Boosting Innovations for better Crops

Arjen van Tunen Crop Innovation & Business – April 4, 2017





Our World

Rocked by change: Wow! What is happening?

Major developments:

- China, India as emerging economies are growing, political turnarounds in USA & Turkey, Brexit, EU under pressure
- Growing and aging world population
- Growing economies
- Need for more, healthy and better food
- **Need** for sustainable agricultural production
- **Need** to adapt to climate change

Significant Crop Improvements are part of the solution









Our Agro Food world Rocked by change: Wow! What is happening?

Global Agro Food developments:

- Large consolidations (resulting in the Big Five: "MonBayer", "SynChina", "DowPio", KWS and Limagrain)
- Countries on the move (e.g. China & India) -
- Agro Food Patents: on Genes, Traits & Plants, relation to Breeders right's
- Regulations on Novel Breeding Technologies and Biodiversity / Germplasm availability
- Technologies: HT DNA sequencing, Big Data, HT Trait Discovery + crossovers with other fields (e.g. ICT, Nanotechnology, BioMedical field, Robotics, Defense Industry, Creative Industry)

KeyGene addresses these challenges by collaborating with industry leaders in partnerships to generate breakthrough innovations.

> KeyGene develops: new Crops & Traits & Technologies for the Future

Our Crops for the Future Genomics enables innovations in all crops

- Accelerate improvement of current cash crops (e.g. corn, soybean, tomato, lettuce, onion)
- **Start** improvement of Industrial crops (e.g. oil palm, banana)
- **Increase** improvement of orphan crops (e.g. cassava, millet, plantain)
- **Develop** novel protein crops (e.g. pulses, quinoa)
- **Domesticate** crops (e.g. dandelion for rubber, stevia for sweetener)

My view: because of cost reductions in genomics we can now molecularly improve crops that we could not touch earlier

Our Traits for the Future Interesting "old" and new traits

- Yield & Yield Stability (feed the world)
- Abiotic Stress Tolerance (adapt our crops to climate change)
- Biotic Stress Resistances (sustainability, reduce the use of agro chemicals)
- Quality, Taste (more middle class consumers)
- Long shelf life (stop reducing waste!)
- Health (longer, better life for all of us)

My view: besides some new traits, most "old" traits are still of high interest





Our Technologies for the Future for Exponential Ag Biotech Innovations

- **Farming:** variety development via crossing and selection supported by DNA technologies & Genomics. Agronomy: with fertilizers and sometimes chemicals. My view: good quality products for acceptable price
- **Industrial Farming:** development via GM: corn, soybean, canola, cotton, sugarbeet. Multinationals. Agronomy: large monocultures. *My view: large scale, innovative, cost effective for farmer,* risk perception often high
- **New Farming:** city farming, vertical farming, NEW. Agronomy: production in multiple layers in factories in the city or at home. Leafy vegetables first. My view: because of food safety, sustainability, local production, too technical?









KeyGene From Technology & Trait Provider to Crop Innovation Company



KeyGene is the go-to AgBiotech company for higher crop yield & quality. With our intellectual capital, solution driven approach and collaborative spirit, we work for the future of global agriculture with partners in the AgriFood sector.



KeyGene **Our partnering strategy**

For the improvement of vegetable crops KeyGene has strong & strategic partners:

- Leading seed companies
- Family owned / cooperative
- Growing strongly
- Innovation is key



For the improvement of other crops KeyGene has strong & strategic partners:

- in ornamentals
- in field crops (e.g. rice, (tropical) corn, cotton)
- in new crops (e.g. stevia, dandelion)
- in polyploid crops (e.g. wheat, potato)
- in orphan crops (e.g. banana, eucalyptus, cassava)







/ilmorin&Cie Limagrain Vegetables Seeds

KeyGene **Our R&D and Innovation strategy**



The crop innovation company



Partners breeding industry

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KeyGene **Our Innovative Technology platforms**

CropPedia

The best platform for gene / trait big data analysis

Lead Discovery & Validation

rated Breeding

Mole

KeySeeQ[®] Lead gene discovery for trait & crop improvement

Gene Editing & KeyBase®

Better traits in your germplasm

Molecular Mutrager KeyPoint[®] Mutation Breeding

Better Traits in your germplasm

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Sequence Based Genotyping

in all your crops

KeyGene®SNPSelect for all your traits

Breeding Strategies Fast stacking of traits in your germplasm

Digital Phenotyping

Measuring better traits in your germplasm

Virtual Reality Breeding

Interactive platform to analyze and visualize trait and crop performance

KeyGene Our Innovative Trait platforms

Drought resistance

Abiotic Stresses

Biokic Skresses

Crop Reproduction

Fungi Bacteria Virusses Sucking Insects

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Clonal seeds without fertilization (Apomixis) Sterility Double Haploid induction



DNA: source of genetic information **DNA: 63 yr**





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DNA has 4 building blocks (GATC) Not digital but guatro-code In all plant cells

KeyGene



DNA variation in our crops DNA from each crop plants differs = genetic variation!

Tomato DNA consists of 1.000.000.000 code letters (human: 3 x more) In DNA of 2 different commercial tomato plants: With a third plant: In 100 different commercial tomato varieties: Between commercial and wild tomato species:

Which DNA differences are important? How can we increase the amount of useful differences? Which differences can we use to develop better crops in a non GM way?

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~ 500.000 differences ~ 800.000 differences ~ 10 million differences ~ 100 million differences



KeyGene & Genetic Variation Use of genetic variation for crop improvement







- Too expensive: 20 100 million €
- Technical issues
- 20 yrs experience: safe
- Societal aspects • (EU / Japan)













KeyGene **Start of modern Breeding: Genome Sequences**



GREEN: by KeyGene

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perfect Reference Genome Sequences

1000s of genomes resequenced

owers	Fun
	Oilpalm
	Tobacco
Orchid	Grape
Petunia	Barley
Inflower	Сасао

Info in proprietary interactive databases: CropPedia



DNA markers & Traits

Variation in genes relates to commercial traits





Value for breeding partner: fast development of orange pepper varieties





Molecular Mutagenesis Approaches and examples



KeyGene **Molecular Mutagenesis**

- Selection of Lead Genes by KeySeeQ[®] using CropPedia Ι.
- **Gene Editing of selected genes** ΙΙ.
- a. via CRISPR/Cas9/TALENs, etc.
 - fast and robust technology
 - issues: FTO and regulation in EU & others

b. via KeyPoint[®] Mutation Breeding: KeyGene's highly successful mutagenesis system using chemicals & Next Generation Sequencing

- large track record
- high throughput & broad mutation spectrum
- allelic series provide new opportunities
- strong proprietary position KeyGene
- mutants obtained: non GM + patentable
- direct input for breeding programs









KeyPoint®Mutation Breeding

Gene targeted random mutagenesis





KeyPoint[®]Mutation Breeding Tomato















Immortal Bulked-M2 Mutant Rice Population

- Rice Japonica type cultivar 'Volano' (risotto)
- Mutagenized plants in field, Italy
 - Sampling ~8000 plants
 - KeyGene & University Milano
- Seed harvesting per plant
- DNA isolated per plant







KeyPoint[®]Mutation Breeding Track record



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Gene



Crop & Trait Improvement Teasers: everything comes together: partners, bio-informatics, (bio) technologies, traits, patents, commercial value



Trait 1: Insect Resistance by Molecular Breeding





Trait 2: Nematode Resistance via KeyPoint[®]Mutation Breeding **Molecular Mutagenesis**

Genomics based molecular mutagenesis will yield durable nematode resistance in tomato



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and will deliver sustained value for the breeder

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Trait 3: Development of Hybrid Rye; PollenPlus



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KerGene

Hybrid rye development was impacted by linkage drag between ergot resistance and seed set. Molecular breeding solved the issue

Resulting in toxin free rye with high flour and feed quality. And an important commercial success for KWS

Trait 4: potential yield improvement in rice

Trials Italy, Po Delta 2016



Rice is a main staple food all around the world including Europe where we have "Risotto" rice production in the Po delta.

Gene

Improved

KeyPoint[®]Mutation Breeding resulted in rice with a single base pair mutation in a gene that has high potential for yield improvement and has erect panicles

Trait 5: Breakthrough Double Haploid induction in rice



KeyPoint[®] Mutation Breeding of candidate genes enables the generation of pre breeding material to induce Double Haploids in commercial rice germplasm. Patent applications published 02/04/2017

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Double Haploids enable a substantial speed increase of breeding programs

Trait 6: Breakthrough in sustainably produced Natural Rubber

Natural rubber remains essential in today's economy. The production is however exposed to threats, including price/supply volatility, diseases and environmental concern.

> Presentation Anker Sørensen Biobased crops section (13.30 hrs)

Early 2016, the application of state of the art molecular technologies has lead to the world first interspecies hybrid dandelion variety. This novel agricultural crop enables annual rubber production in temperate climates.





An example

of an innovation for better crops for the future

We know much about the DNA of our crops 1. 2. Phenotyping has become a bottleneck now

Therefore: investments in

- Digital & Robotized Phenotyping -
- Big data handling & analysis -
- Visualization of analysis: Virtual Reality Breeding



Digital Phenotyping - PhenoFab[®] Robust, automated digital phenotyping

The traditional way of reporting:

- Paper text
- Photo's
- Graphics



An experiment with 900 plants and 9 photo's per plant per day, will generate **396.900** digital images in seven weeks! BIG Data! Strong need to interactively visualize such data: VR Greenhouse







Virtual Reality Breeding

A new proprietary way towards collaborative and VR Breeding

With respect to visualization of big data and reporting, KeyGene researchers have developed the Virtual Reality Breeding tool. It was successfully introduced and demonstrated in January 2017 at the Plant and Animal Genome conference in San Diego. At the Crop Innovation & Business Conference in Amsterdam, held April 2 – 4, 2017 the Virtual Reality Breeding tool was explained by KeyGene's CEO Arjen van Tunen. Conference attendees were able to step into the virtual breeding world by a demo in KeyGene's booth.

For a preview of the virtual reality breeding tool:

https://www.youtube.com/watch?v=ou5 Q1mMLZs&feature=youtu.be



With all of this we, together, will improve our crops for the Future!













THANK YOU