CROP INNOVATION & BUSINESS CONGRESS 2024
INTEGRAL TECHNOLOGY DEVELOPMENT: THE FUTURE OF CROP IMPROVEMENT

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START PRESENTATION

ABOUT KEYGENE

We develop and apply technology innovation for crop improvement, for and with partners

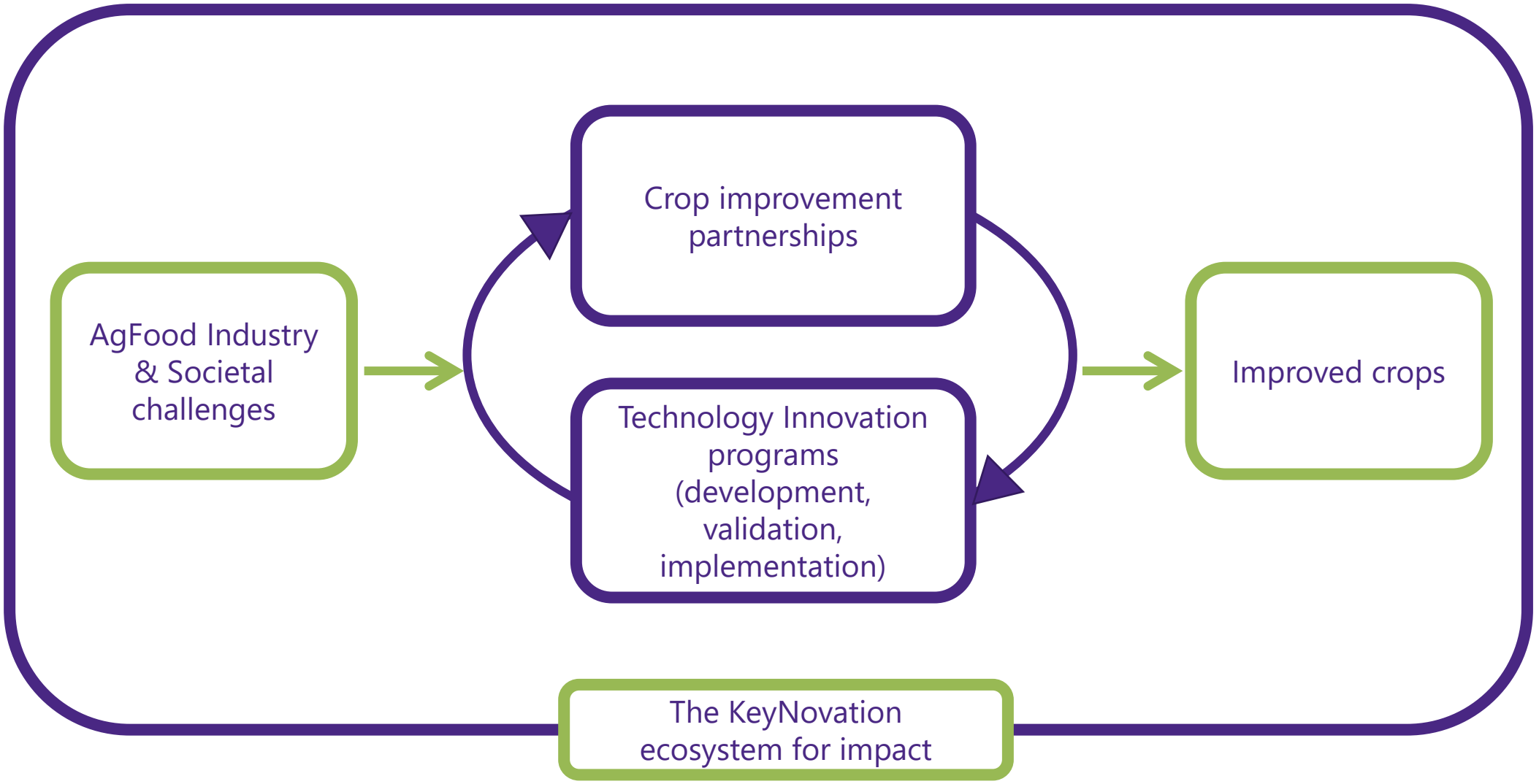
ENZA ZADEN

RIJK ZWAAN

Vilmorin & Cie
The Limagrain seed business

TAKII

INNOVATION; THE KEYGENE WAY

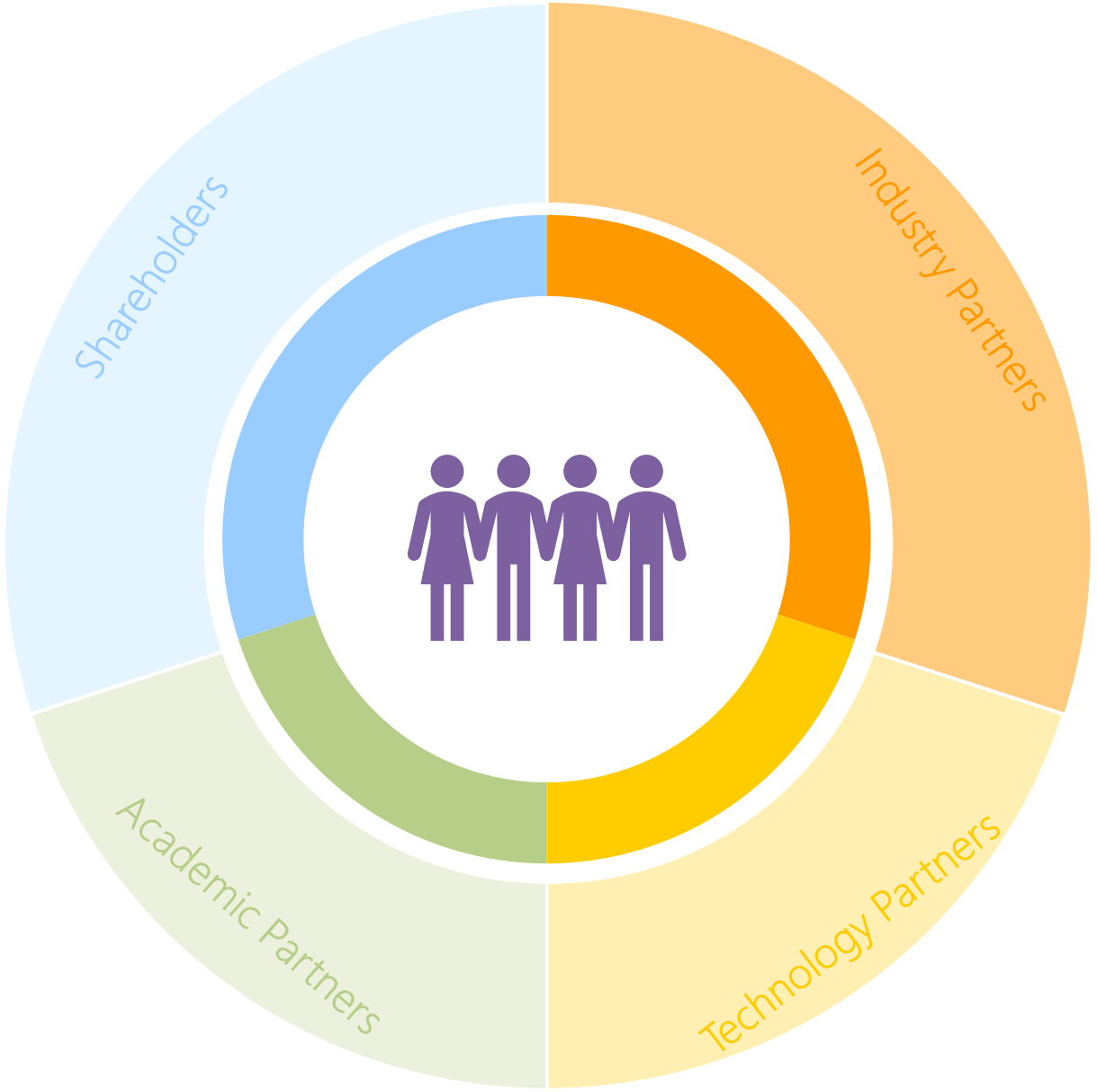


KEYGENE'S COMMUNITY INITIATIVE

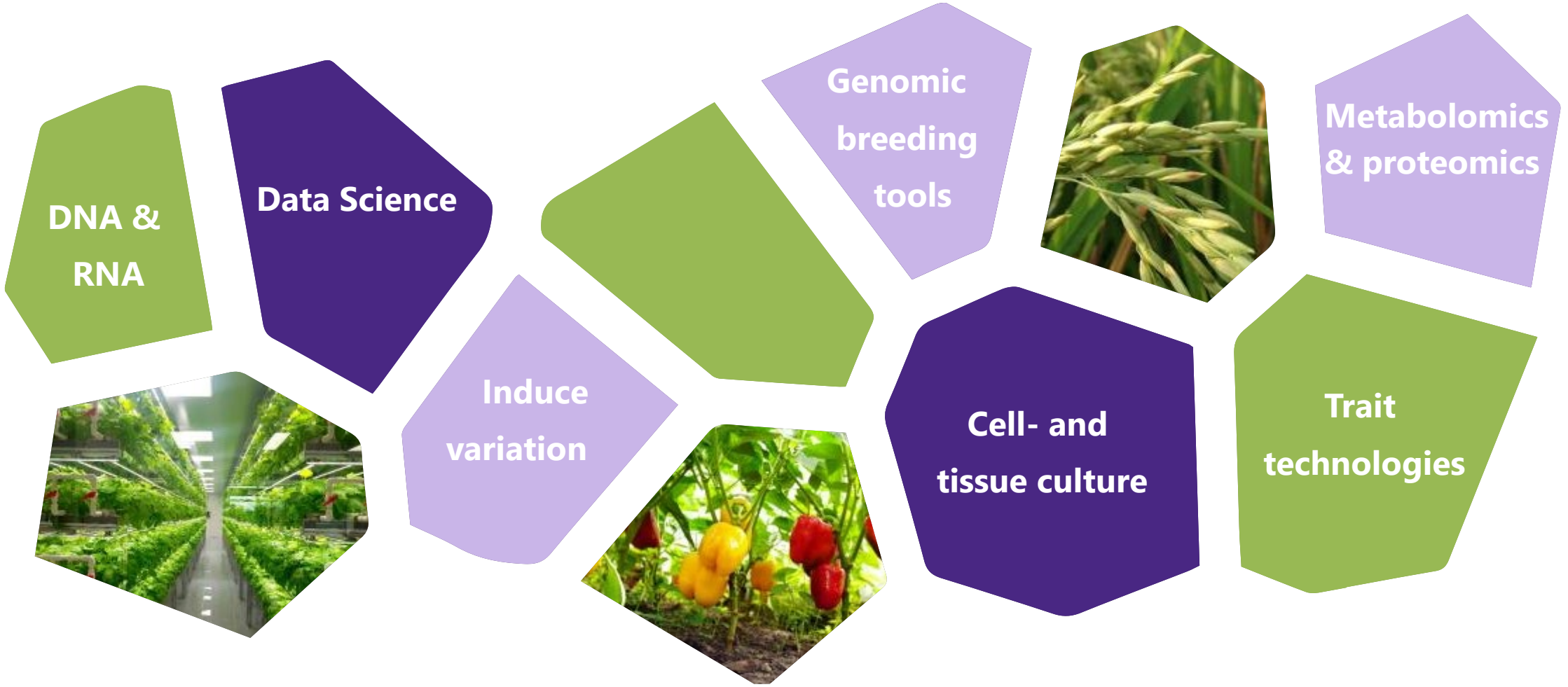
Mission

> Effectively bring together & support our partners to:
  - Foster innovation
  - Drive crop improvement
  - Identify & exploit novel opportunities
  - Maximize impact

> Provide strategic value to our partners through:
  - Knowledge building
  - Shared inspiration & insights
  - Connection with peers and opinion leaders
  - Access to resources



FROM GENERIC TECHNOLOGY DEVELOPMENT TO CROP IMPROVEMENT



Crop improvement of the future will be dominated by the integration of new generation technologies and data-driven decision-making in plant breeding

Examples of KeyGene technologies

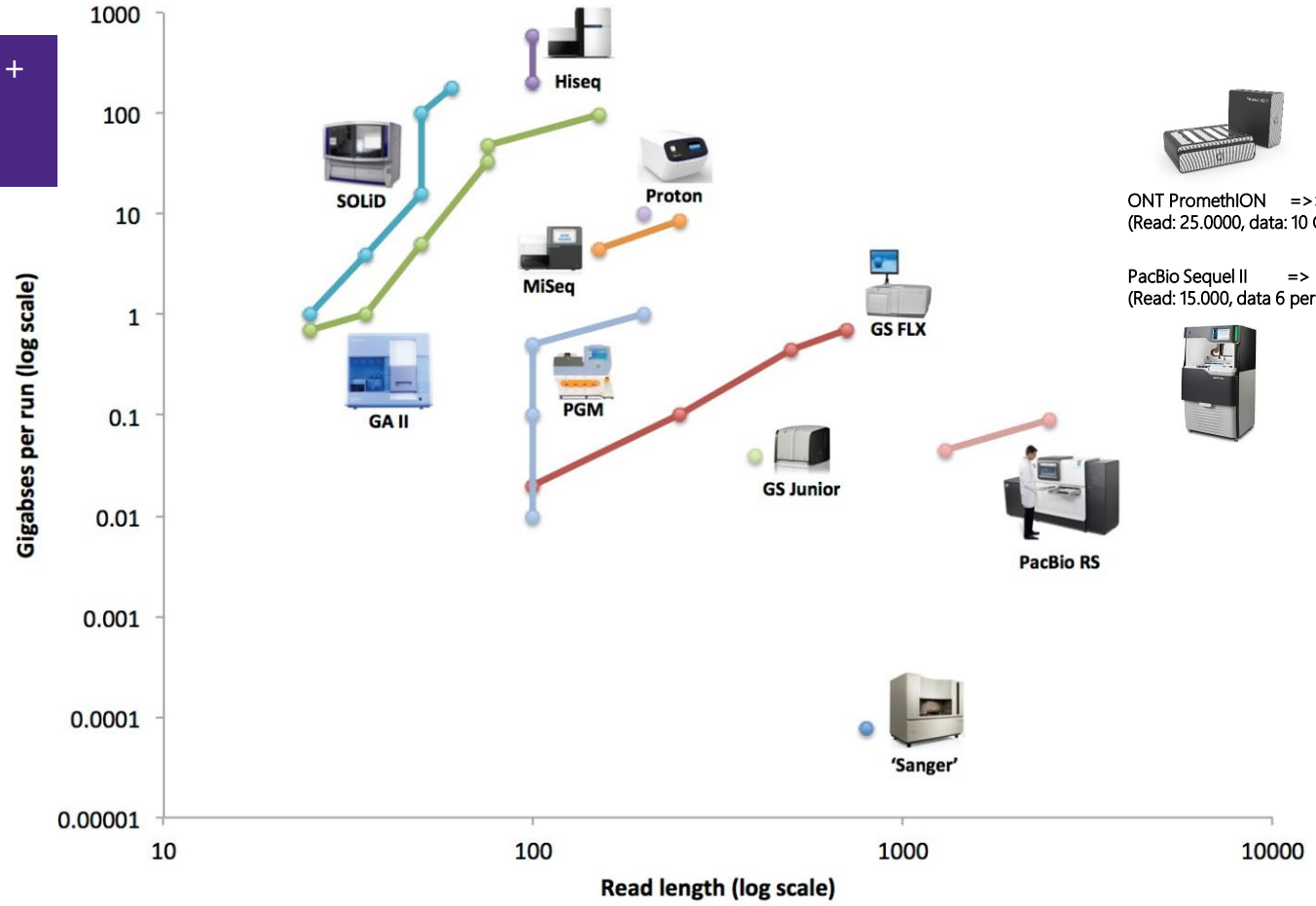
Integral approach

Examples of crop improvement

STRATEGIC ALLIANCES WITH TECH PARTNERS

Effective use of latest sequencing technologies for solving research & breeding questions

High throughput + Short read sequencing



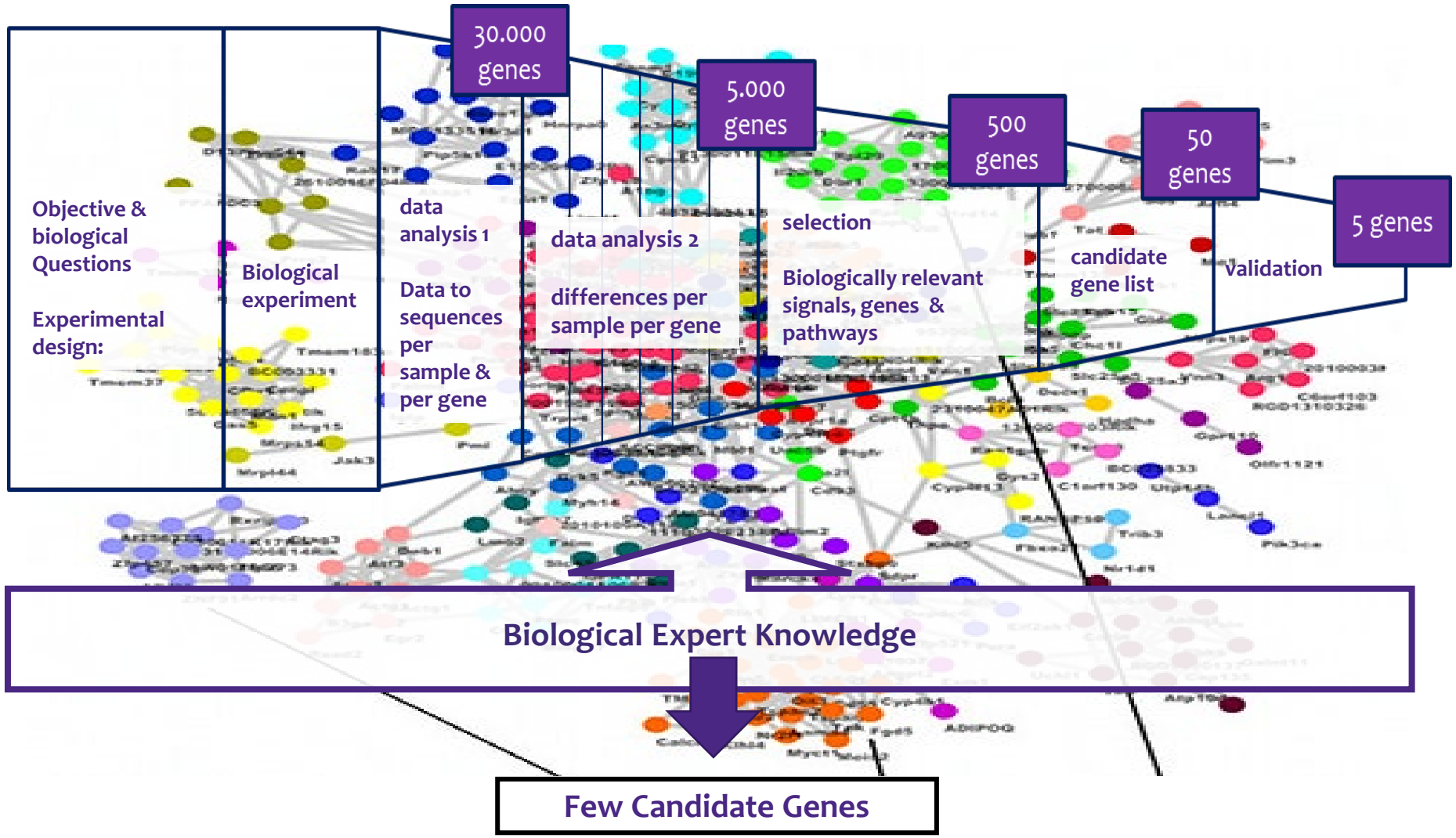
High throughput + Long read sequencing

ONT PromethION =>>
(Read: 25.0000, data: 10 GB per flow cell)

PacBio Sequel II =>
(Read: 15.000, data 6 per flow cell)

Impact: High quality & high speed sequencing in research partnerships

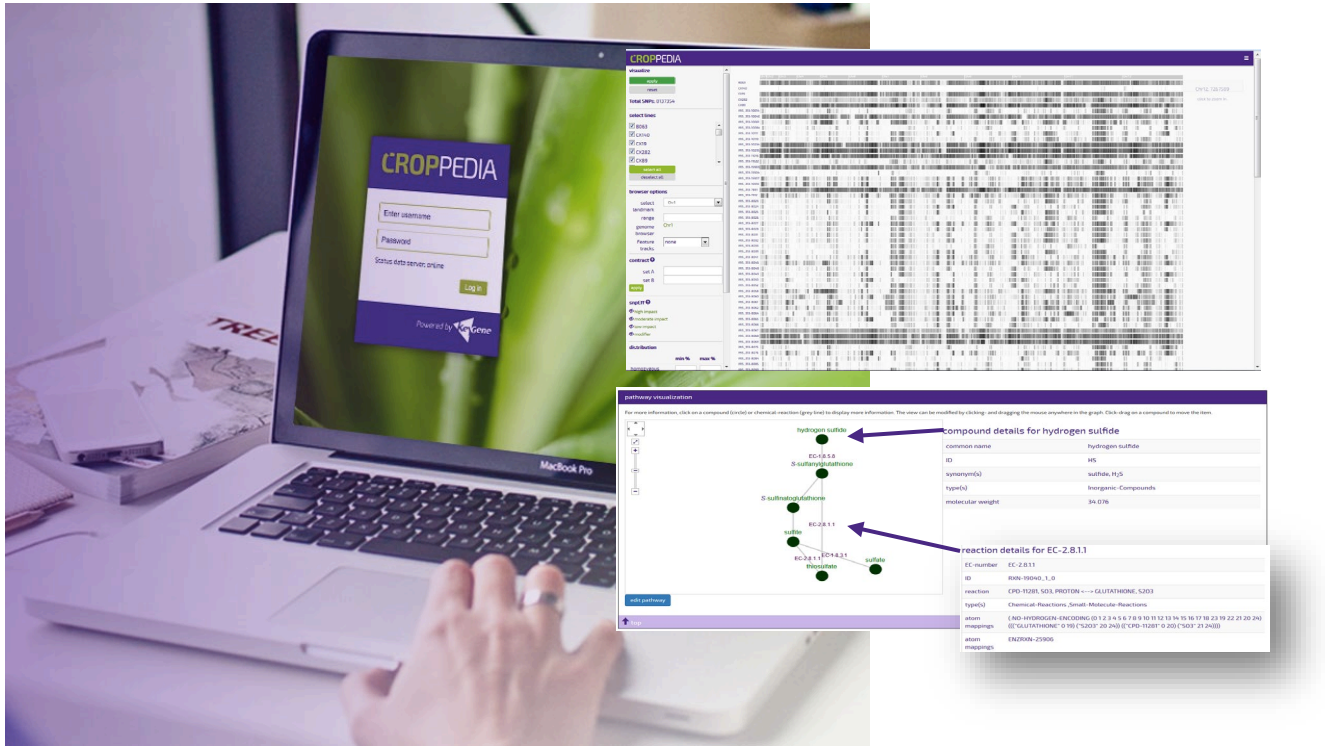
KEYSEEQ® FOR EFFECTIVE TRAIT DISCOVERY



Impact: Better, faster identification of candidate genes involved in 'any' trait

CROPPEDIA® SOFTWARE PLATFORM

Powerful data analysis & visualization platform to handle proprietary & public data for any crop



- advanced compute
- data integration
- data storage
- public & proprietary data sources
- automated input quality control
- system integration
- data security
- available as SaaS
- advanced user management

Impact: Discover more key genes & markers to accelerate breeding

KEYPOINT® BREEDING

Sequence based mutagenesis breeding system


Tomato

Operational in many crops

Vegetables
Tomato, Sweet & Hot Pepper, Cabbage, Cucumber, Melon, etc.
Field Crops
Potato, Rye, Wheat, Sugar Beet, Tobacco, Dandelion, Soybean, Corn, Canola, Sorghum, Rice, Barley, Cassava, Sunflower, etc.

In-house industrialized procedure in one run

- typically 4,000 – 25,000 mutagenized plants
- up to 20 genes simultaneously screened, number still growing
- patentable induced variations
- combined with CropPedia® & KeySeeQ® gene discovery system
- many mutants phenotyped and introduced in breeding programs


Risotto rice

Impact: Development of unique breeding material, attractive for introduction in commercial breeding

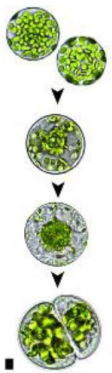
INDUCE NEW VARIATION THROUGH GENOME EDITING

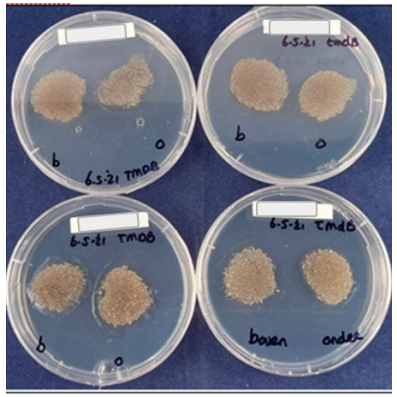
Enable

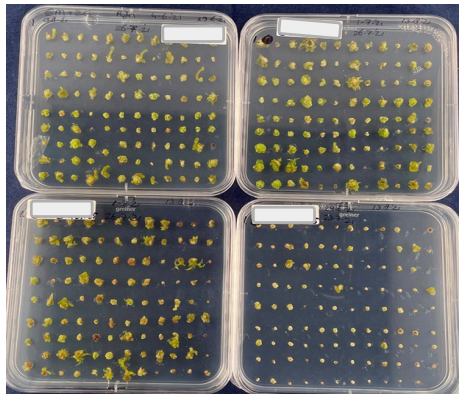
Make Versatile

Make efficient

Target Identification → Delivery system → Editing technology → Regeneration → Validation & Phenotyping







BREED

"~~CHAT~~GPT"

Examples of KeyGene technologies

Integral approach

Examples of crop improvement

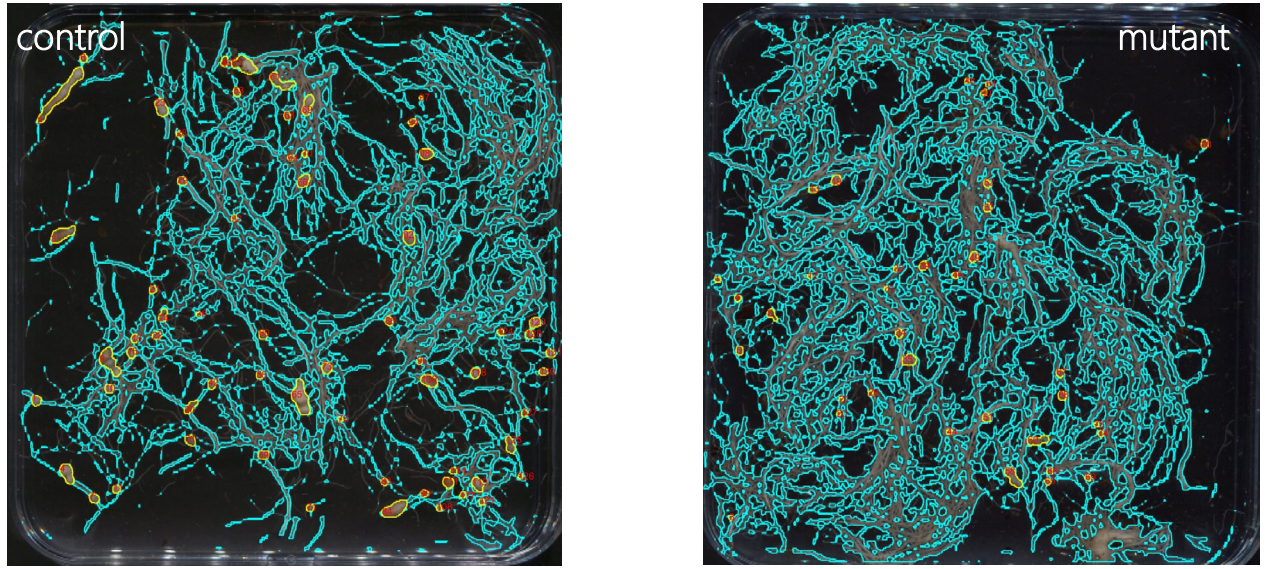
GENOME EDITING FOR S-GENE LEAD VALIDATION

Finding S-gene homologues in crops genomes

Validation of S-gene homologues in model plants

Genome editing of validated S-genes in crops

Phenotype resistance in edited crops



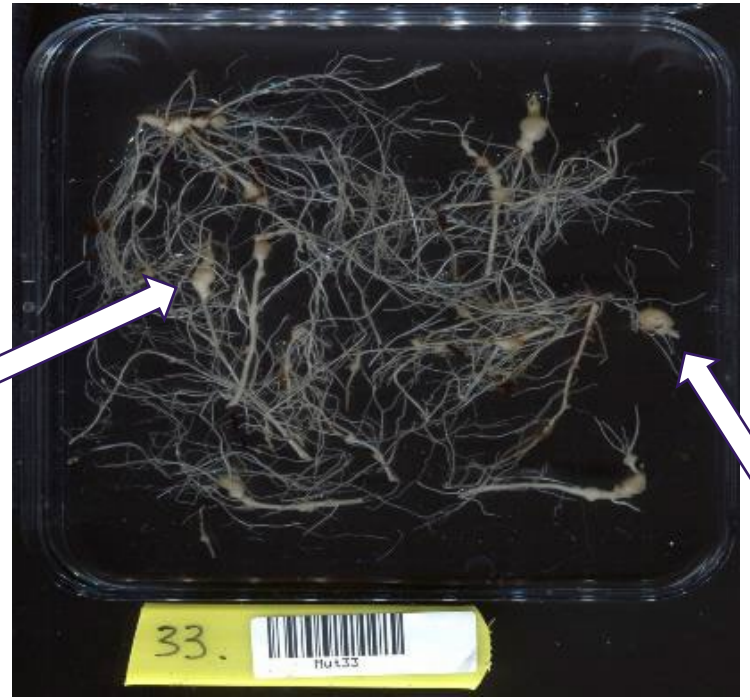
Digital phenotyping

NEMATODE RESISTANCE IN TOMATO

Resistance against *Meloidogyne incognita* breaking root knot nematodes was generated by using KeySeeQ® & KeyPoint®

sensitive

nematode galls



resistant

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TAKII

Impact: durable resistance against soil borne nematodes in tomato now available for breeding

ACCELERATED RESISTANCE BREEDING IN ORNAMENTALS

Development and use of advanced genomic tools and phenotyping protocols were instrumental for the fast and effective introgression of resistance against Downy Mildew in impatiens.

Ball

Impact: Ball Horticultural could rapidly confirm its position as market leader, introduction of Beacon

BANANA BREEDING & RESEARCH

State of the art genomics tools & wild banana types for banana plants resistant to Fusarium (Panama disease) & Mycosphaerella (Black Sigatoka), and increased diversity for sustainability

yelloway
the banana breeders

Chiquita

MusaRadix

WAGENINGEN
UNIVERSITY & RESEARCH

Impact: International breeding collaboration started in 2020, academics & business: Yelloway

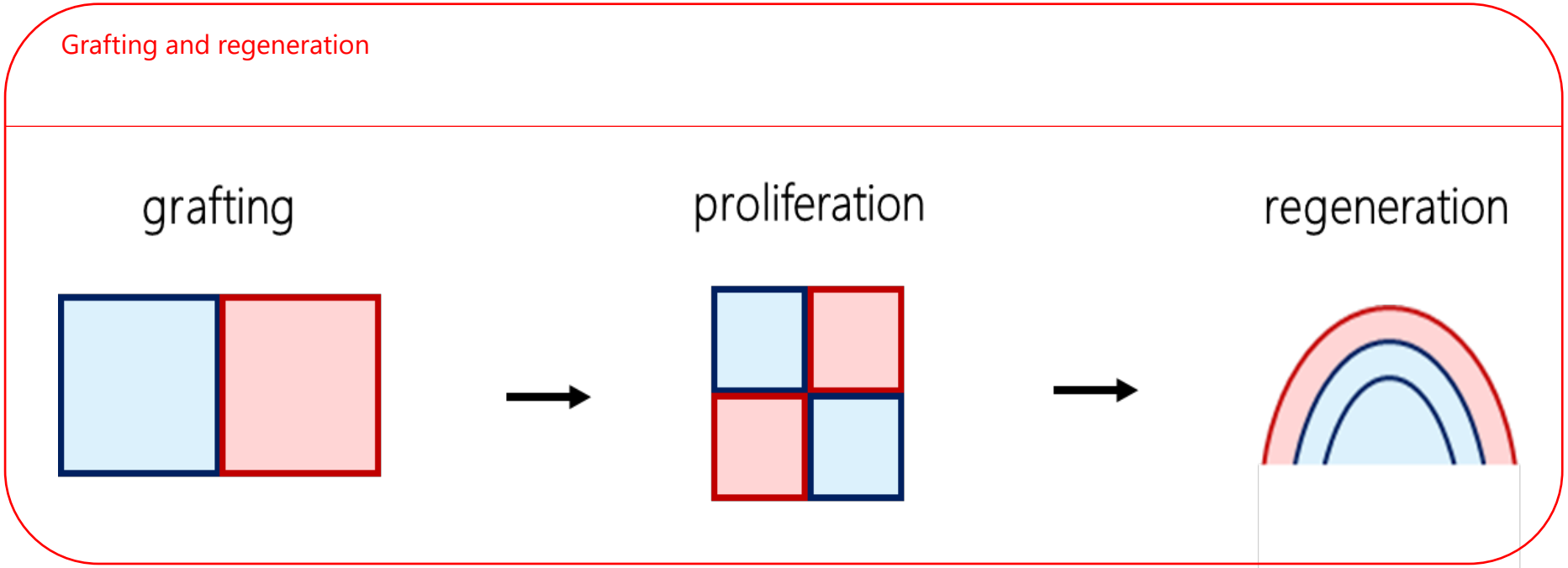
2S1® TISSUE TECHNOLOGIES

2S1® is a disruptive KeyGene technology enabling the development of graft hybrid varieties, by combining growth layers (L1, L2, L3) of different selected genotypes into one plant.

IMAGINE

- ✓ High quality seed production of all possible tomato F1 hybrids
- ✓ The production of a wide variety of plants with (new) complex traits in a relatively fast time span
- ✓ ..... in a non-GM fashion

THE ROAD TO GRAFT HYBRIDS



Grafting is a horticultural technique whereby tissues of plants are joined so as to continue their growth together

2S1: APPLICATIONS

SuMo
Surrogate mothers

► reproduction

seed quality &
seed production

► clonal crop breeding

graft hybrid cultivars
resistances, taste etc.

EpiX
Epidermis exchange

SUMO FOR HQ F1 SEED PRODUCTION

Requirements HQ F1 seed

- ≥98% purity
- ≥92% germination
- early emergence
- uniform emergence

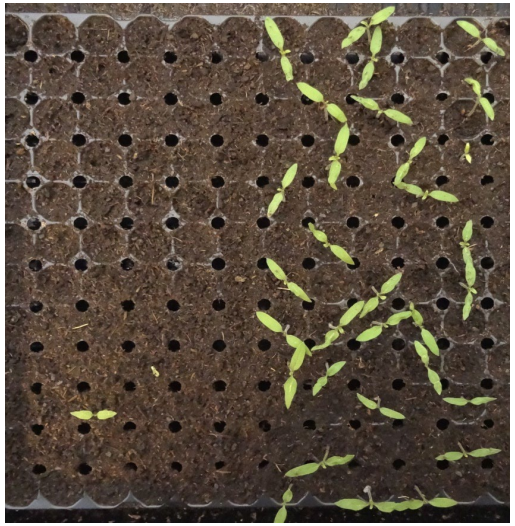
- Significant proportion of new F1 tomato hybrids do not enter the market because of inferior seed quality
- Seed quality can be improved by breeding -> long and costly process
- Need for a method that is:
  - Fast
  - Cost efficient
  - Universal

SUMO FOR HQ F1 SEED PRODUCTION

wild **graft hybrid** tomato

double seed yield

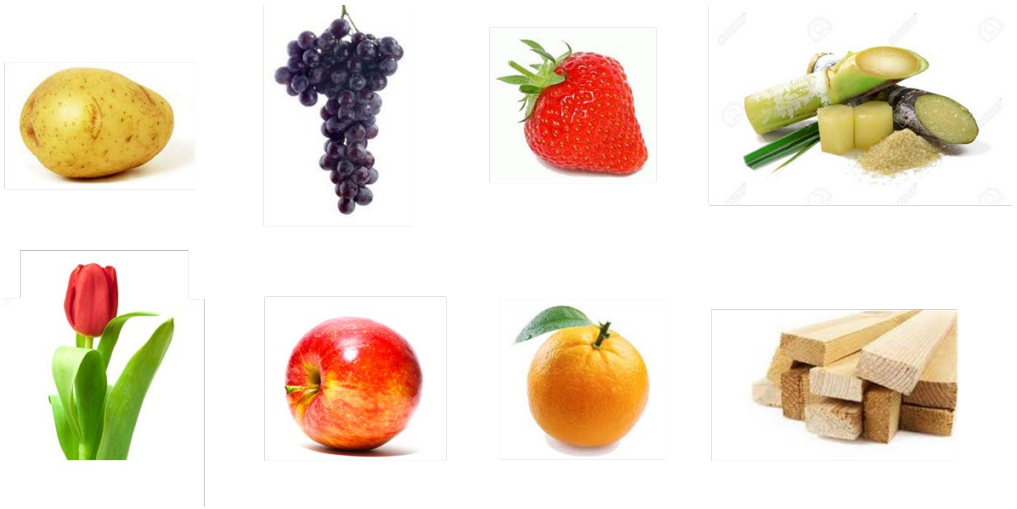
improved germination



Quality problem is overcome

EPIX FOR GENERATION OF NEW GRAFT HYBRID VARIETIES

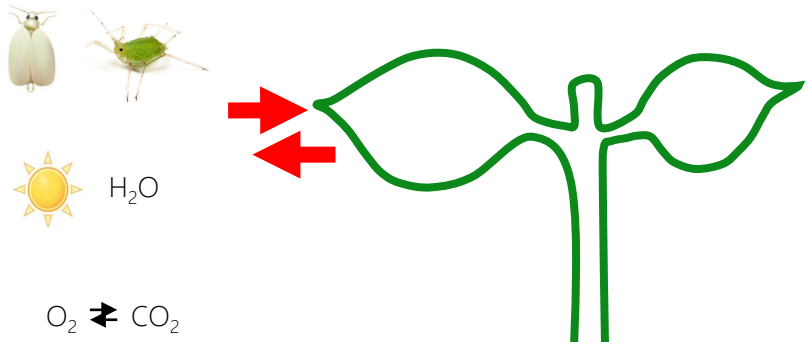
A **breeding** problem



- **EpiX** is a revolutionary & fast, variety development method for clonally propagated crops, exploiting existing natural variation
- **EpiX** enables creation of <u>new</u> varieties by combining the best of two clones into one variety; number of combinations is inexhaustible

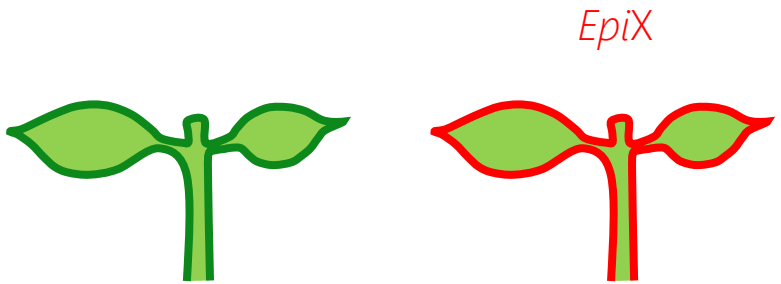
- Clonal crops of very high societal value
- Often recalcitrant to modern (molecular) breeding methods
- **Commercial utility hindered by lack of suitable cell- and tissue technologies**

EPIDERMIS: A PROTECTIVE SHEET



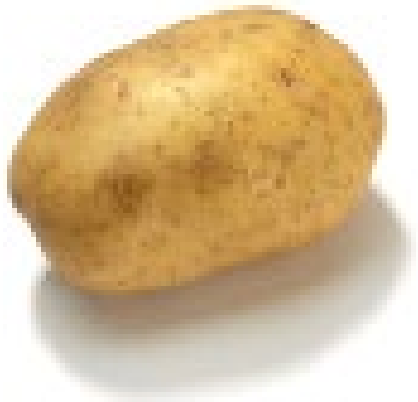
EpiX:

- Exchange of the epidermis (L1 layer), e.g. with the epidermis of a resistant genotype
- Generates end-products: graft hybrids are multiplied by vegetative propagation
- Integral transfer of <u>complex traits</u>
- Adds value by superior epidermal properties



POTATO

- 3rd most important world food crop
- Netherlands:
  - Largest exporter of seed tubers (60%) in the world
  - 100% clonal varieties
  - Major threat = late blight (*Phytophthora*)



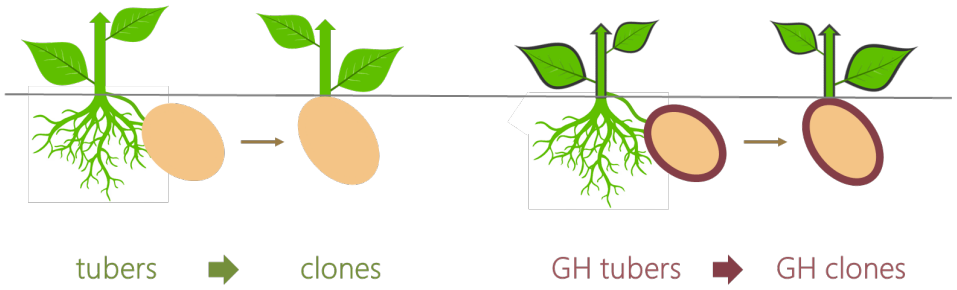
- **Breeding needed in the clonal cultivars**

EPIX IN POTATO TO OBTAIN BIOTIC STRESS TOLERANCE

Pimpernel **EpiX** Bintje

L1 of bintje is replaced by the L1 of a pimpernel

Status:
- Field trials ongoing
- First positive results obtained -> good stability
- Can be grown and multiplied as regular potato
- New options for use of genetic resources



EPIX IN PEPPER FOR INTEGRAL TRANSFER OF PUNGENCY

cultivar graft hybrid donor

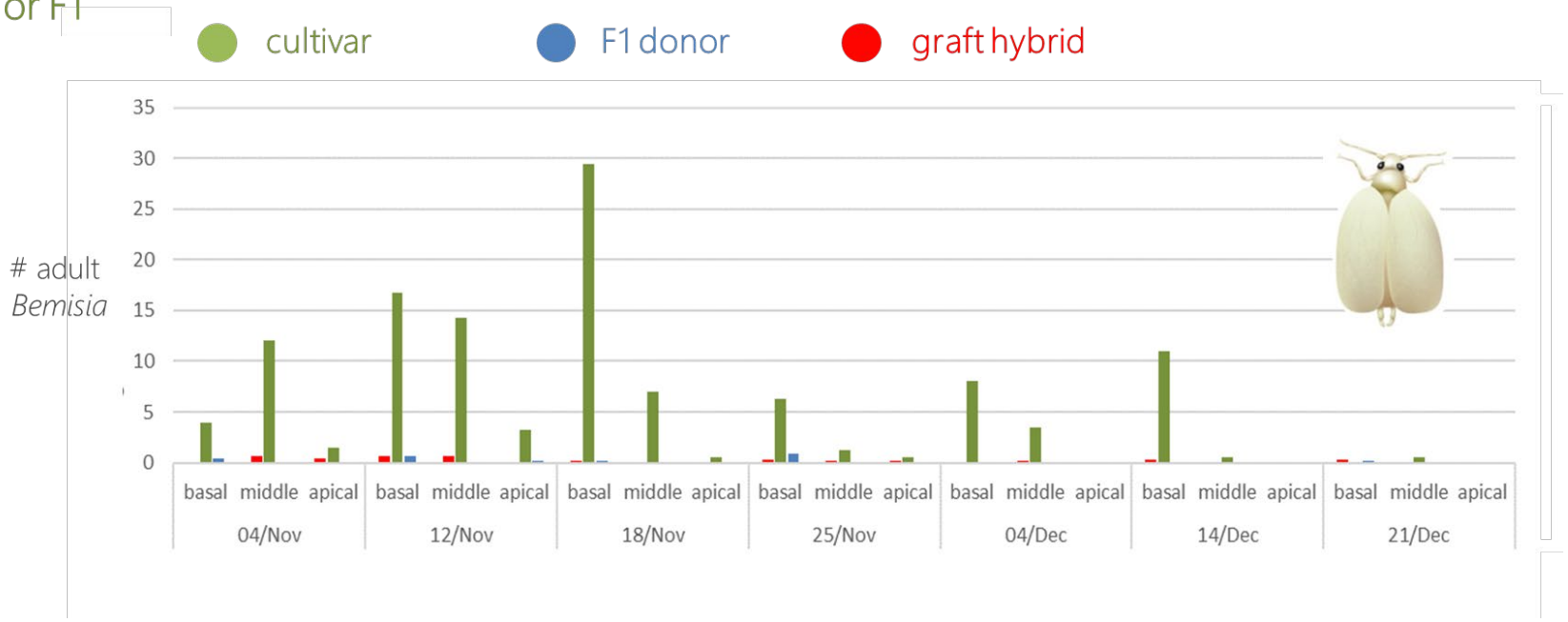
hot sweet sweet

wild graft hybrid cultivar

hot sweet-hot sweet

EPIX IN TOMATO FOR PEST RESISTANCE

cultivar graft hybrid donor F1



CONCLUSIONS 2S1 TECHNOLOGIES

SuMo

- Directly applicable for F1 seed production
- High yield / high quality seed production
- Lower seed price - higher margin

EpiX

- Highly accelerates the development of new varieties
- The production of commercially relevant crop plants harboring new trait combinations
- Without making use of genetic modification techniques

CROP IMPROVEMENT OF THE FUTURE WILL BE DOMINATED BY THE INTEGRATION OF NEW GENERATION TECHNOLOGIES AND DATA-DRIVEN DECISION-MAKING IN PLANT BREEDING

Overall

- Breakthrough innovations have been, are, and will be KEY in tackling constantly emerging challenges to food security
- Partnerships: KeyNovation ecosystem
- Integration: innovative solutions map over the entire crop and trait improvement pipeline

Farm to Fork aims to transition towards **a fair, healthy and environmentally-friendly food system** in Europe.

THANK YOU!

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