

Research in Castor: What is Needed for the Next Phase in Castor's Evolution

Value Chain Event on Oilseed Crops

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PANACEA
Non Food Crops for a EU Bioeconomy



kaiima

Corporate profile

Kaiima is a plant genetics and breeding technology company

Kaiima's market-leading castor program was established in 2006 and is based on elite germplasm coupled with advanced breeding, agronomic and cutting-edge biotech capabilities.

Headquarters

Moshav Sharona,
Israel

Global presence

Regional offices in the U.S., Brazil &
China



Business segments

Castor

Breeding, sales and agro-technical advancement
through the CastorMaxx© system

Technology

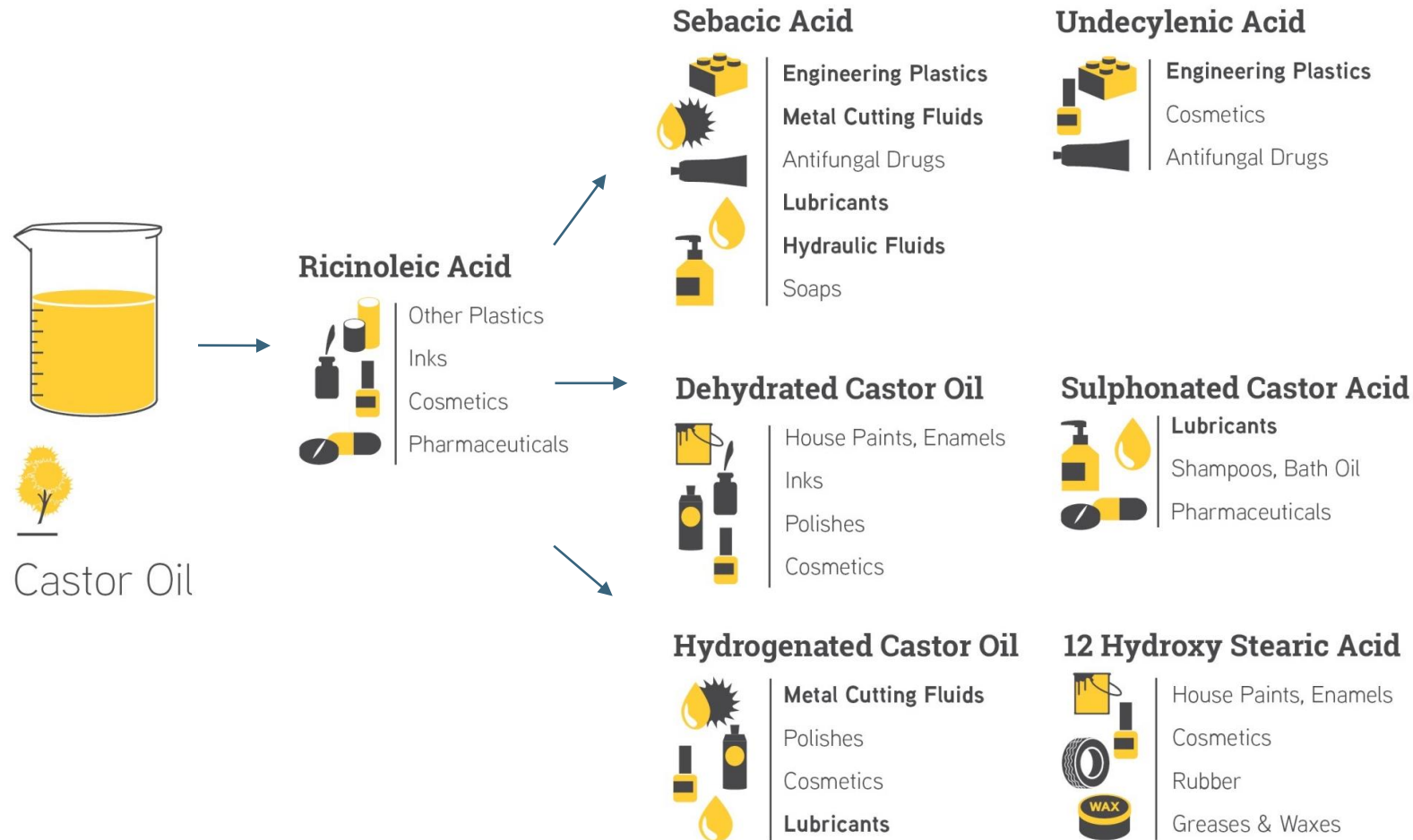
EP™ platform projects with Partners to
help boost crop productivity

Castor is an orphan crop yet to be modernized

- Castor is a well adaptive plant with seeds providing 45-50%+ oil content.
- Castor oil's chemical qualities are ideal for many industrial applications.
- Castor was domesticated and traditionally used for many years, but yet to be adapted as a fully mechanized, industrial crop.



Castor oil has many industrial derivative applications



* Application where a derivative is a primary component

Castor oil demand is constantly growing

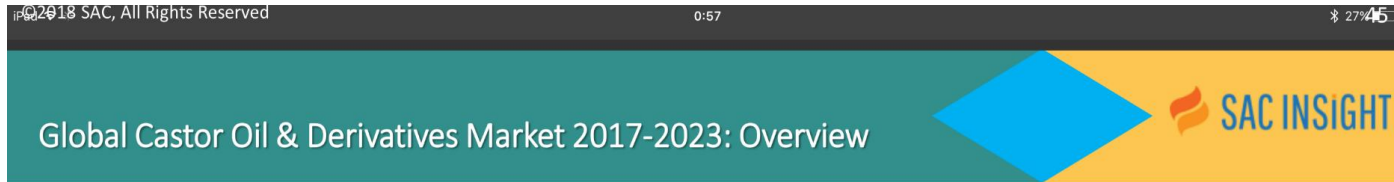
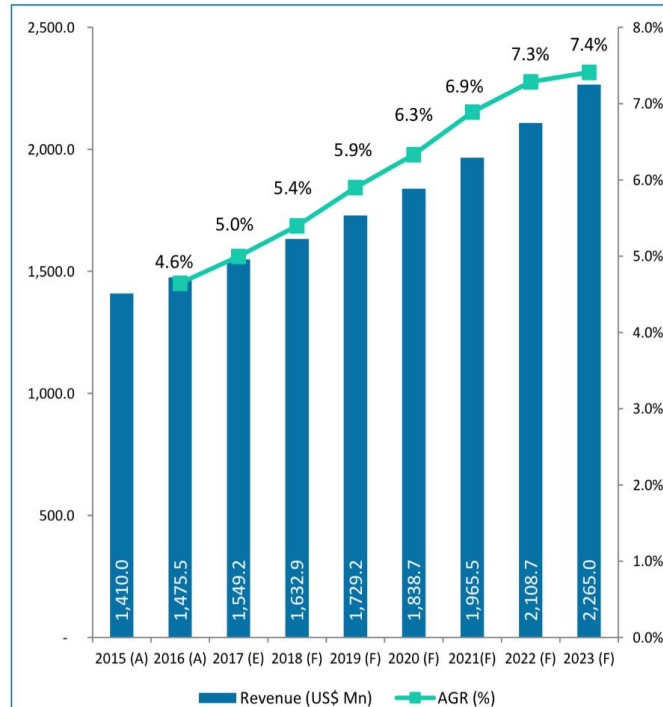


Figure 07: Global Castor Oil & Derivatives Market



Analysis

- ❑ The Global castor oil & derivatives market is set to experience considerable growth over the forecast period.
- ❑ The main drivers for the growth of global castor oil & derivatives market includes increasing demand for sustainable and biodegradable products due to the shift of the industry towards diminishing dependence on petrochemicals.
- ❑ The growth of petrochemical prices are anticipated to drive the growth of global castor oil & derivatives market. Growing end-user industries such as healthcare industry & increasing applications of castor oil derivatives are expected to drive the growth of castor oil & derivatives market during the forecast period.
- ❑ Due to these favorable factors the global castor oil & derivatives market is expected to follow similar current growth rate and is anticipated to grow at a CAGR of 6.5% from 2017 to 2023, reaching US\$ 2,265.0 Mn in 2023 from US\$ 1,475.5 Mn in 2016.

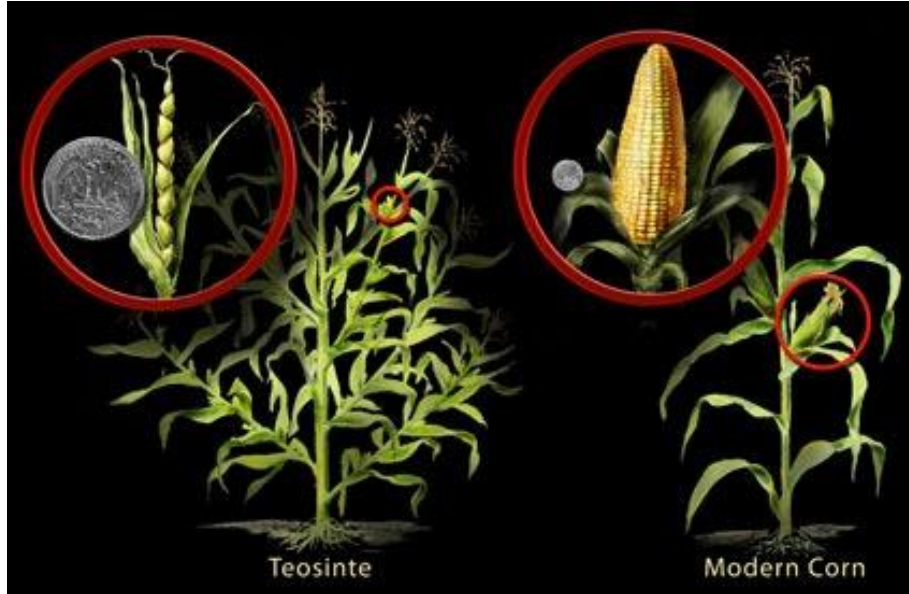
The Castor Industry is growing, yet, the basic seeds and harvest processes need to be modernized

- 86% of the oil supply is from India, family farms, with 1-20 ha, and hand harvested.
- Oil supply is sporadic, quality is difficult to monitor, and scale is limited.
- Oil buyers want alternative sources of supply.



Castor oil industry needs castor crop to evolve into an industrial, big scales, and fully mechanized crop.

Modern cultivation of Maize is a paradigm Kaiima's castor aims to duplicate



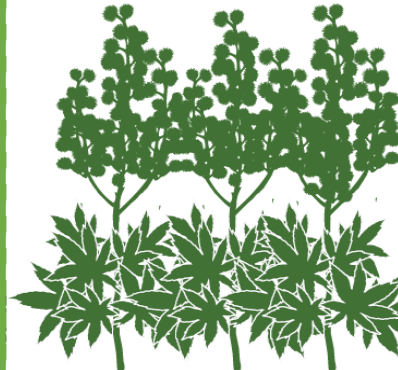
Kaiima's Next Generation Breeding Program



Wild Castor
*tall plant, low yield,
multiple branches
Gradual maturation
Natural dehiscence*



Industrial Standard
*bred for higher yield
150-200 days cycle,
manual harvested*



**Compact Hybrid
Castor 2.0**
*uniform architecture,
150 days growing cycle,
yield concentration
mechanized harvest*



**Determinate
Castor 3.0**
*ideal architecture for
mechanical harvest
100 days growing cycle,
simultaneous maturation
high population crop*

*Patented
Feb. 20th, 2018*

Kaiima's Castor Breeding Program:

Global, diverse, experienced, commercial, & a broad pipeline of new products



- Genetic origin: seed collection from Brazil, Paraguay, Mexico, China, India, Ukraine, Israel, Nigeria, and Ethiopia
- Hybrid seeds as commercial products: high heterosis potential (20%-80%)
- Compact castor hybrids are designed for mechanical harvest in big scale farms.
- Breeding programs are market-oriented and aimed for fast commercialization.
- Globally integrated breeding program utilizes shared knowledge from various climates throughout the world: Brazil, China, Mexico, and Israel.

The Evolution of Castor crop must integrate breeding and agronomic R&D for an industrial scale development.

Breeding

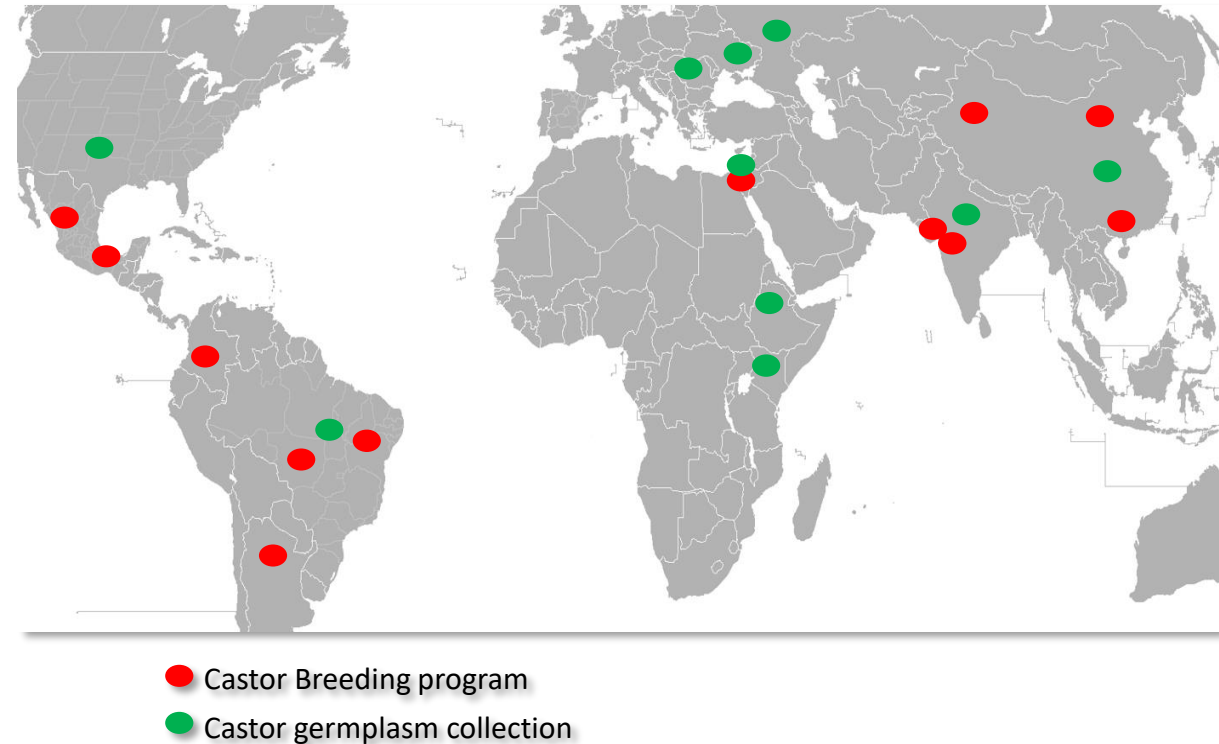


Agronomy



Global Castor Breeding

- Diverse germplasm collections not fully used by the many breeding programs around the globe.
- Excellent breeding is done by academic researchers and governmental institute.
- Focus on yield, oil quality, cycle length, soil and plant diseases, and different climatic adaptations.
- Most of breeding programs are local.
- Most are located at the tropics or semi-arid regions.
- 50% is breeding for hybrids; 50% for OP varieties.
- Breeding mostly done for non-mechanized market.



Challenges and needs in Castor breeding research

What should be done in breeding R&D?

1. **More breeding for compact - mechanized castor**
(less than 5%)
2. **More commercial Castor Breeding Programs:** better collaboration of academic research and commercial breeding companies.
3. **Increase genetic polymorphism within breeding programs:** better use of seed collection in breeding programs
4. **Enhanced breeding process using modern breeding tools.**



Challenges and needs in Castor breeding research

Marker assisted breeding:

1. Trait-related markers are already in use for breeding.
2. Polymorphic molecular markers for an advanced and cost-efficient Quality-control.

- ☐ Needs to invest in gene discovery
- ☐ Better genome drafting.

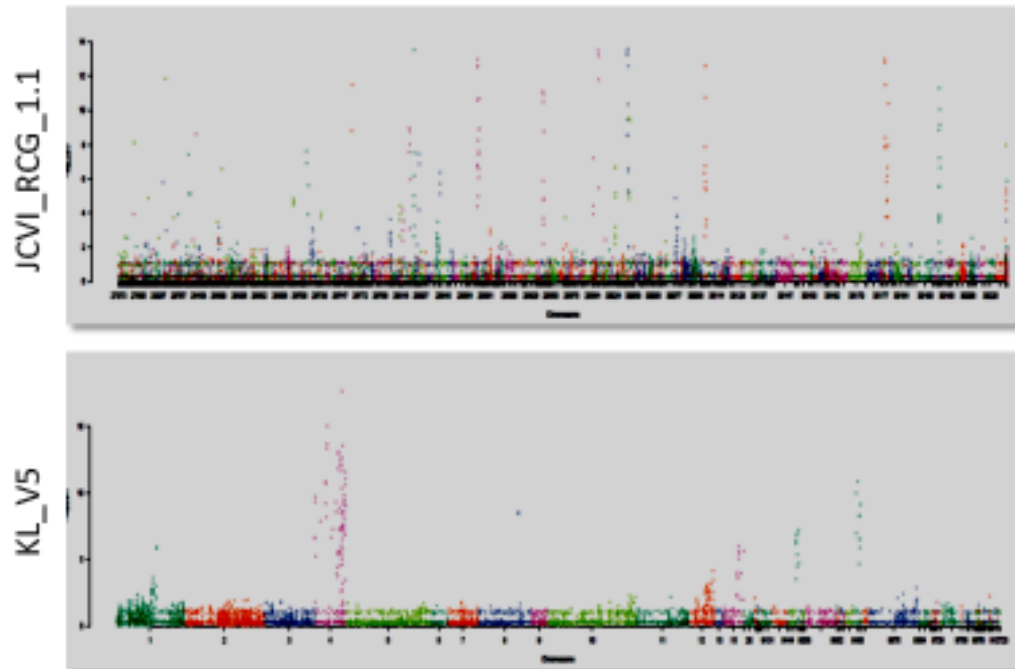
			compact
	185	115	kl104
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K9-1-3	H	H	C
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K9-1-5	H	H	C
K9-1-6	H	H	C
K9-1-7	H	H	C
K9-1-8	H	H	C
K9-1-9	H	H	C
K9-1-10	H	H	C
K9-1-11	A	A	C
K9-1-12	H	G	C
K9-1-13	H	H	C
K9-1-14	H	H	C
K9-1-15	H	H	C
K9-1-16	H	H	C

Challenges and needs in Castor breeding research

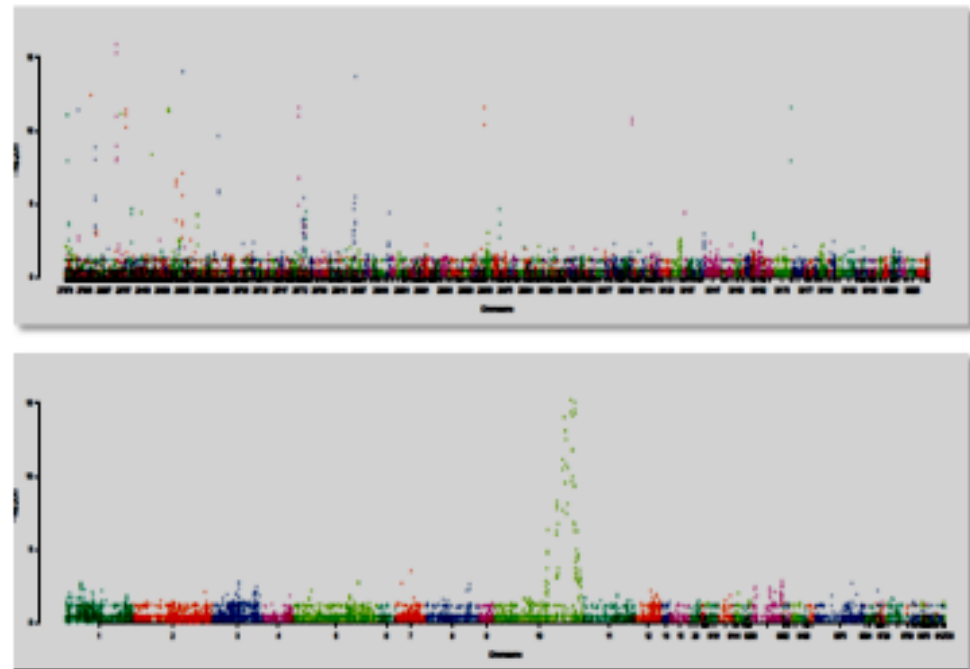
Improving genomic draft will enable us a better gene-trait association

- Example of two cases of trait mapping by association – same sequencing data mapped to two genome drafts for comparison

Capsule size association mapping



Anthocyanin expression association mapping



Challenges and needs in Castor breeding research

Genomic breeding:

- Better draft and easier gene discovery for complicated traits (high oil).
- Prediction of hybrid performance, using parental lines genotypes.
- Defining heterotic groups and improve parental selections.
- Efficient selection of new breeding populations for new markets.
- Speed up breeding throughout fast back-crosses and fast fixation.
- Genetic fingerprinting for QC and IP purposes.

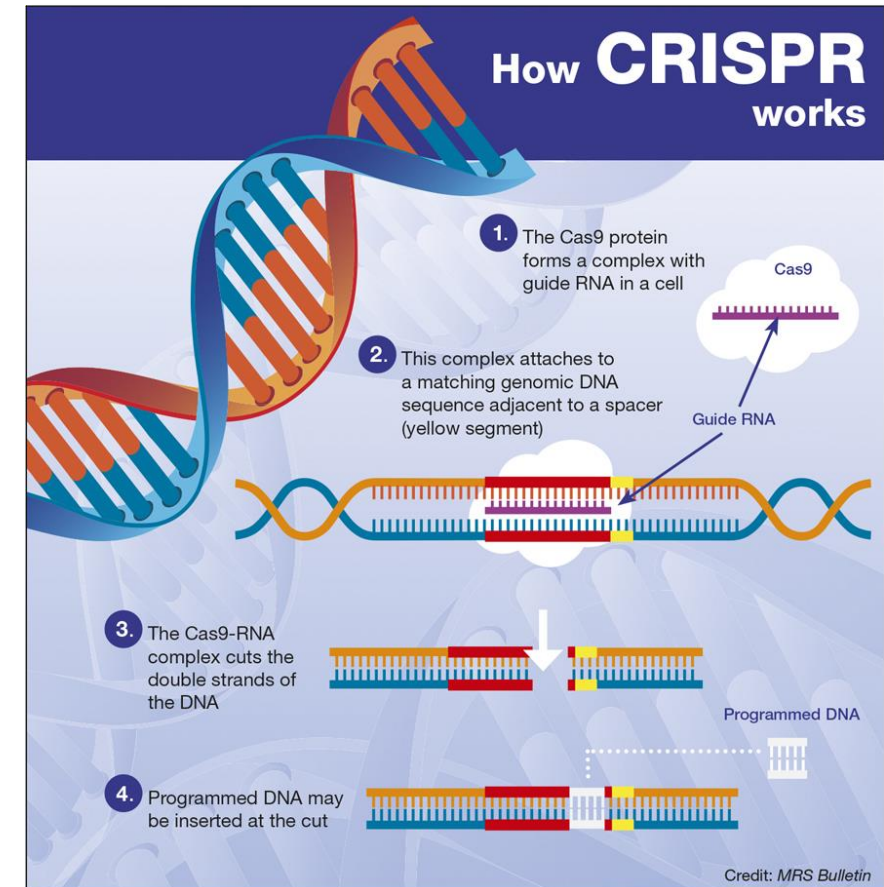
❑ The technology is already out there

Challenges and needs in Castor breeding research

Gene editing and GMO technologies

- Knock-out non desirable traits (RICIN)
- Introduce new traits (herbicide resistance)
- Improve existing traits (oil content, Ricinoleic acid, etc.)
- Enhanced breeding tools (DH breeding).

- ☐ Technology is not efficient enough
- ☐ Regulatory? Still a barrier/mystery
- ☐ Cost? will farmers pay high seed price for these technologies?



Challenges and needs in Castor Agronomy research

- 99% of the market is harvested manually, with small farm holders, low-tech management, low yields (despite high genetic potential).
- Mechanical harvest solutions are still insufficient (harvest speed & loss).
- Modern farmers are high tech farmers.
- Agronomic protocols are not well adapted to these farmers.
- Lack of modern crop solutions is prohibiting large farmers from entering the castor market.



New (2019) harvest header for castor developed in Brazil:
Speed: 7km/h
Loss: ~8%

Challenges and needs in Castor **Agronomy research**

What should be done in agronomy R&D?

1. Adapt growing protocols for modern high-tech agriculture:
 - Weed control, diseases control, pest control.
 - Optimize fertilization & irrigation protocols.
 - Pre harvest management.
 - Seeds quality: seed production protocol and post harvest practices.
 - Develop crop rotation management and maximize the advantages of castor.
2. Machinery:
 - Optimize harvest solution.
 - Adapt farm equipment.
 - Improve seed processing machinery for better seed quality.

Summary

- Castor oil is the world's crown jewel of industrial renewable oils, with a diverse range of existing applications.
- In order to have a stable oil supply, Castor crop needs to evolve into fully mechanized modern crop.
- To enable this evolution, a coordinated program of R&D is required, both in breeding and in agronomy.
- Kaiima is leading the way and is interested to partner with researchers, corporations, government entities, NGOs and green energy philanthropic grants, to help the castor industry grow.

Thank you for your
time.

