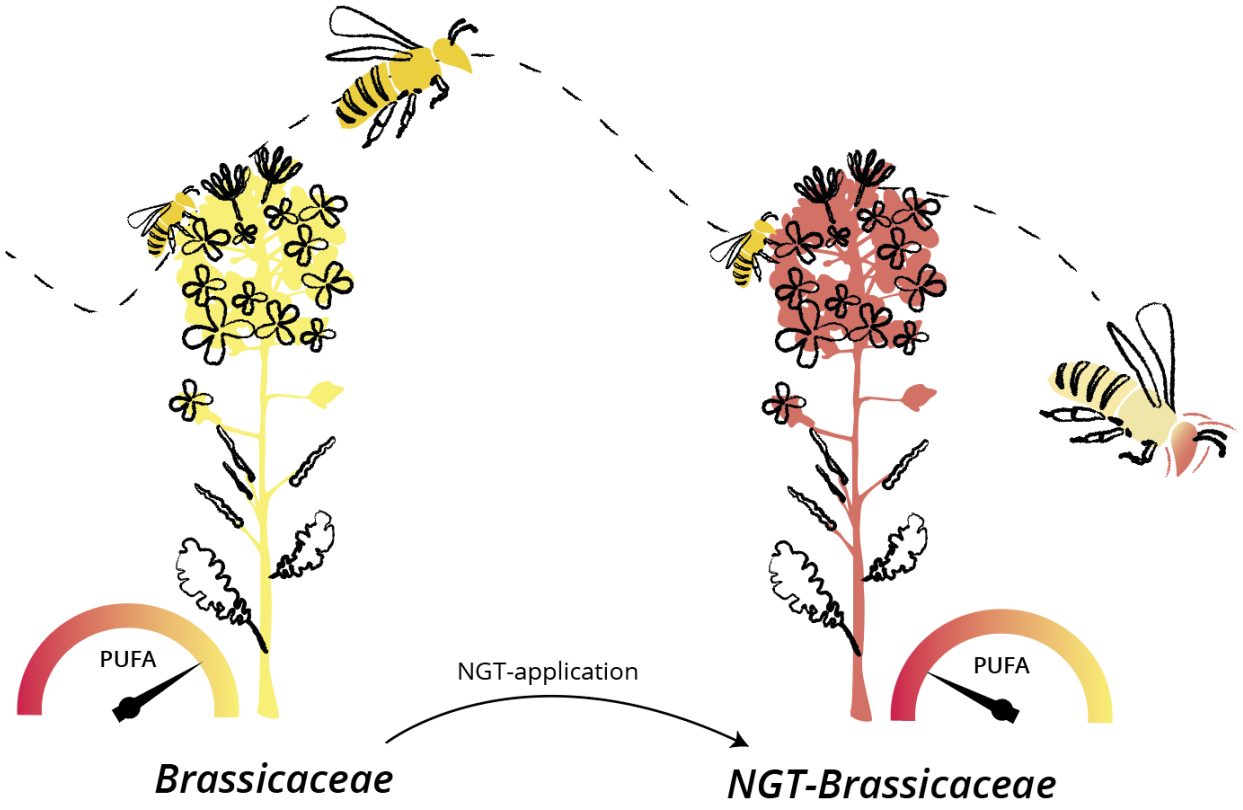
Current NGT applications in *Brassicaceae*



Changed oil content or composition

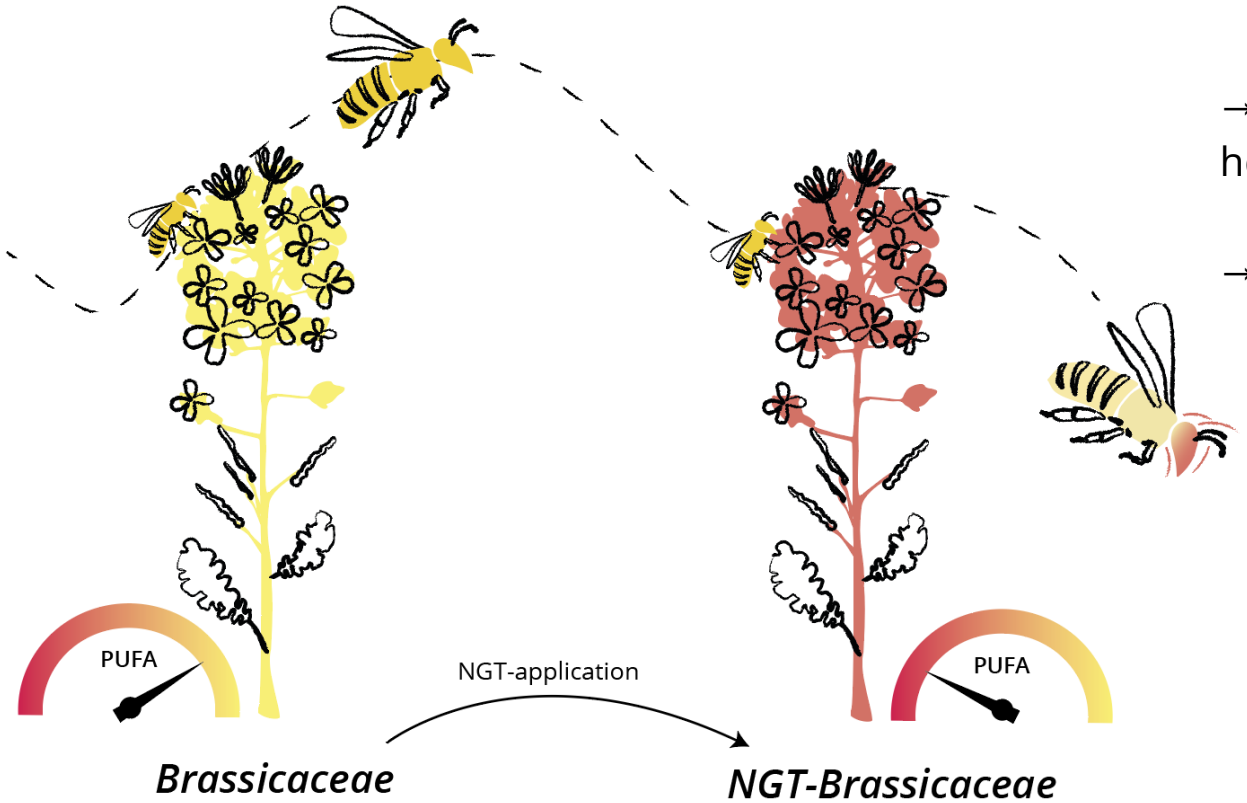
Brassicaceae

Changed oil content or composition



decreasing amount of certain fatty acids in NGT plant can negatively affect the health of pollinators

Changed oil content or composition



→ Pollinator may suffer a PUFA deficiency in NGT monoculture

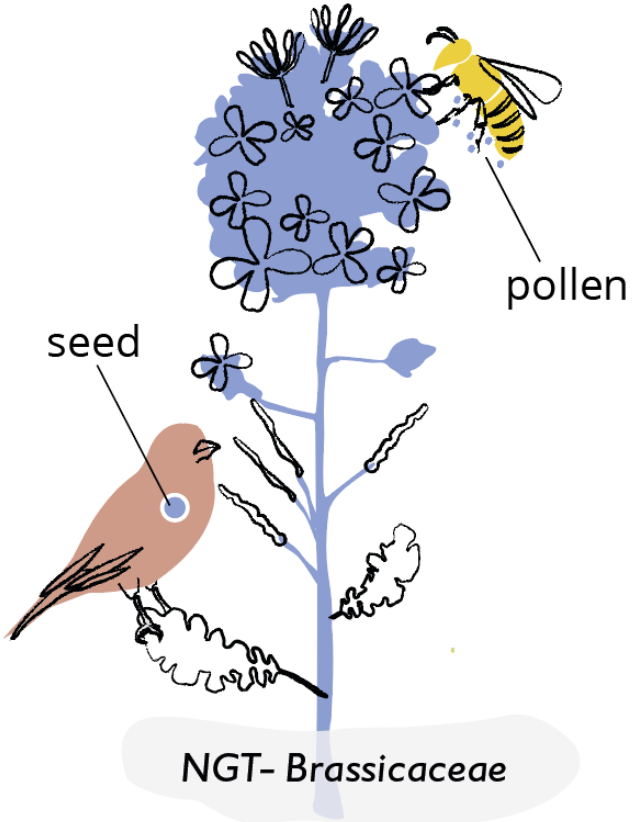
→ PUFA deficiency greatly impairs honey bees brain funtion*

→ Balanced PUFA also important for brood development and adult longevity*

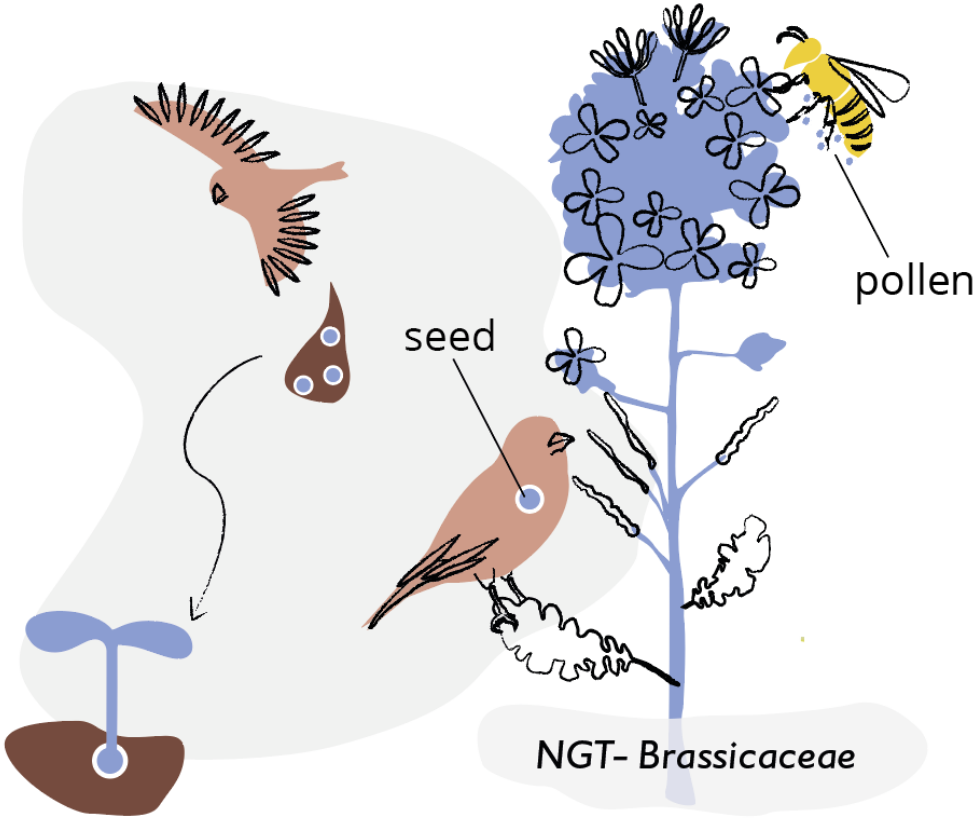
decreasing amount of certain fatty acids in NGT plant can negatively affect the health of pollinators

* *Arien et al (2015/2020)*

Positive fitness effects

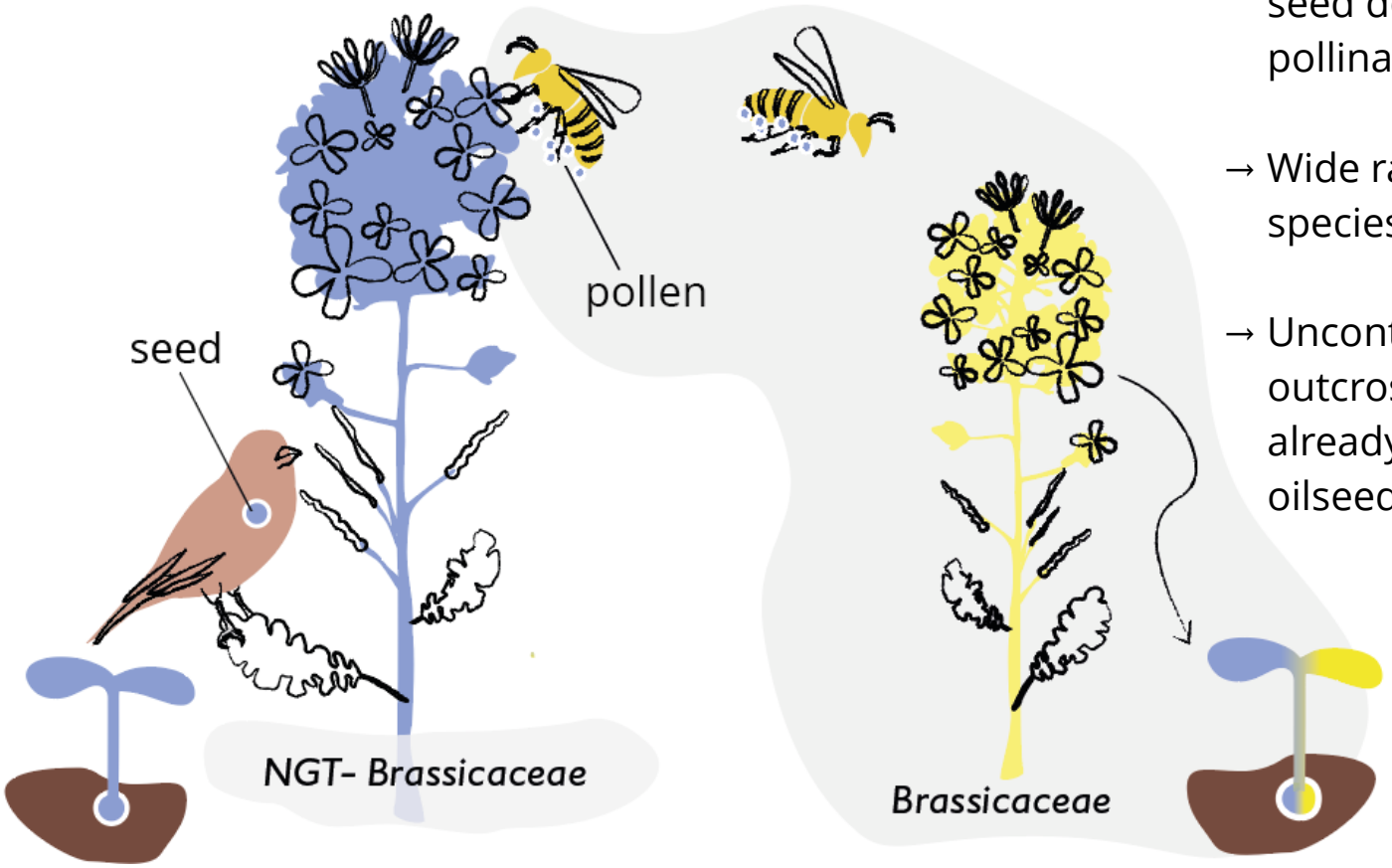


Positive fitness effects



→ Weedy caracteristics, long seed dormancy

Positive fitness effects



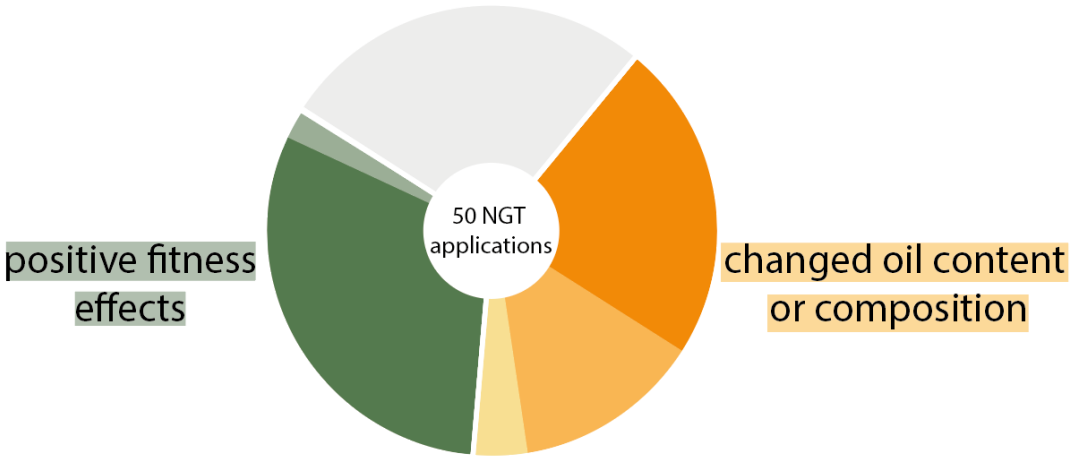
→ Weedy caracteristics, long seed dormancy and pollination over long distance

→ Wide range of Brassicaceae species can hybridise

→ Uncontrolled spread and outcrossing in weedy species already shown for transgenic oilseed rape

increasing fitness can further increase the risk of spread and persistence

Current NGT applications in *Brassicaceae*

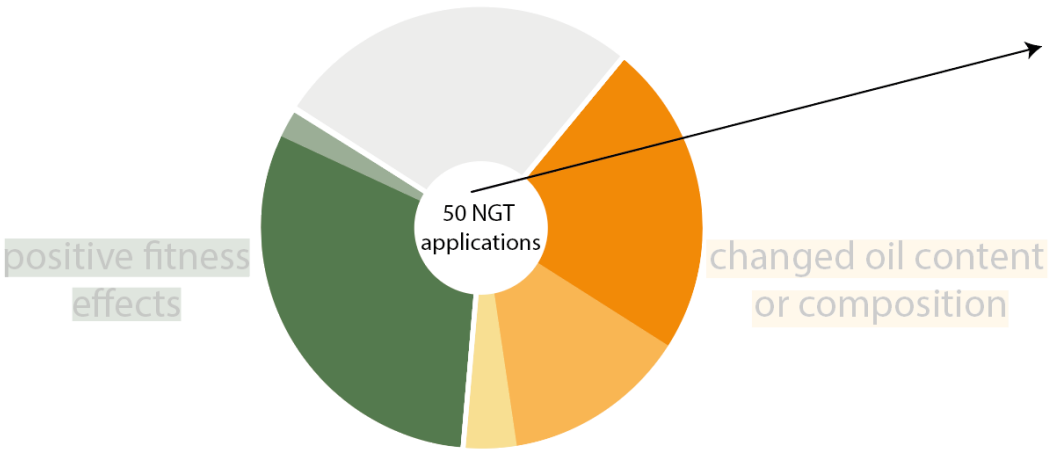


spontaneous crossing and stacking

Release of NGT Brassicaceae may result in spontaneous crossing and combination of different NGT-traits

Stacking of category 1 NGT plants without further restrictions and monitoring

Current NGT applications in *Brassicaceae*



Further NGT applications concerning traits relevant for pollinator interaction:

→ changed flowering time
→ reduced expression of various flavonoids
→ impact on hormon signaling...

→ With increasing complexity and (intended or spontaneous) combination of the traits, undesirable pleiotropic effects and unintended consequences become more and more difficult to predict.

Summary

→ Traits such as the composition of fatty acids and the number of seeds can also be influenced by conventional breeding. However, the results of using NGTs now and in future can go beyond the currently known characteristics of conventional plant breeding.

→ The technical potential of NGTs already allows (new) genotypes and traits to be developed within **short periods** of time.

→ In future, **combining and stacking** NGT-derived genotypes of various genes is expected to lead to even more extensive overall genomic change in NGT plants.

→ In addition to the intended alteration in the phenotype (and their combination), **unintended changes** can also occur, with consequences for plant health and interactions with the environment (such as pollinators).

→ With increasing complexity and (intended or spontaneous) combination of the traits, undesirable effects become more and more **difficult to predict**.

In addition...
unintended genetic changes by NGTs

→ Using NGT, **unintended genetic changes** can occur and affect small and large sections of chromosomes and result in unintended gene products.

→ The **sites of the mutations**, their **genomic context** and their **frequency (in regard to specific sites)** can differ when compared to conventionally bred plants.

→ The biological effects (phenotypes) can therefore be different and may cause specific risks for health and the environment.

* *Koller & Cieslak (2023)*

Outlook

→ As the number of applications increases, it becomes increasingly difficult to reliably assess the risks for the environment such as for pollinators and the foodwebs.

→ If NGT plants are introduced into agriculture, it is essential to examine both the risks of the individual plants as well as their interactions (accumulated effects).

→ This is particularly relevant, if several NGT plants are released into the same receiving environment.

→ Regulatory provisions need to consider these aspects.

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Thank you for your attention!

Arien et al (2015) *Omega-3 deficiency impairs honey bee learning. Proc Natl Acad Sci U S A. 22;112(51):15761-6.*
Arien et al (2020) *Effect of diet lipids and omega-6:3 ratio on honey bee brood development, adult survival and body composition. J Insect Physiol. 2020 Jul;124:104074. doi: 10.1016/j.jinsphys.2020.104074.*

Further references can be found in
Backgrounder: *The application of NGTs in Brassicaceae: environmental risk assessment scenarios. Available at: fachstelle-gentechnik-umwelt.de*
Koller & Cieslak (2023) *A perspective from the EU: Unintended genetic changes in plants caused by NGT – their relevance for a comprehensive molecular characterisation and risk assessment. Front. Bioeng. Biotechnol. 11:1276226.*