



Is phenotyping useful for breeding ?

Marco van Schriek

01-07-13



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How to execute phenotyping

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Passion

KeyGene's passion is a *Green Gene Revolution* approach to explore and exploit existing and induced genetic variation in vegetable and other 6F crops



Food



Feed



Fiber



Fuel

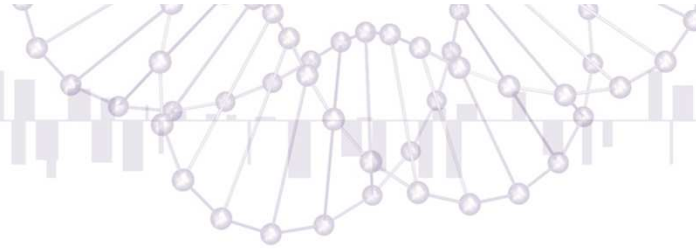


Flowers



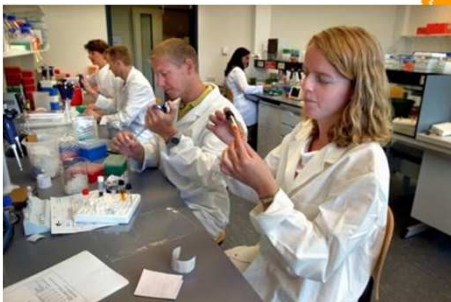
Fun





KeyGene

Leading Research Company in molecular plant breeding



20 years experience, 135 scientists

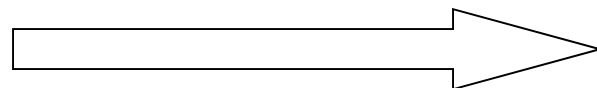
Long-term partnerships

With leading industry players

Exclusively vegetables



Clients



Partnerships

R&D Strategy

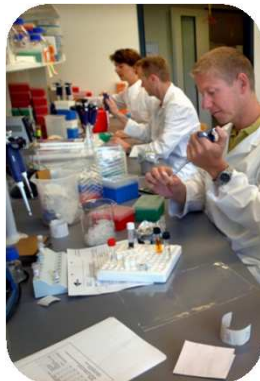
Licensing in

Collaborations

Universities

KeyGene

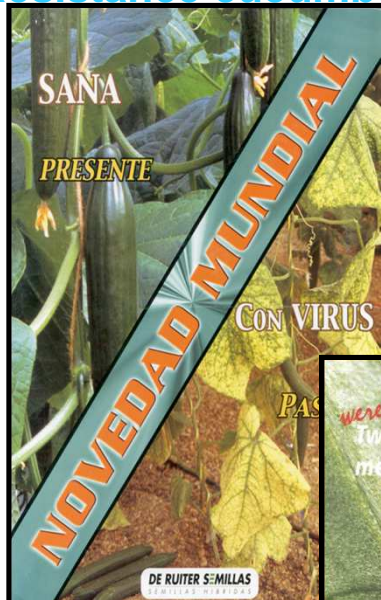
Partners Breeding industry



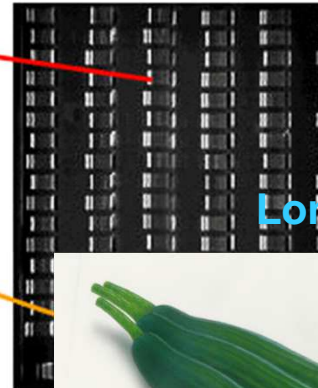
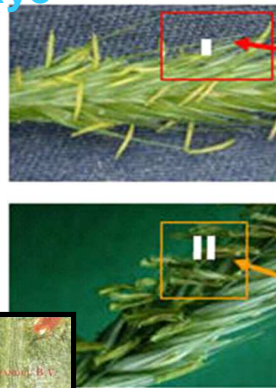
Commercial products with KeyGene technology inside

CYSD Virus

Resistance cucumber



Super fertile Rye



Long shelf life Cucumber

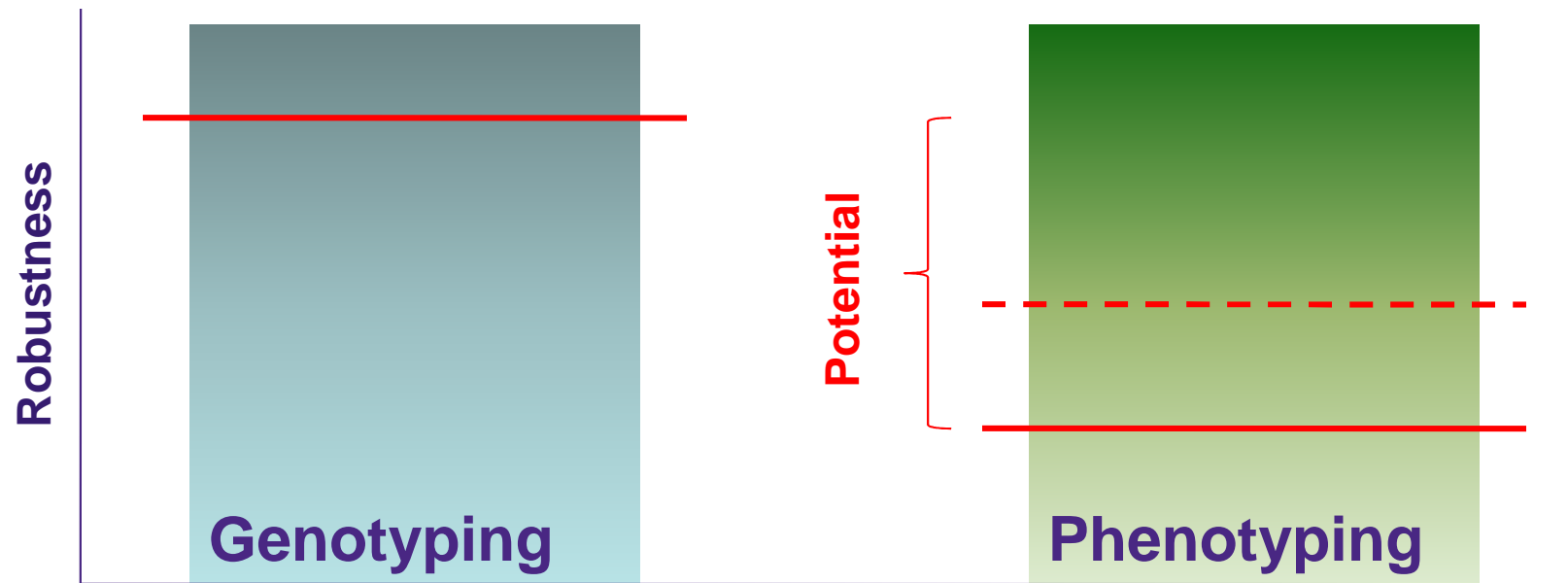


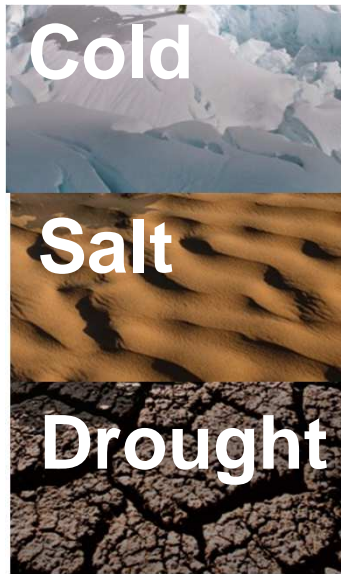
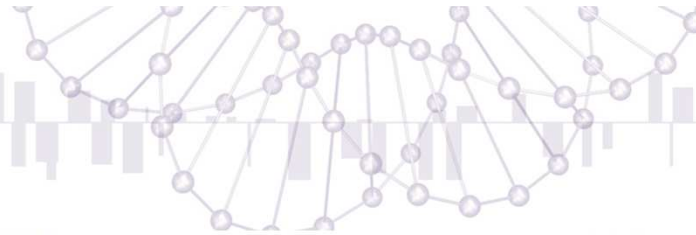
Brown Aphid Resistant Lettuce



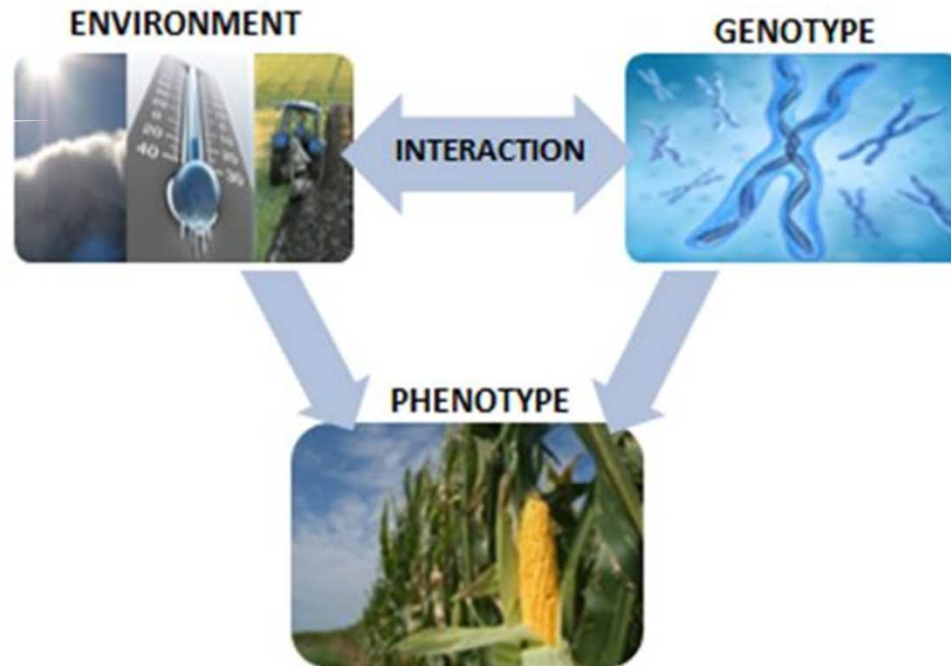
Stacking Resistances

Genotyping – Phenotyping potential





Abiotic agents



Biotic agents



Subjective/biased scoring

The importance of phenotyping

- For plant breeders the phenotype is the final goal...
- Detection of QTLs requires:
 - high quality molecular markers
 - high quality phenotypes!
- But ..Phenotyping is not (always) straightforward
 - Genetic and environmental factors are intertwined
 - Subjective / biased observations
 - Phenotype may depend on complex interactions of plant and (a)biotic agent (resistance, tolerance)



Is phenotyping useful for breeding ?

How to execute phenotyping

Disease phenotyping

Quantitative scoring of mildew resistance in *Arabidopsis*



1



2



3



4

Disease phenotyping

Quantitative scoring of mildew resistance in Arabidopsis



1

2

3

4

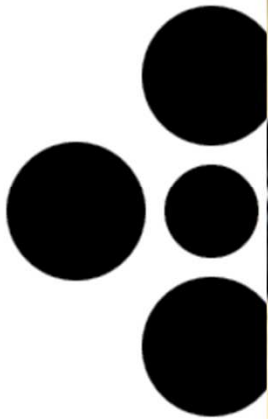
- Resolution
- Subjective

Objective vs subjective

	Quantitative	Qualitative
Objective	"The chip speed of my computer is 2 GHz"	"Yes, I own a computer"
Subjective	"On a scale of 1-10, my computer scores 7 in terms of its ease of use"	"I think computers are too expensive"

High quality phenotypes

Left centre circle smaller than right one? Two chicks of food in this picture?



How to go from this



1



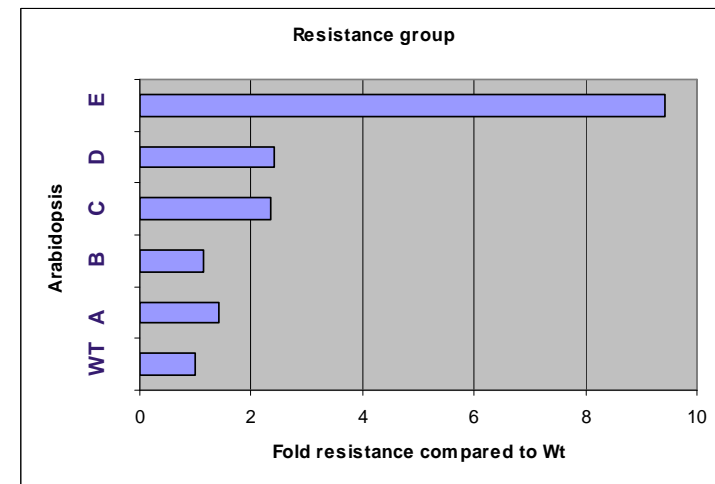
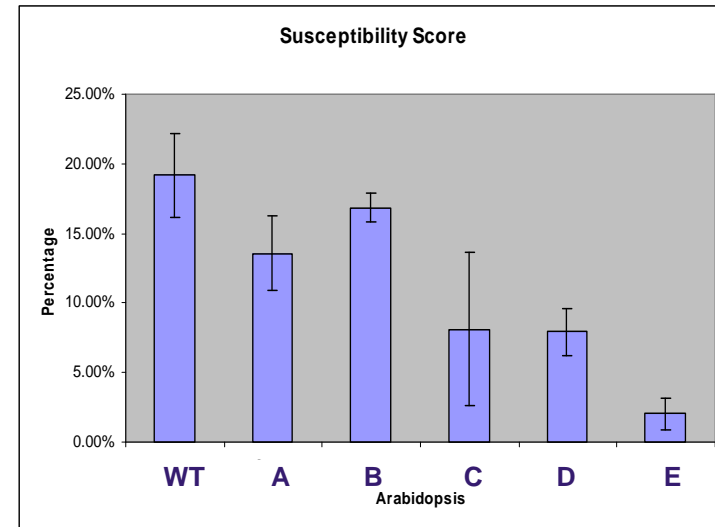
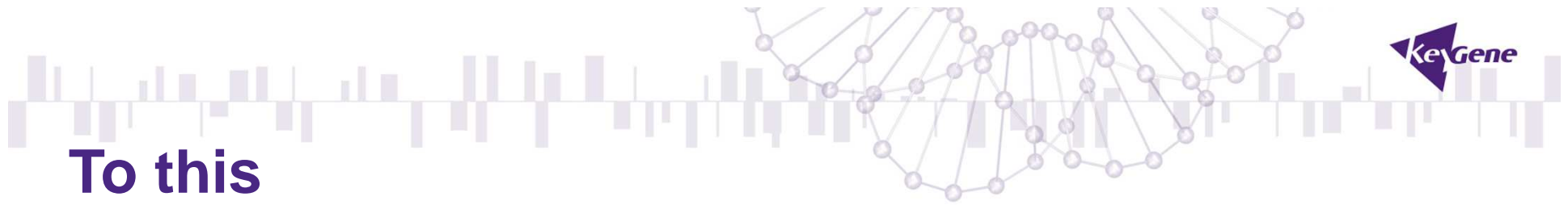
2



3

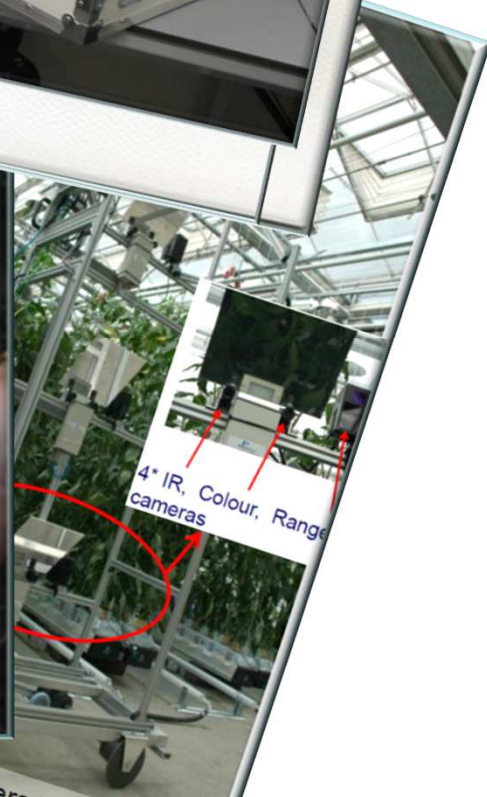
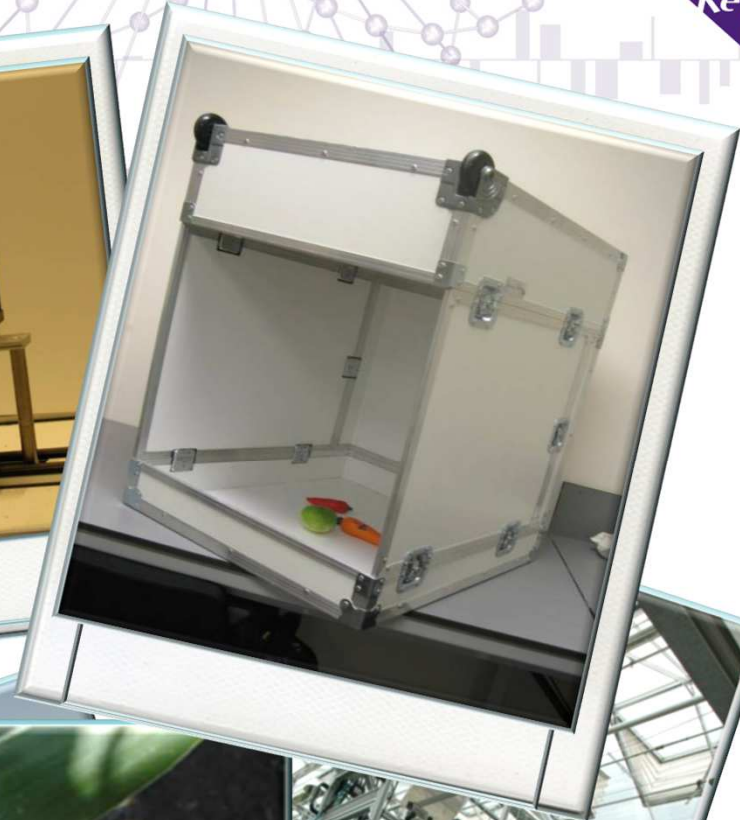


4



Plant to camera

Camera to plant



SEE: bring camera

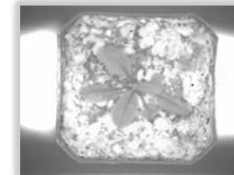
What is the PhenoFab™ system



What is the system



PhenoFab® – the facility



Fluorescence

- Chlorophyll analysis
- Stress

RGB (Visible light)

- Shape
- Color

NIR

- internal structure
- Water content

From PhenoFab™ system to a digital phenotyping project

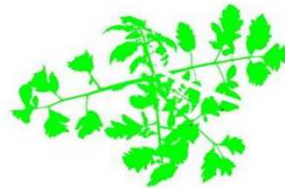
**Idea
to workplan**

**PhenoFab
run**

**From image
to digital
phenotyping**

**Statistic
correlation
study**

Conclusions



The PhenoFab™ system

Tomato phenotyping



104 tomato plants were analysed using the PhenoFab



Total plant area was calculated digitally

- FW of the plants were measured (destructive method)

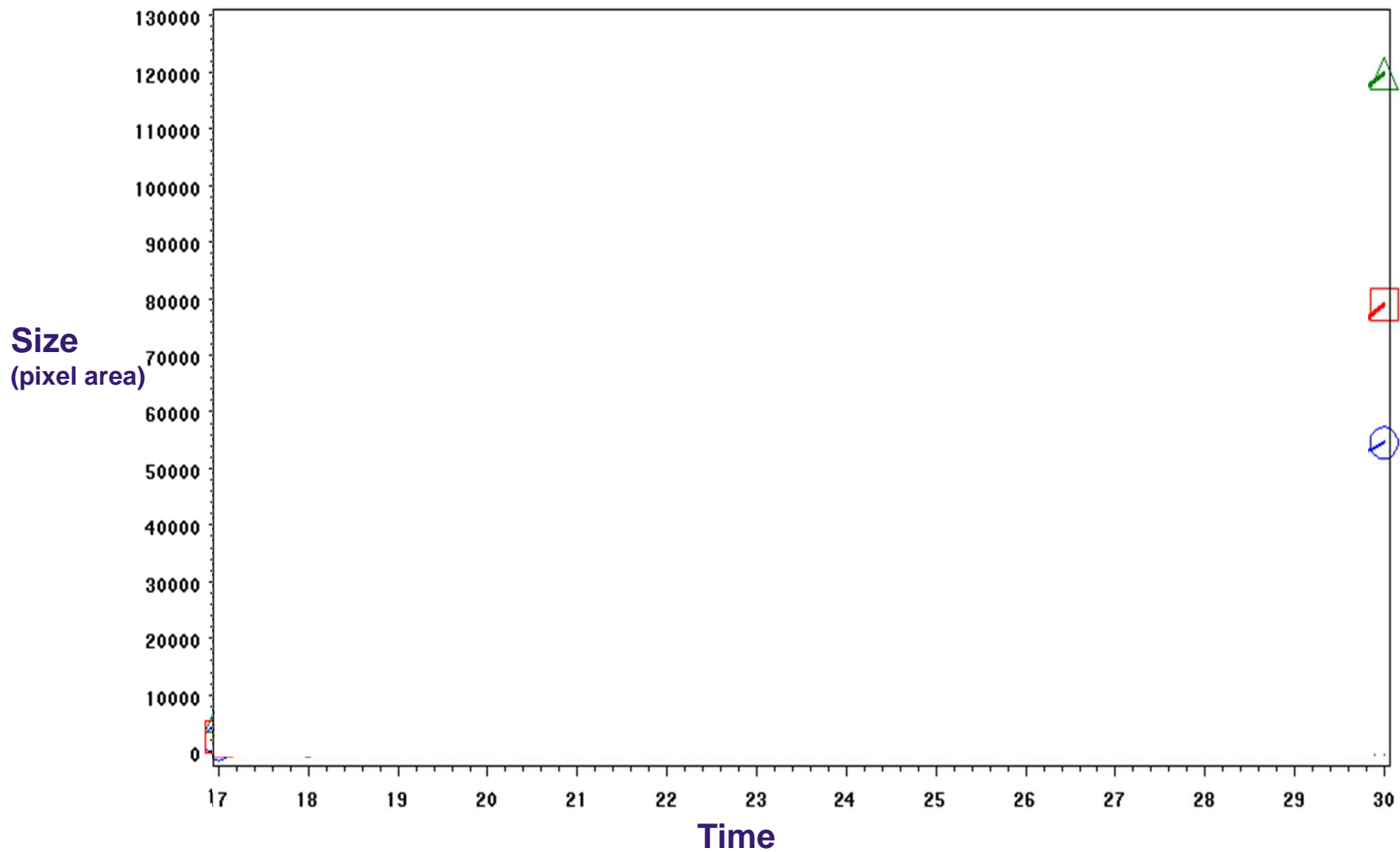


Correlation (>90%) established between total plant area and the FW of the plant



The PhenoFab™ system

Phenotyping over time.....



The PhenoFab™ system

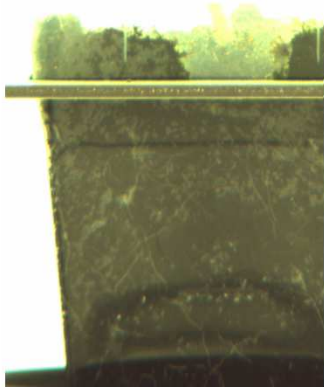
Exposing the roots.....



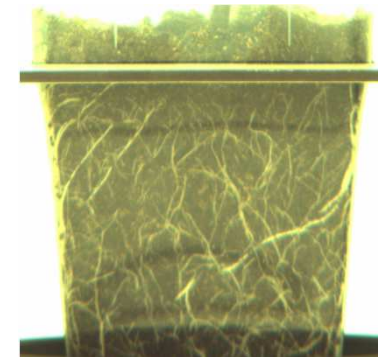
Root imaging using PhenoFab™

- Zamir Tomato ILL
- Parents : M82 and *S. pennellii* (10 replicates)
- 35 ILL lines in 5 replicates
- 4 side imaging for 18 day's

Root imaging using PhenoFab Imaging



S. penn



IL 3

Root imaging using PhenoFab

From image to digital phenotype



**Digital based
phenotype**



Root imaging using PhenoFab™



**PhenoFab root
measurement**

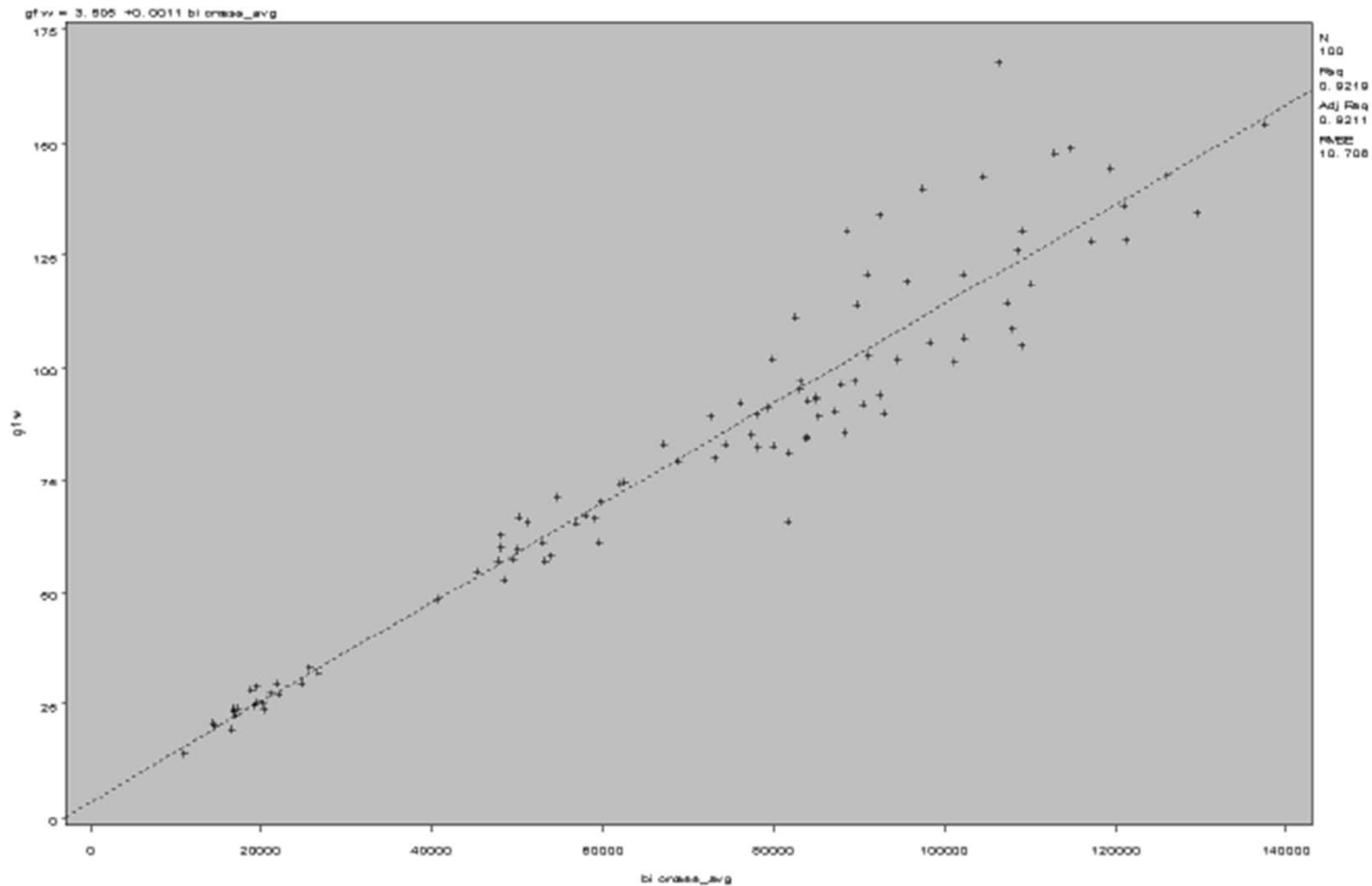


**Direct root mass
measurement**

Root imaging using PhenoFab™



Root (FW)



pixels



Role of digital phenotypes in predicting later yield related traits in crops

Role of digital phenotypes in predicting later yield related traits in crops



Early crop trait



Late crop trait

Role of digital phenotypes in predicting later yield related traits in crops

Experimental Set-up

PhenoFab

30 genotypes
5 replicates
5 weeks



Early crop trait

Breeders/commercial greenhouse

30 genotypes
Two greenhouse locations



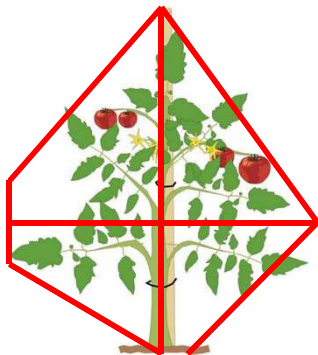
Late crop trait

Role of digital phenotypes in predicting later yield related traits in crops

Early crop trait

Digital phenotype data

- Breeding values
- Daily averages
- Growth parameters



Late crop trait

Later “yield-related” traits

- Fruit quantity
- Fruit yield (kg)



Role of digital phenotypes in predicting later yield related traits in crops

- Yield related trait: **Tomato fruit weight**



**0.4 R-square
(-0.63 correlation)**

- Single digital phenotype describing plant architecture

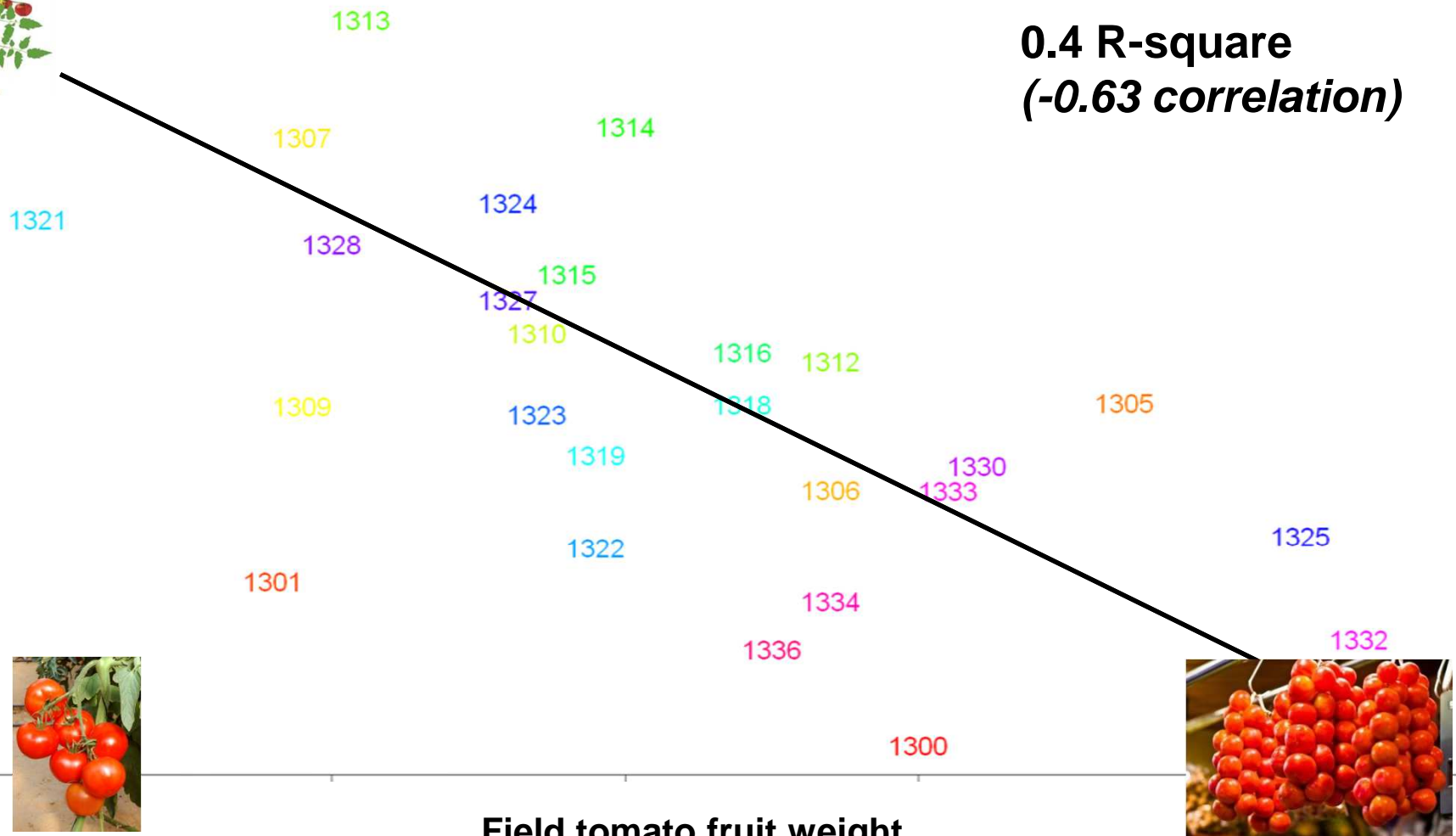
Role of digital phenotypes in predicting later yield related traits in crops

Single digital phenotype



Digital phenotype

0.4 R-square
(-0.63 correlation)



Role of digital phenotypes in predicting later yield related traits in crops

- Yield related trait: **Tomato fruit weight**



0.57 adj. R square
(0.75 multiple correlation)

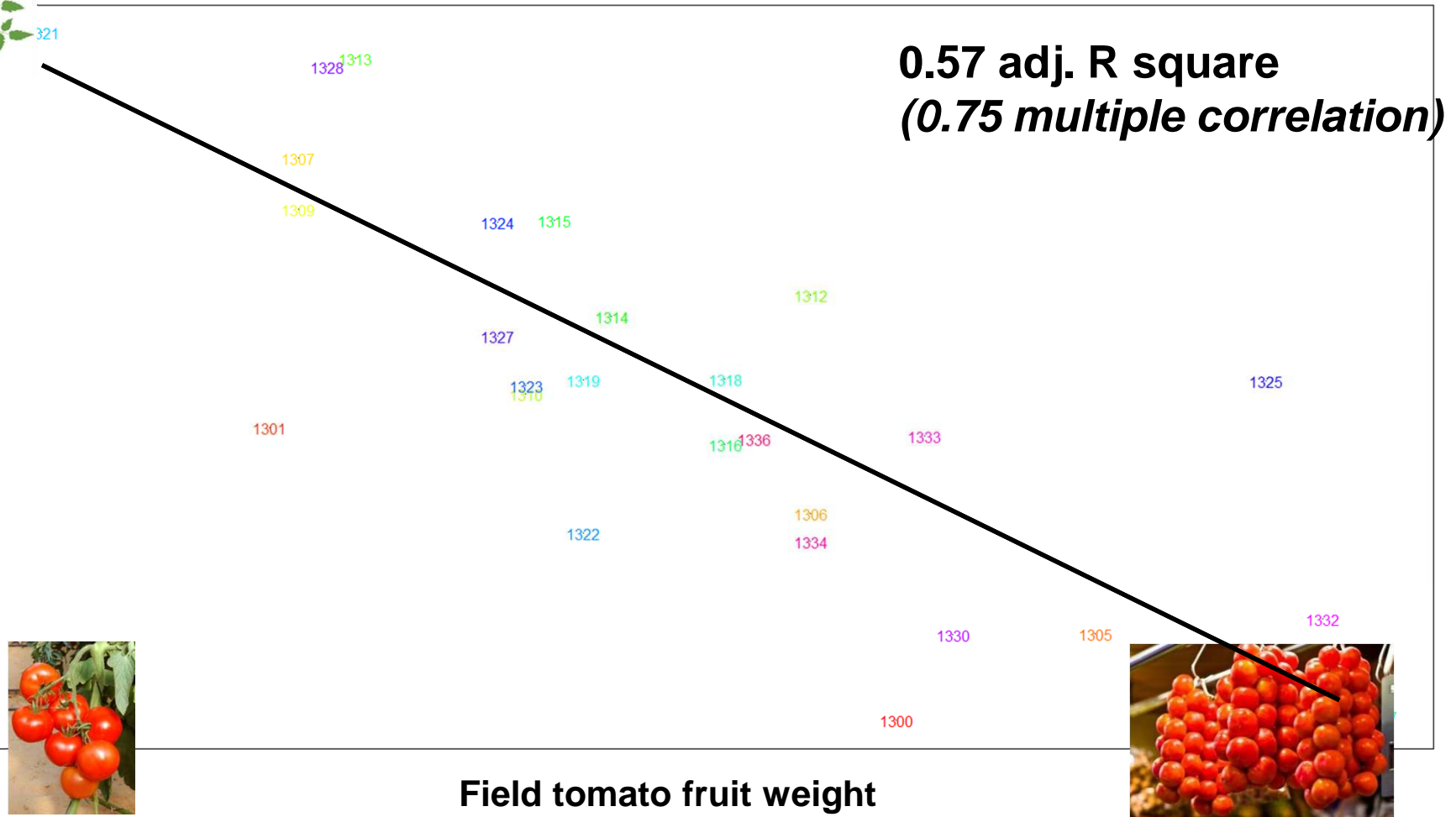
- Model using two digital phenotypes (describing plant architecture)

Role of digital phenotypes in predicting later yield related traits in crops

Two digital phenotype model



Digital phenotype model



The KeyBox system

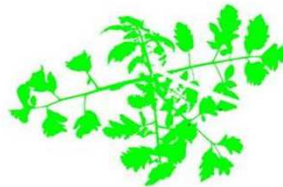
**Idea
to workplan**

**KeyBox
data**

**From image
to digital
phenotyping**

**Statistic
correlation
study**

Conclusions



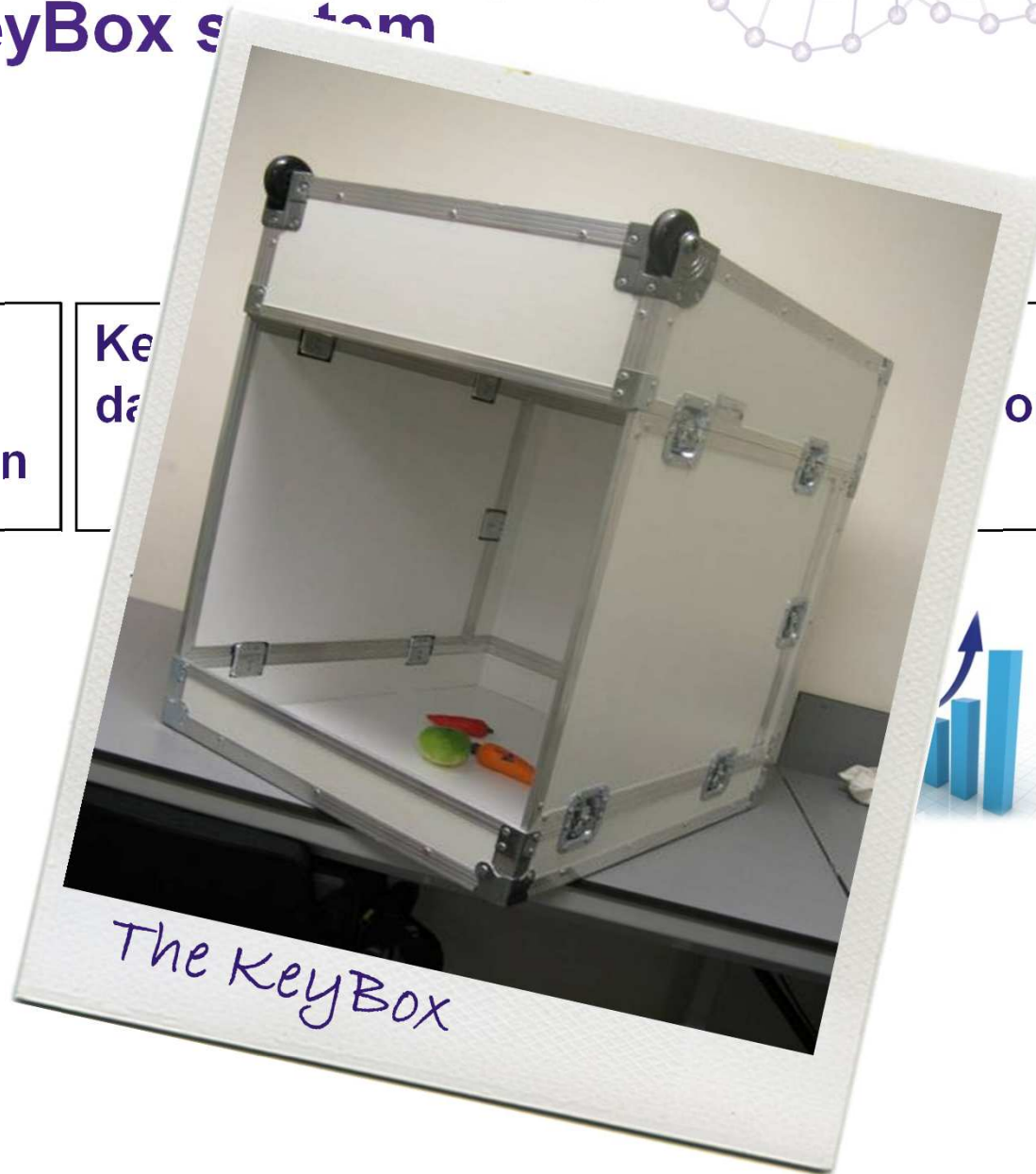
The KeyBox system

Idea
to workplan

Key
data

on

Conclusions



The KeyBox



The KeyBox system

Idea
to workplan

istic
relation

Conclusions



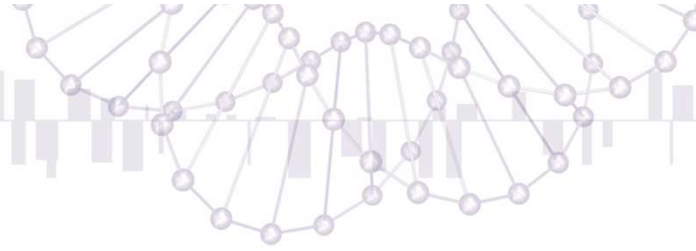
KeyBox software



The top of the slide features a decorative header. On the left, there is a horizontal bar chart with numerous vertical bars of varying heights, some above and some below a central axis. To the right of this bar chart is a complex network diagram consisting of numerous small circular nodes connected by thin lines, forming a web-like structure. The text "The KeyBox system" is positioned below the bar chart and to the left of the network diagram.

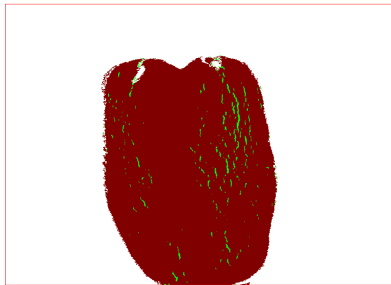
The KeyBox system

Possibilities



The KeyBox system

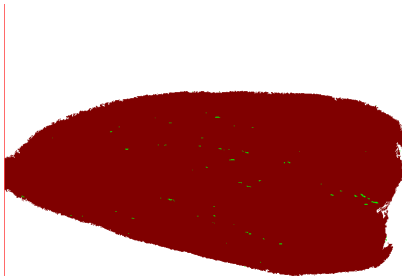
Fruit quality traits



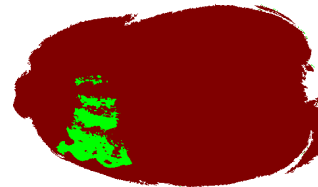
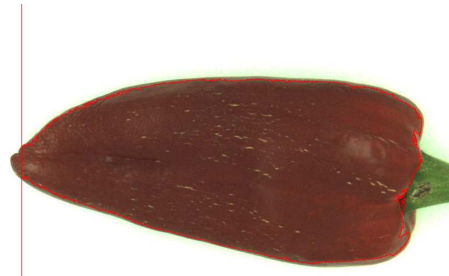
red area in pixels: 155275
Cracked area in pixels: 3188



red area in pixels: 157381
Cracked area in pixels: 118



red area in pixels: 191589
Cracked area in pixels: 345

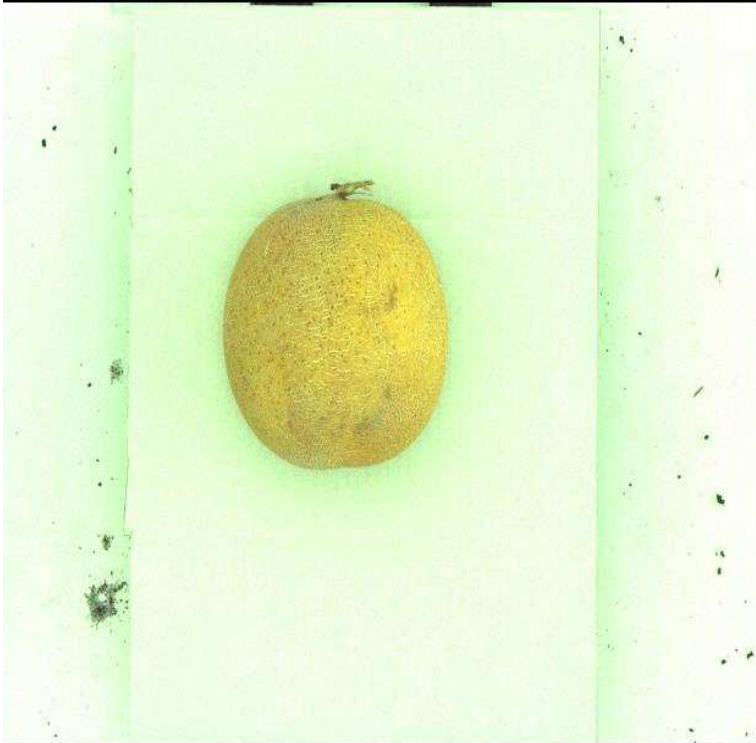


red area in pixels: 113847
Cracked area in pixels: 6670

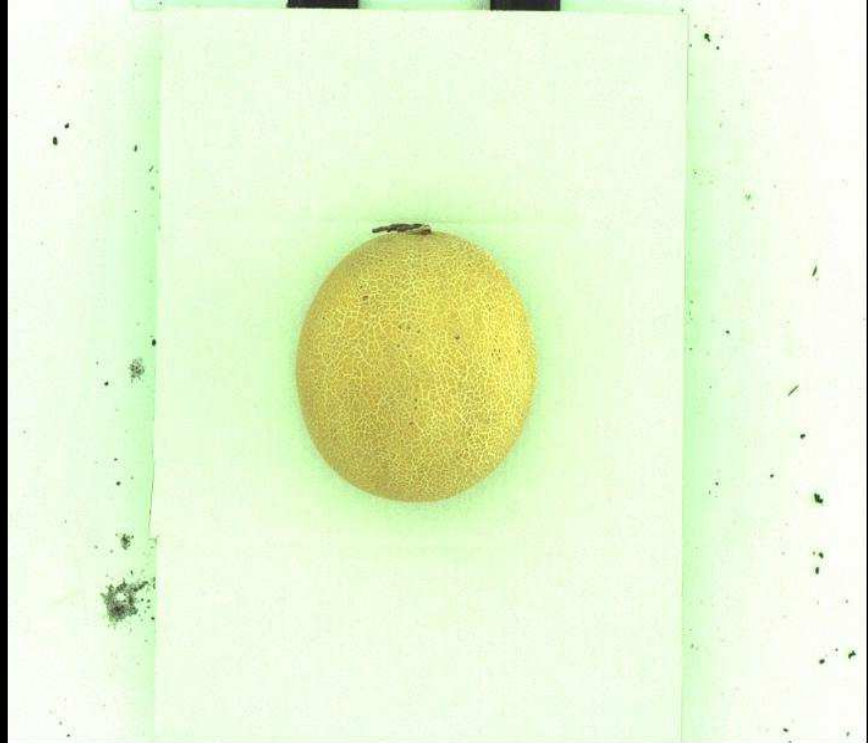


The KeyBox system

Fruit quality traits



Crack: 6892 pixels; 37%
Dark spots: 2430
Roundness Deviation: 296



Crack: 84561 pixels; 51%
Dark spots 1461
Roundness deviation: 25

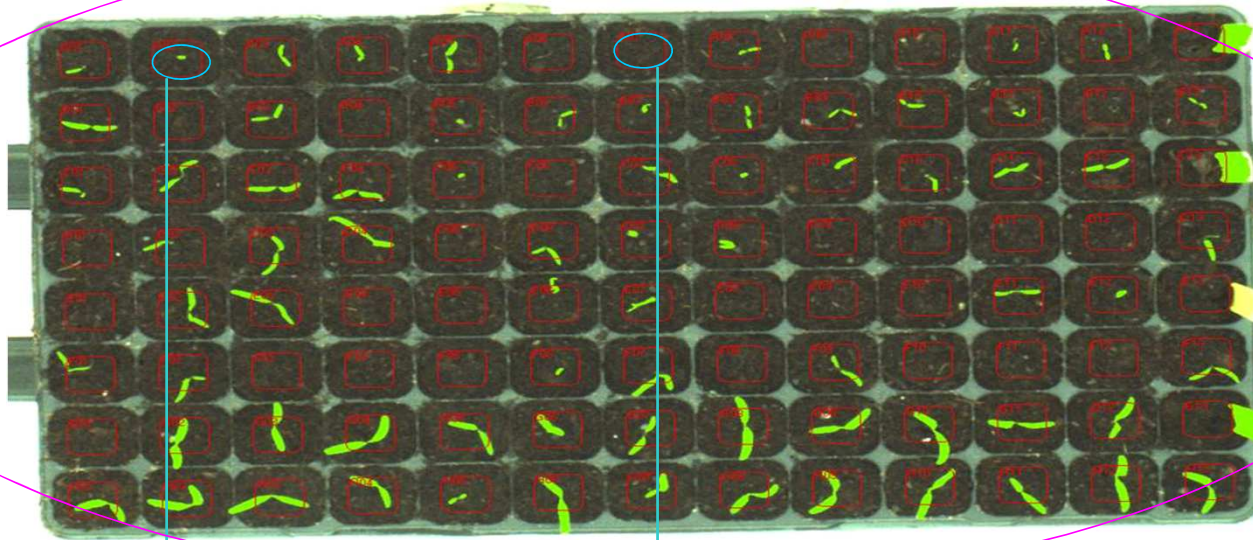
The KeyBox system

Leaf shape, area, color



The KeyBox system

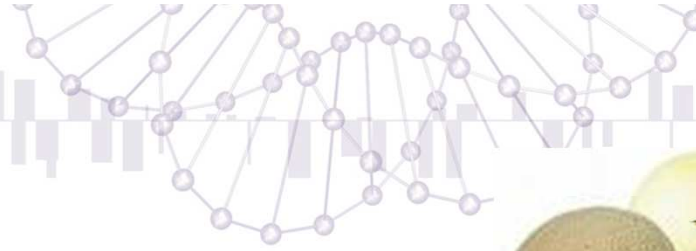
Germination



Correctly recognized plant

Correctly recognized: no germination

Correctly recognized and
Processed plate of 104 samples

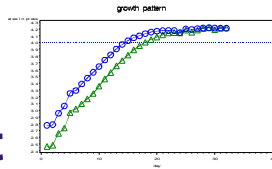


Crop Phenome Center

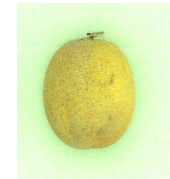
Summary



**Biomass
development**



Fruit shape / color



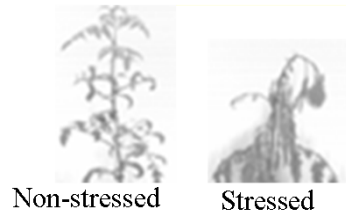
**Root
development**



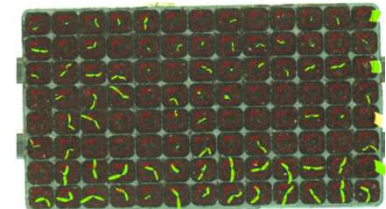
**Canopy
structure**



**Abiotic
stress**



Germination



And more...

Acknowledgement



- Gert-Jan Speckmann
- Jose Guerra
- Koen Huvenaars
- Shital Dixit
- Marco van Schriek



- Dirk Vandenhirtz
- Joerg Vandenhirtz
- Kevin Nagel
- Ralph Schunk





THANK YOU

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mvs@keygene.com

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