Scientific training Center of Plant Biotechnology

- Modern Plant Breeding -

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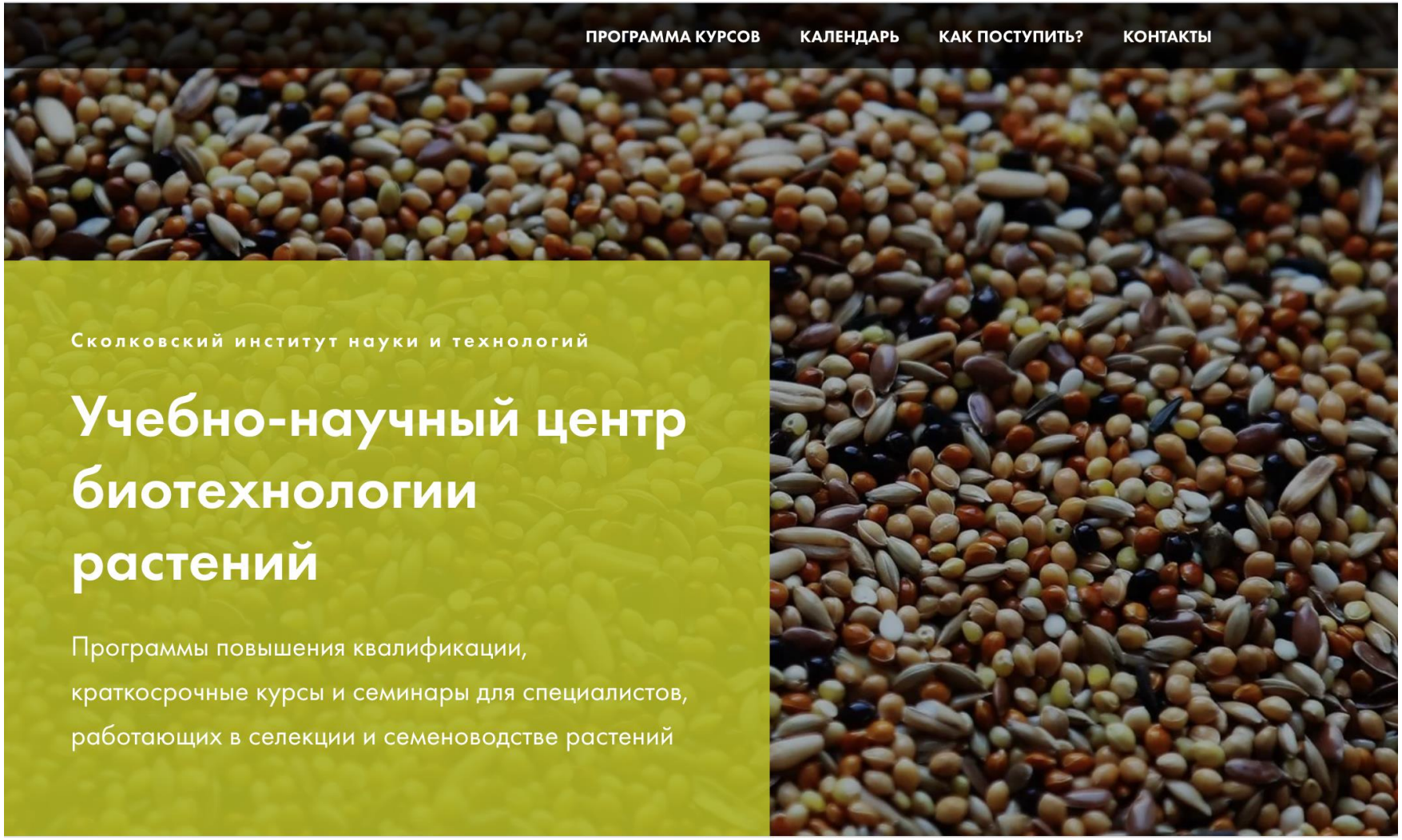
RSAU – MAA named after K.A. Timiryazev

ICIG SB RAS

Belgorod SAU named after V. Y. Gorina

Dec, 6th , 2021

Welcome to our training session “Modern Plant Breeding” – Beginner level -



http://biotech-educenter.skoltech.ru/

December 2021

about me

Gentzbittel

Laurent

Head of Digital Agriculture Laboratory, Skoltech
Full Professor

Prof. at Higher School of Agricultural and Life Sciences in Toulouse, National Polytechnic Institute (France),

30 years of experience in genetics

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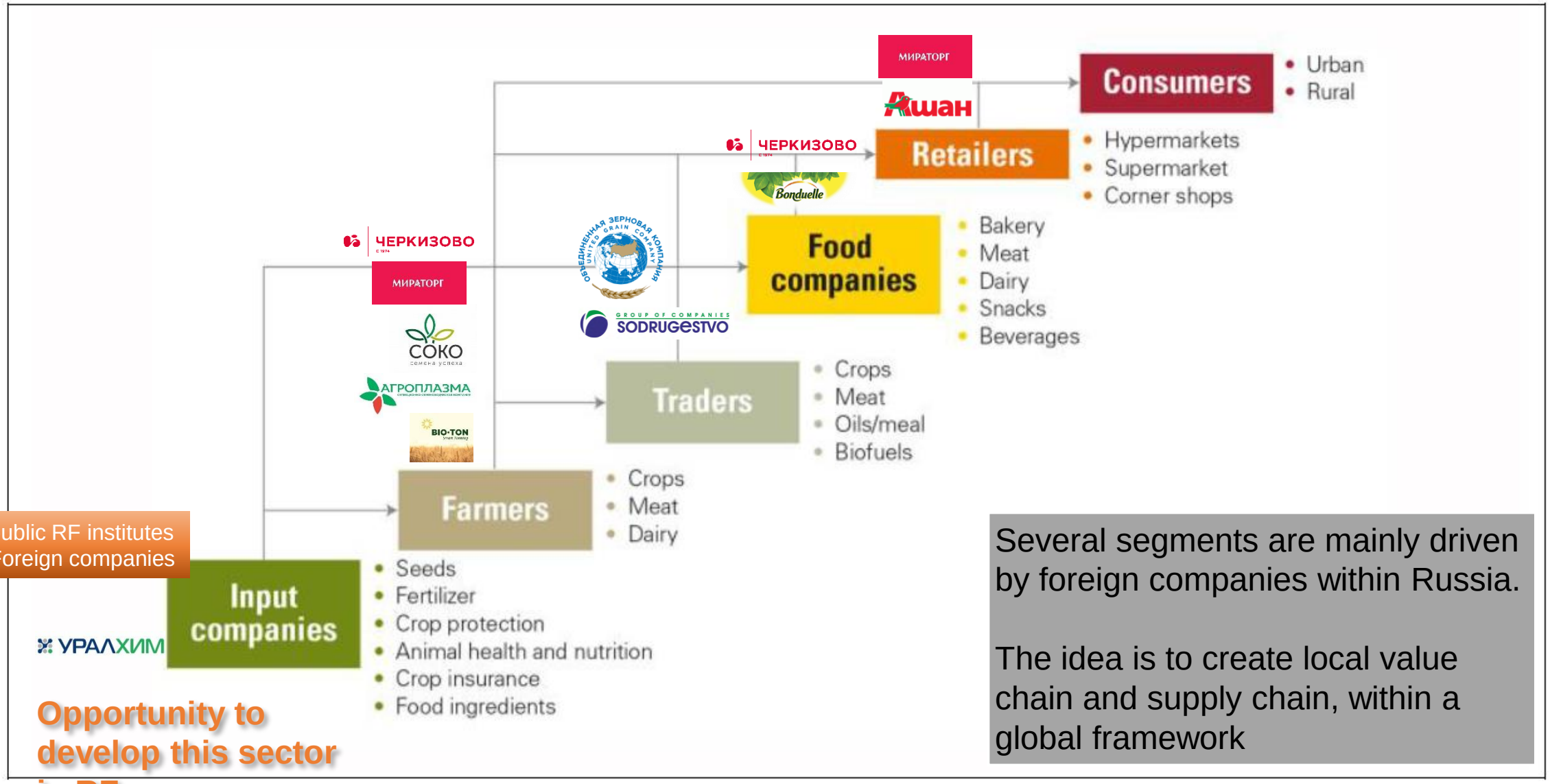
Publications
82 papers, **3** book chapters, **2** patents ;
H-index : **34** (WoS),
37 (GoogleScholar)

The Agri-food value chain



Based on : KPMG 2013; Phillips McDougall/IHS Markit

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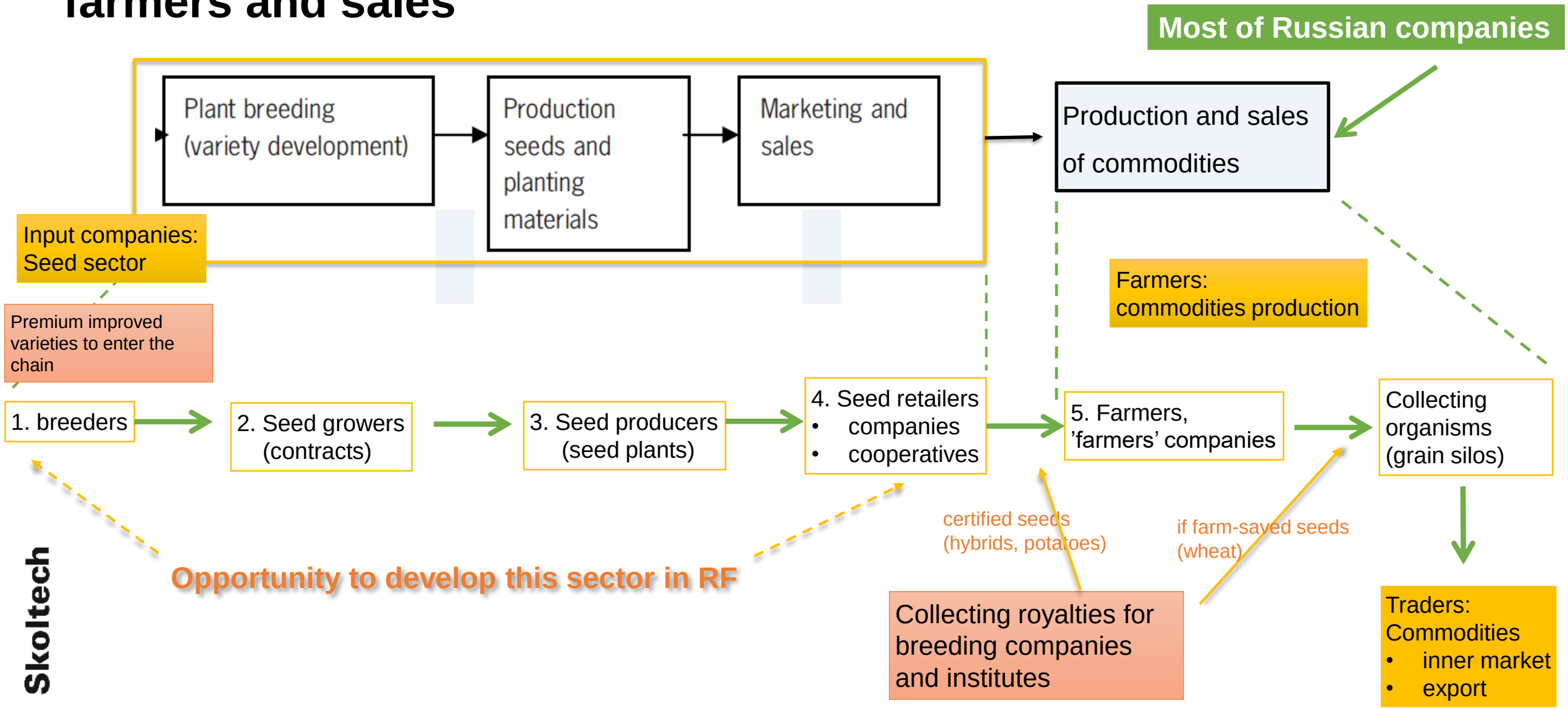
Details of the value chain “seed sector” from breeders to farmers and sales



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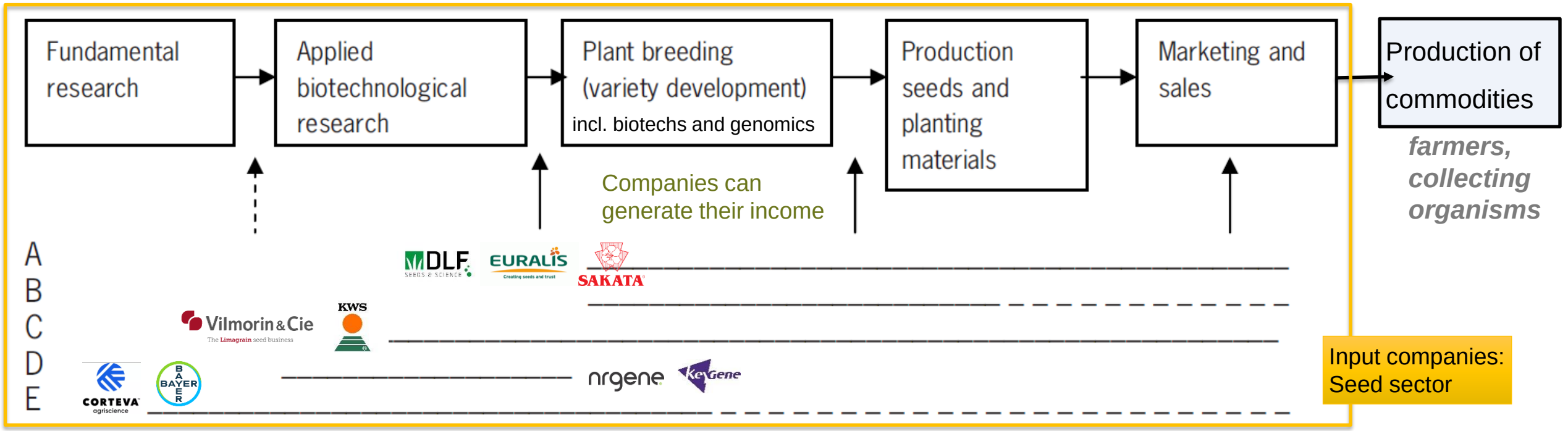
The seed sector : from new improved varieties to the seeds for the farmers



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A: “classical” breeding company.

C: Companies that create biotechnologies for breeding programs.

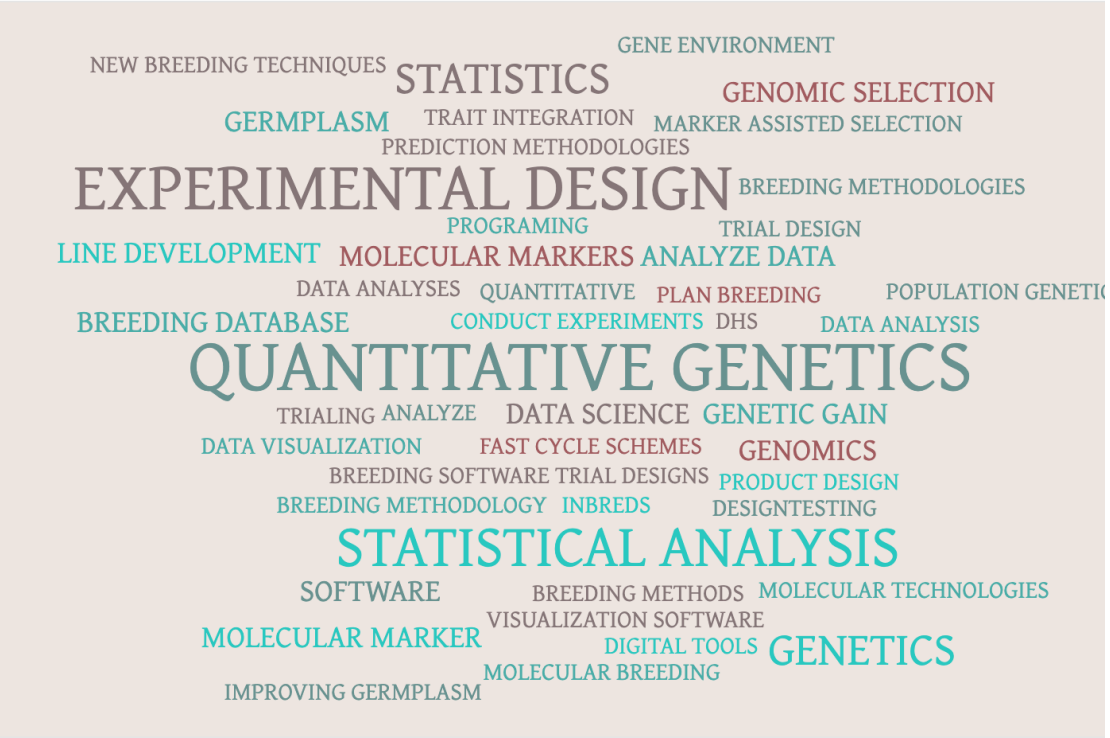
D: biotechnology ‘only’ companies.

E: most multinationals in the seed sector.

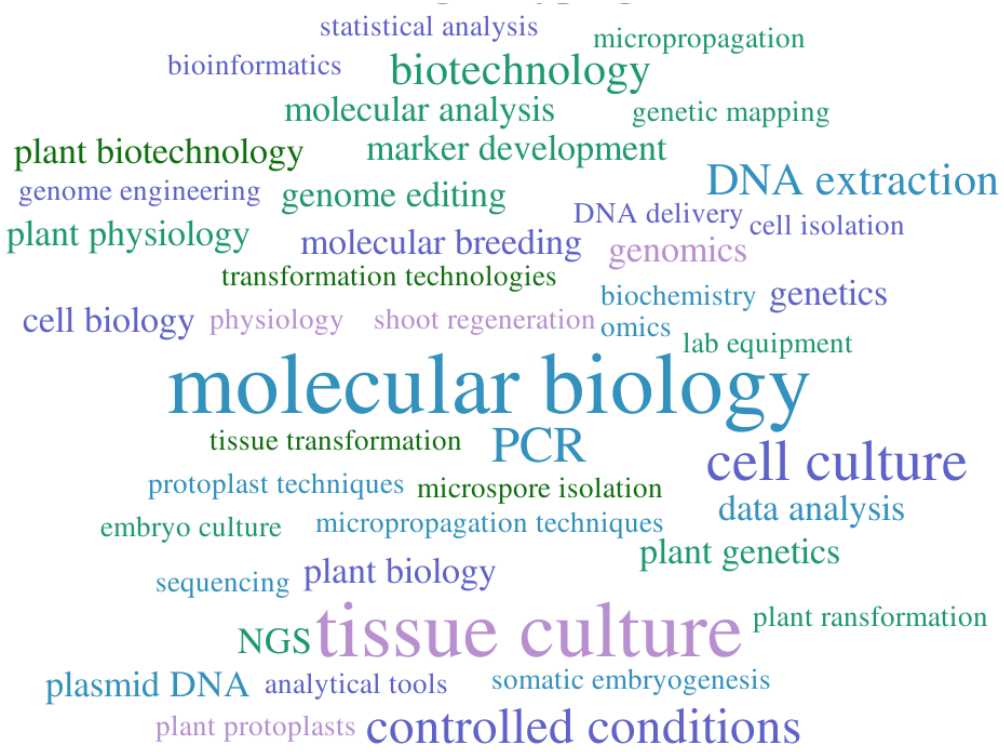
turnaround	2018 – bln euros	2018 – bln RUR
Bayer (Monsanto, Dekalb)	9.1	819
Corteva (Dow DuPont)	7.3	657
ChemChina (Syngenta)	2	180
Vilmorin (Limagrain)	1.4	126
BASF, KWS	0.9	81

Different specialists needs different competencies

Plant breeders



Plant biotechnologists and genetics



Word clouds created on the analysis of job requirements, Linkedin (June 2020)

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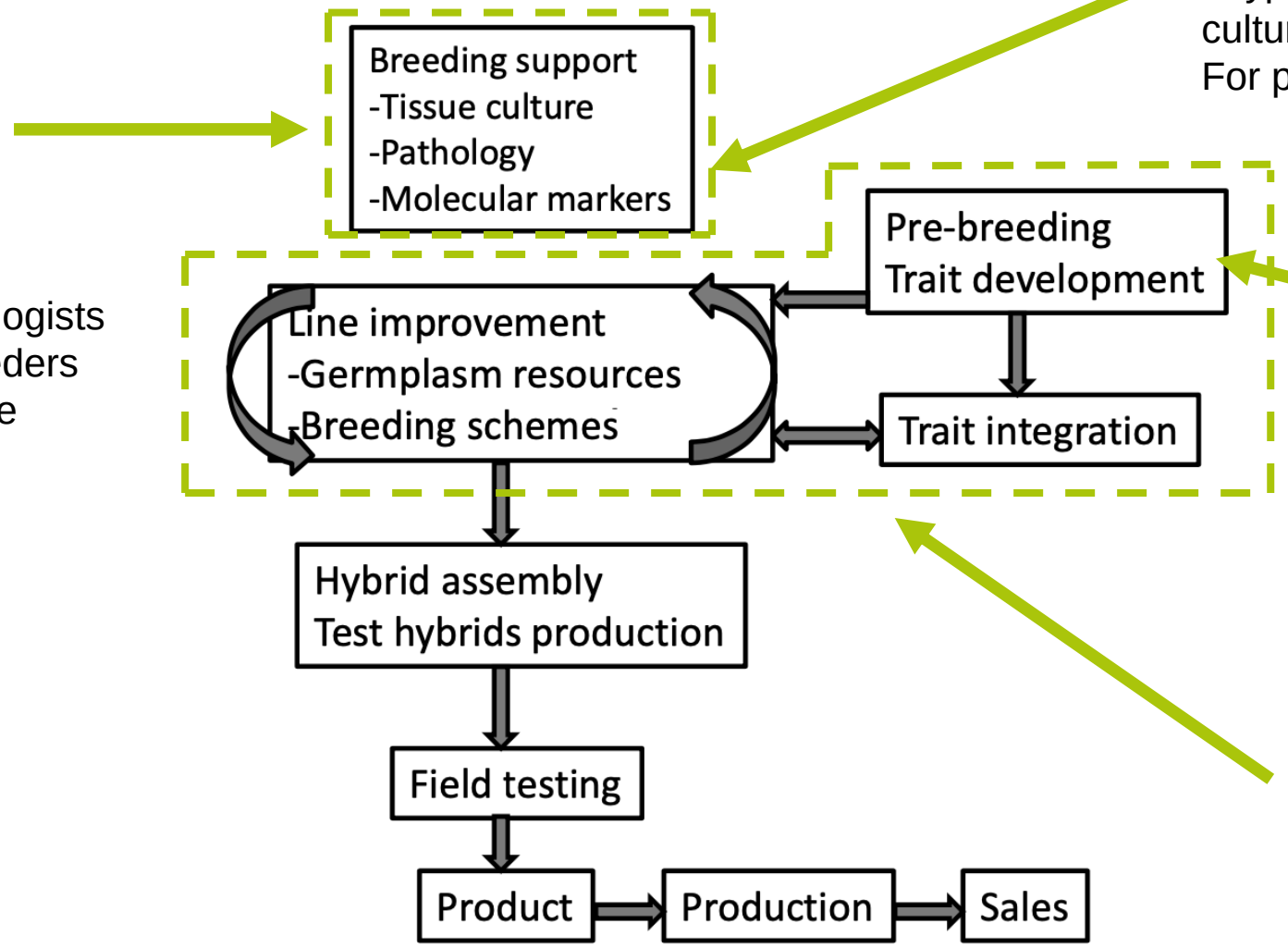
Concept of the training program – skilled based teaching

ICIG SB RAS
Biotechnology in plant breeding.
2 modules
For genetics, biotechnologists
And, also, for plant breeders who want to dive into the biotechnology



RSAU – MAA named after K.A. Timiryazev
3 types of lab practice programs for cell culture and molecular biology.
For plant breeders

Belgorod SAU
Courses ”Plant breeding for biotic and abiotic stresses”
For plant breeders

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Modern plant breeding.
3 modules
For plant breeders

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Crop Modification Techniques

Cross Breeding

Combining two sexually compatible species to create a variety with the desired traits of the parents

The Honeycrisp Apple gets its famous texture and flavor by blending the traits of its parents.

Mutagenesis

Use of mutagens such as radioactivity to induce random mutations, creating the desired trait

Radiation was used to produce a deeper color in the red grapefruit.

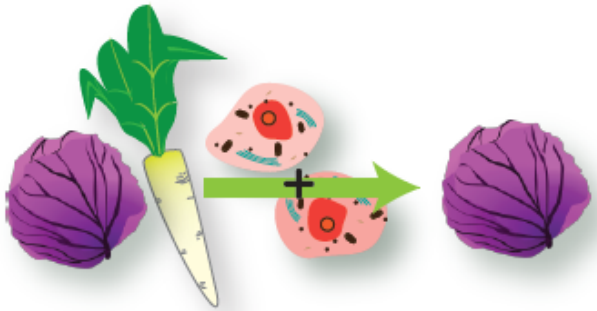
Polyploidy

Multiplication of the number of chromosomes in a crop to impact its fertility

Seedless watermelons are created by crossing a plant with 2 sets of chromosomes with another that has 4 sets. The seedless fruit has 3 sets.

Protoplast Fusion

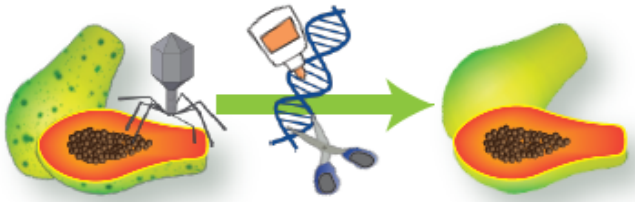
Fusion of cells or cell components to transfer traits between species



Male sterility is transferred from radishes to red cabbage by fusing their cells. Male sterility helps plant breeders make hybrid crops.

Transgenesis

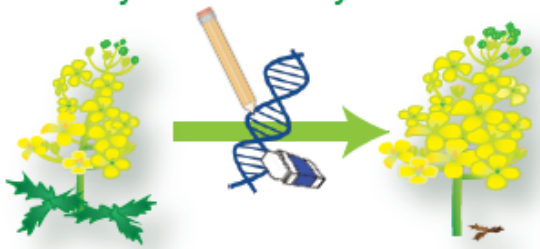
Addition of genes from any species to create a new variety with desired traits



The Rainbow Papaya is modified with a gene that gives it resistance to the Papaya Ringspot Virus.

Genome Editing

Use of an enzyme system to modify DNA directly within the cell



Genome editing was used to develop herbicide resistant canola to help farmers control weeds.

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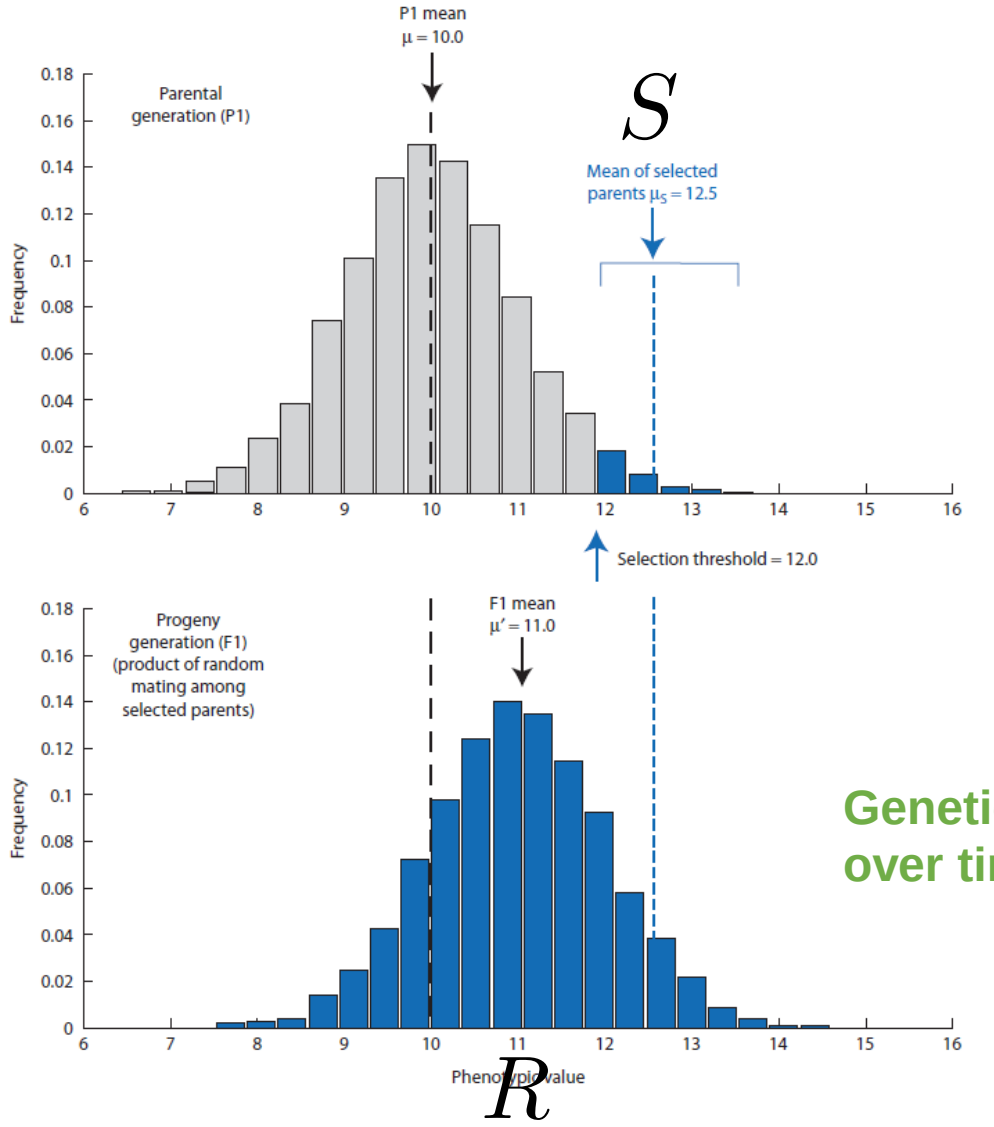
Concept of the training program – around the very practical breeder's equation (Lush, 1945)



$$R = h^2.S$$

Selection intensity

Selection accuracy

Genetic variance

Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle

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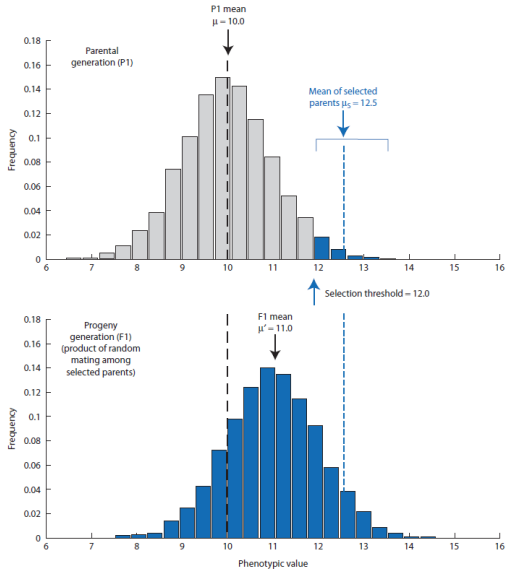
Concept of the training program – around the very practical breeder's equation (Lush, 1945)



Selection intensity

Selection accuracy

Genetic variance

Increase

Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle

Decrease !!

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The breeder’s equation as the practical guide:

Selection intensity

- Large F2 populations
- Big screening nurseries
- Many crosses / populations

Selection intensity

Selection accuracy

Genetic variance

Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle

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The breeder's equation as the practical guide:

Selection accuracy

- Replicated testing
- International trials

Separate genetics from noise

Selection intensity

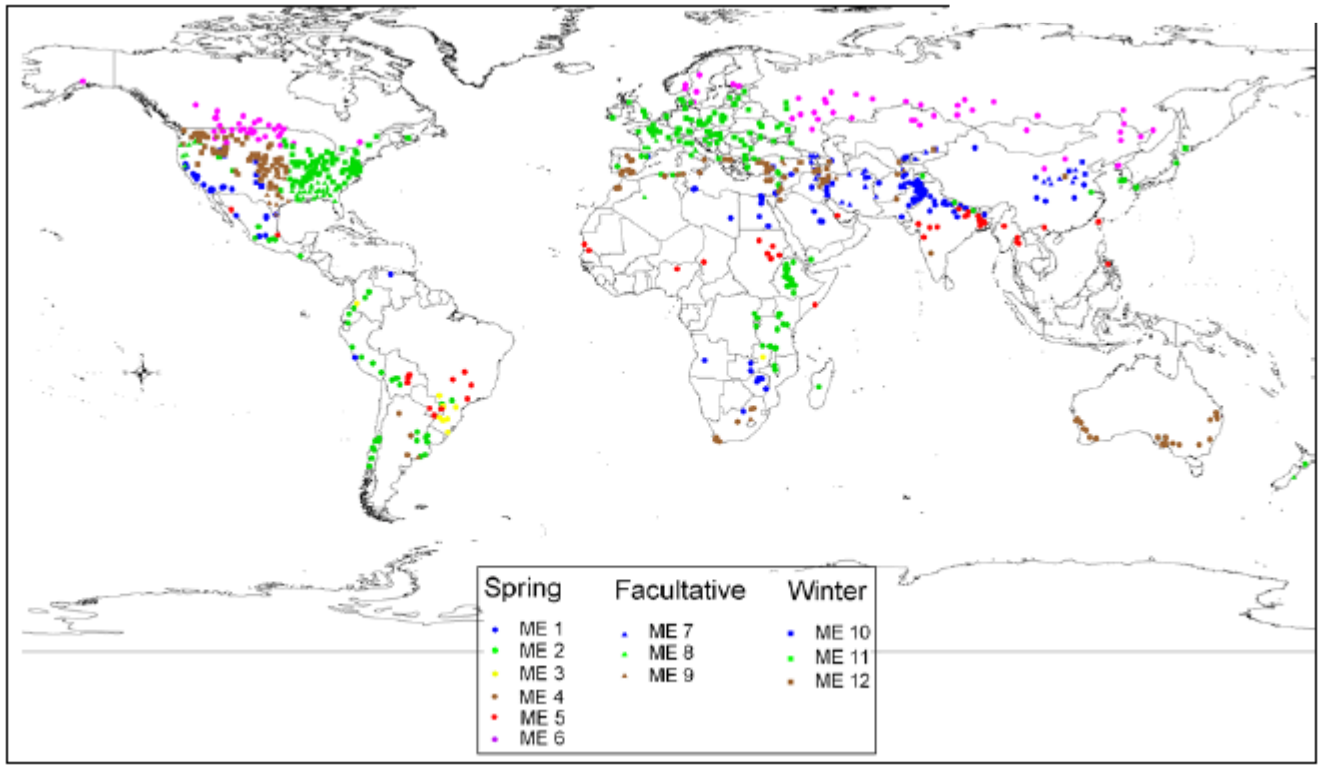
Selection accuracy

Genetic variance

Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle



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The breeder's equation as the practical guide:

Genetic variance

- Bring new genes (alleles) not present in current programs

Selection intensity

Selection accuracy

Genetic variance

Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle

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The breeder's equation as the practical guide:

Dr Borlaug's original 'shuttle program"

Selection intensity

Selection accuracy

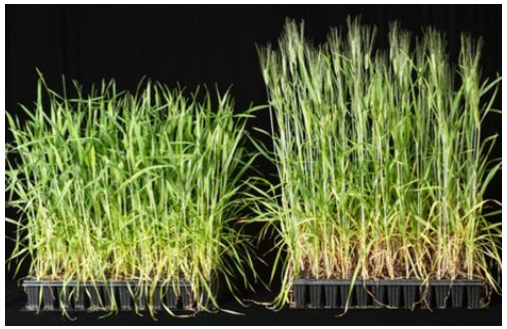
Genetic variance

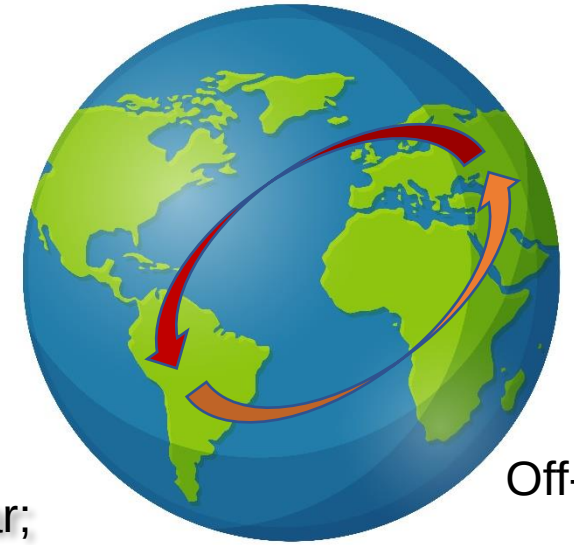
Genetic gain over time

$$R_t = \frac{i \cdot r_A \cdot \sigma_A}{y}$$

Years per cycle

Speed breeding: Rapid Generation advance





Off-season nurseries

The three objectives in the off-season nursery system are:

1. to advance breeding material by an extra generation per year;
2. to screen for diseases and adaptation;
3. to multiply seeds of promising lines.

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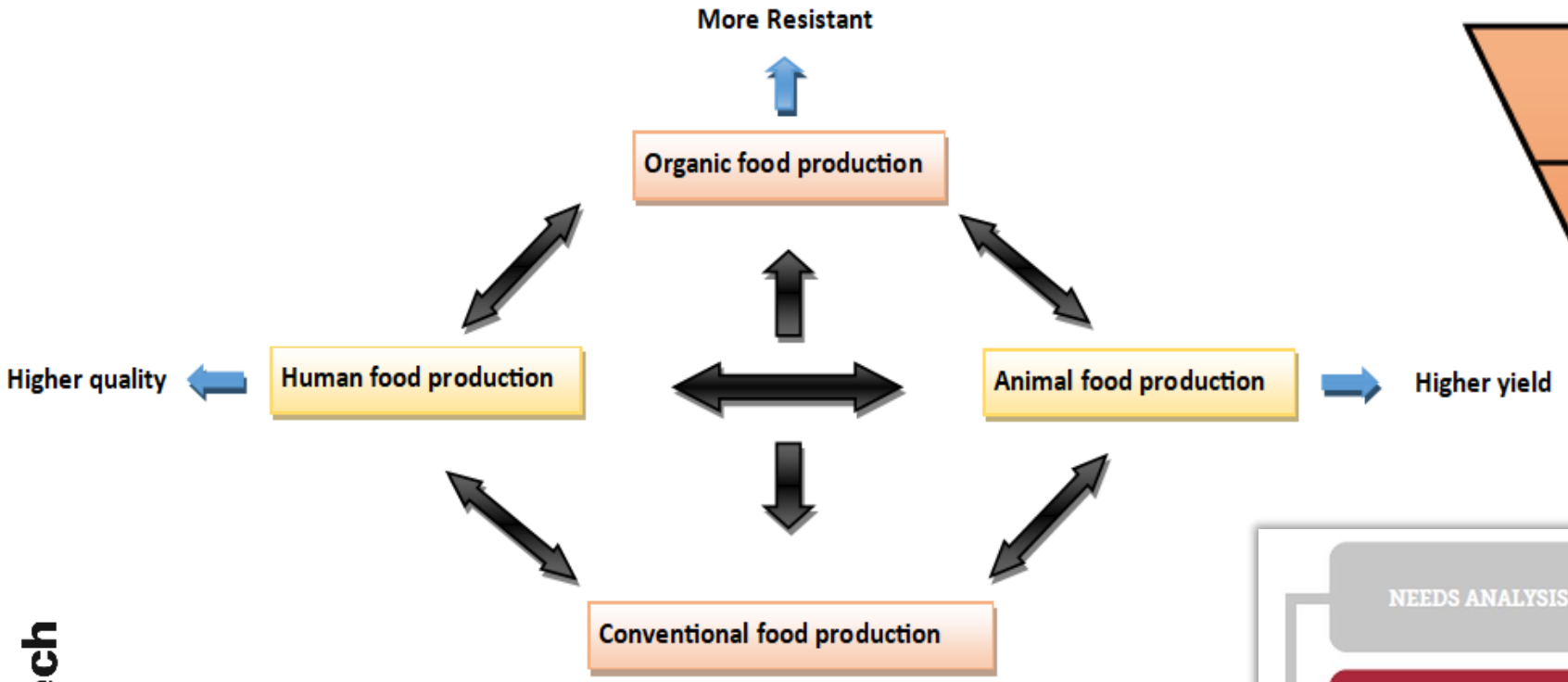
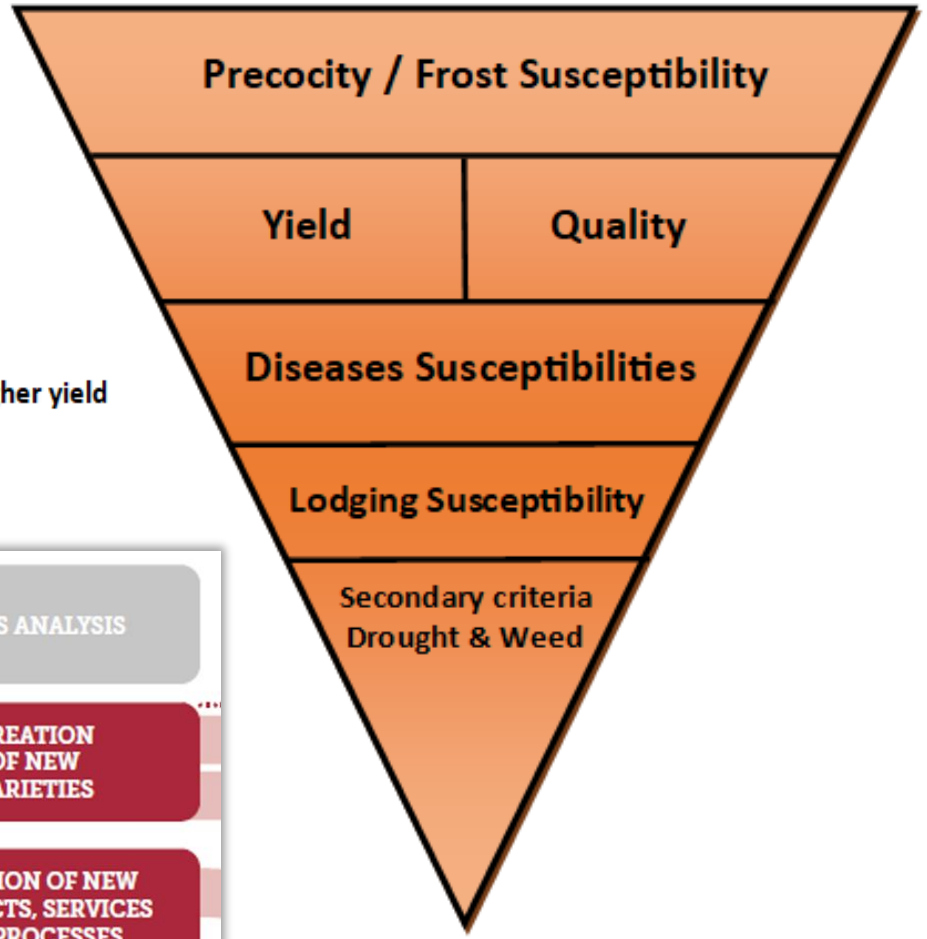
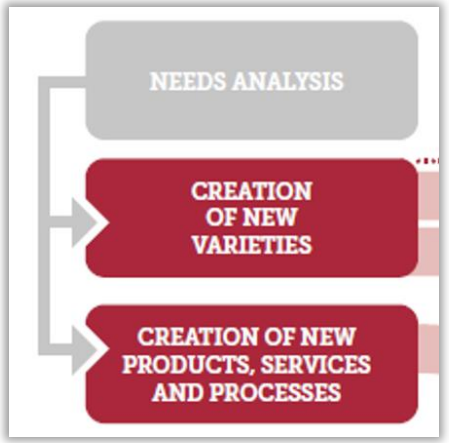
The breeder answers to customer needs / governement policies : the cultivars are depending on different aims

Which target ?



Which priorities?





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Example of soybean in the EU

PRE-BREEDING

Germplasm: Exotic varieties, Competitors varieties, Registered and non-registered varieties, Varieties resulting from interspecific crossing or crossing with exotic varieties (synthetic varieties)

Activity of phenotyping and selection of new parents by BACK-CROSS

Nb of individuals

Data accuracy

In greenhouse
Introduction of the best lines

AxB
F1

Genetic resources, Initial crosses

In nursery

F2
F3
F4
F5

Lines creation and fixation

From F2: Selection on highly heritable traits e.g. morphology, qualitative disease resistances, lodging, maturity, etc.

-From F4: Selection on more complex (moderately heritable) traits e.g. grain quality, uniformity/stability

Multi-environment trials (MET)

F6
F7
F8
F9

From F6 : Yield evaluation
- microplots in multi-environment trials (MET)

G0
G1
G2
…

MET, repeats

Official registration in the catalog
DUS & performance tests

F10
F11

Pre-basis seeds multiplication

MARKETING OF THE NEW VARIETY

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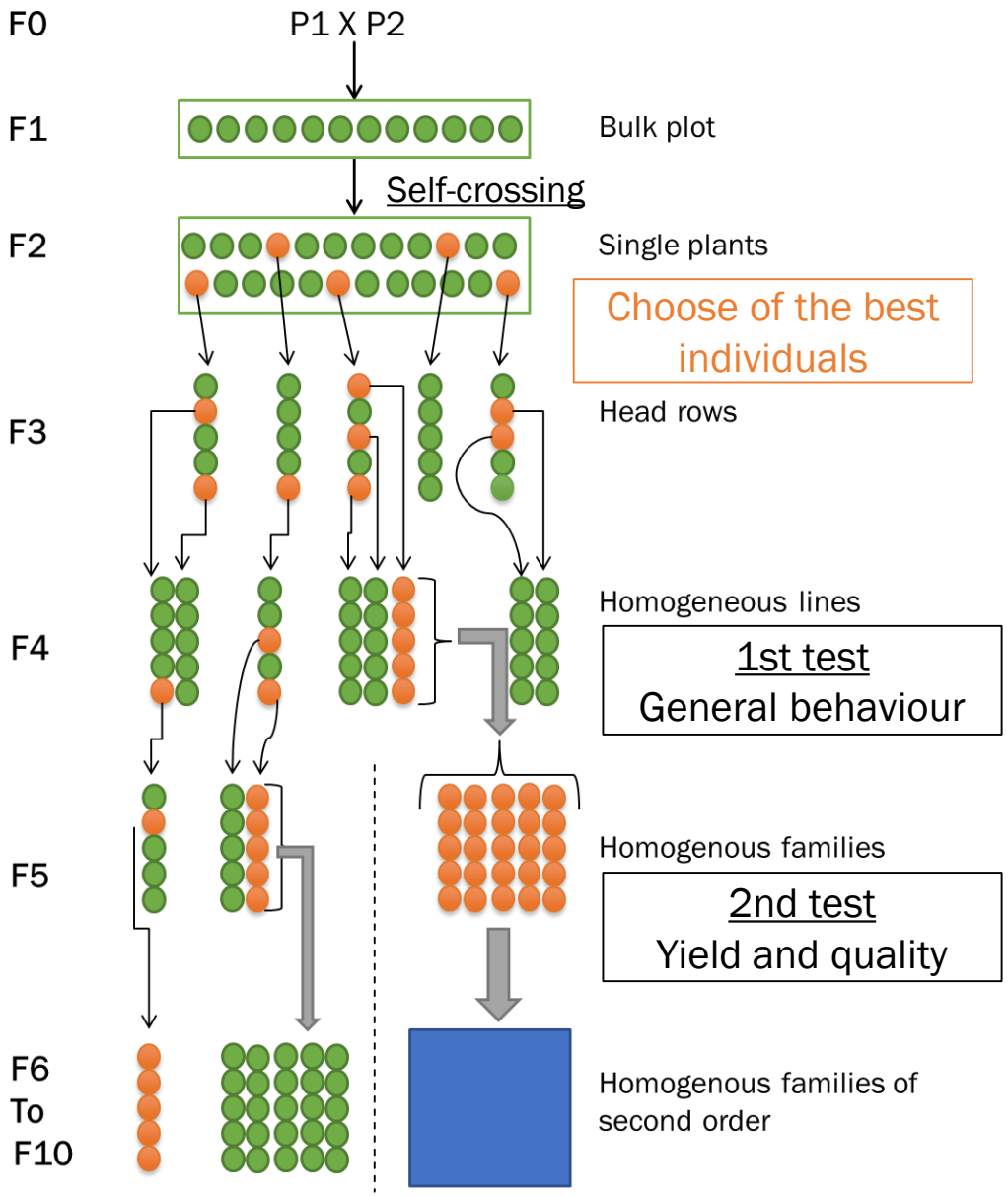
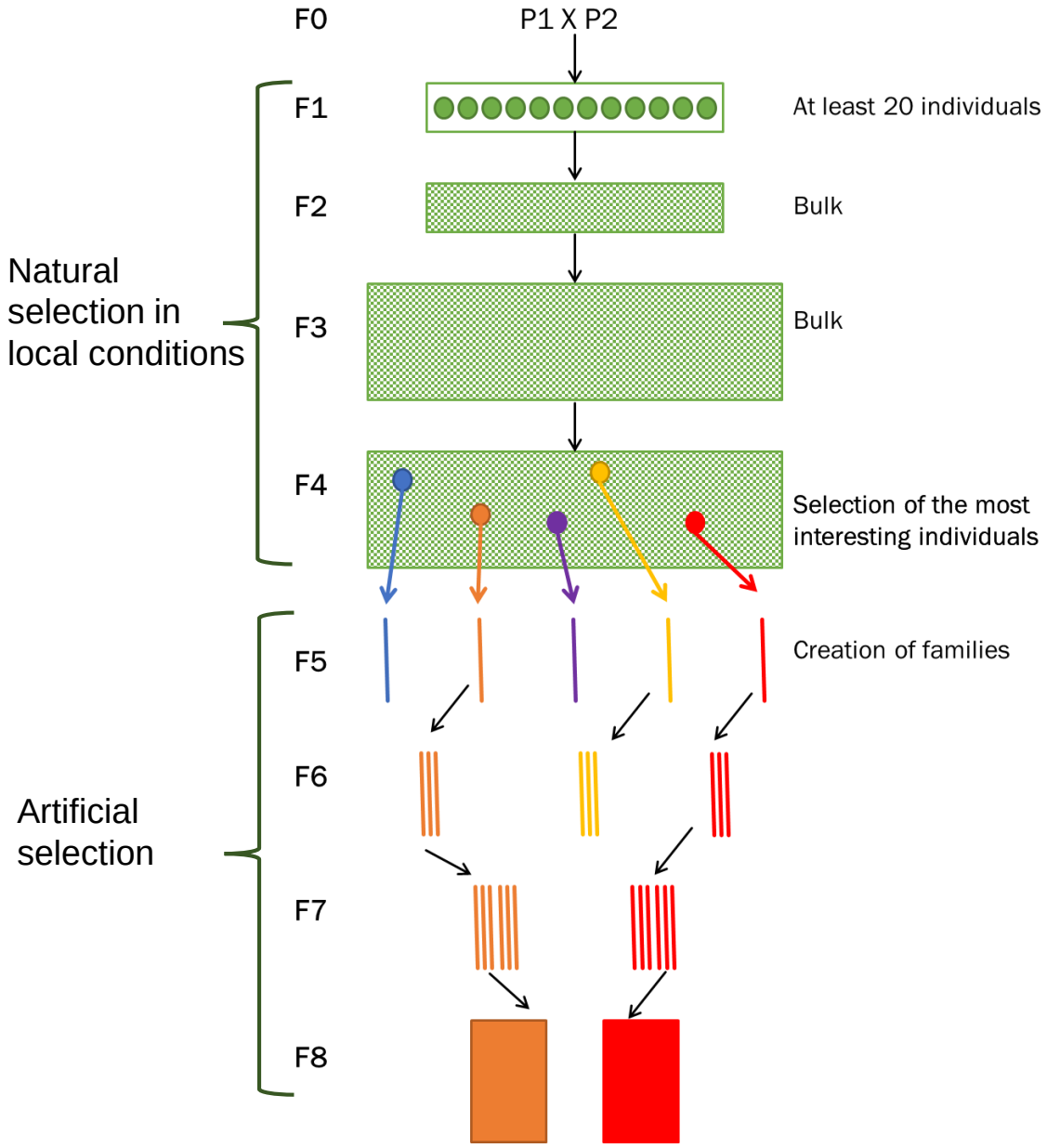
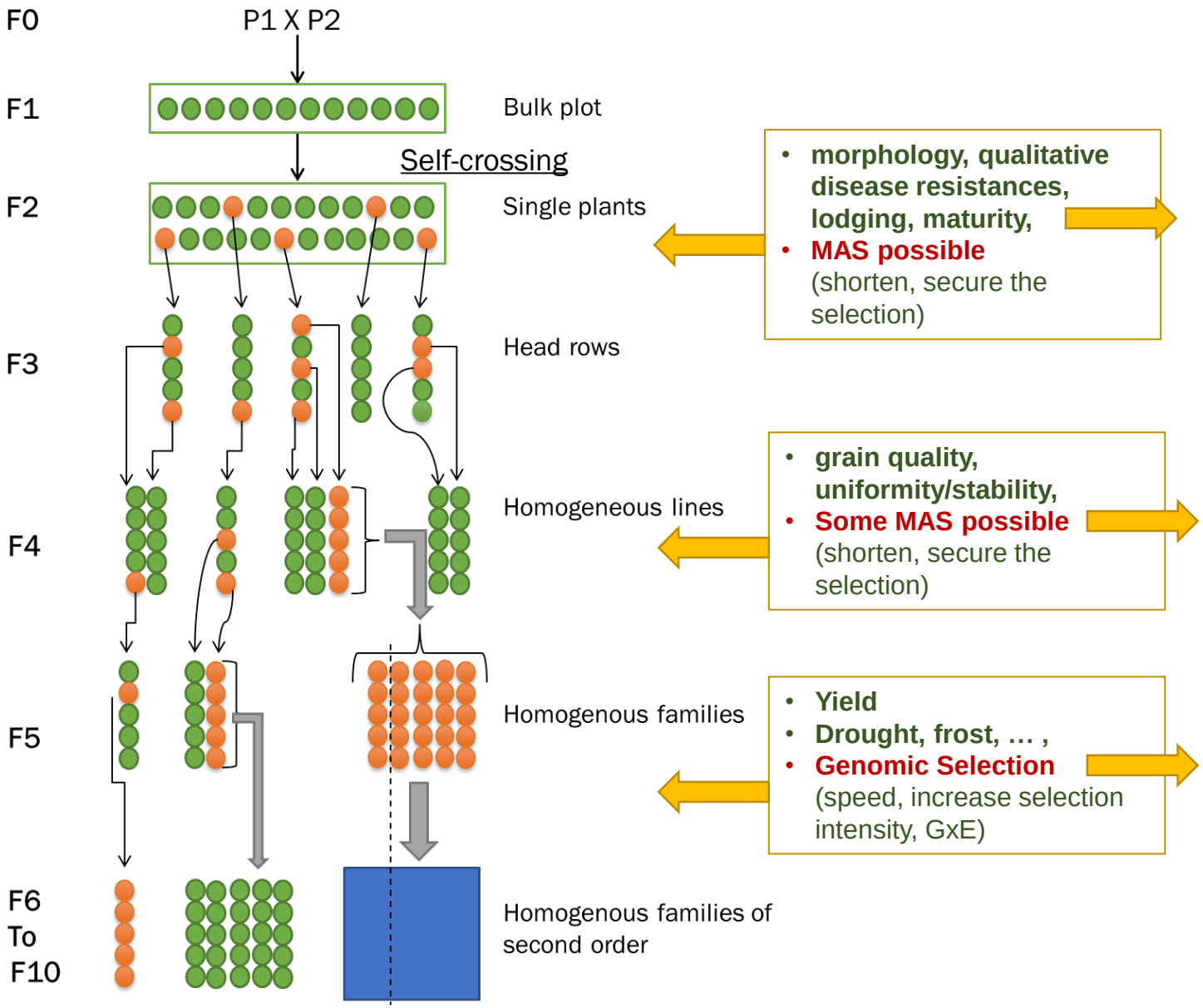
PEDIGREE SELECTION



BULK SELECTION



PEDIGREE SELECTION

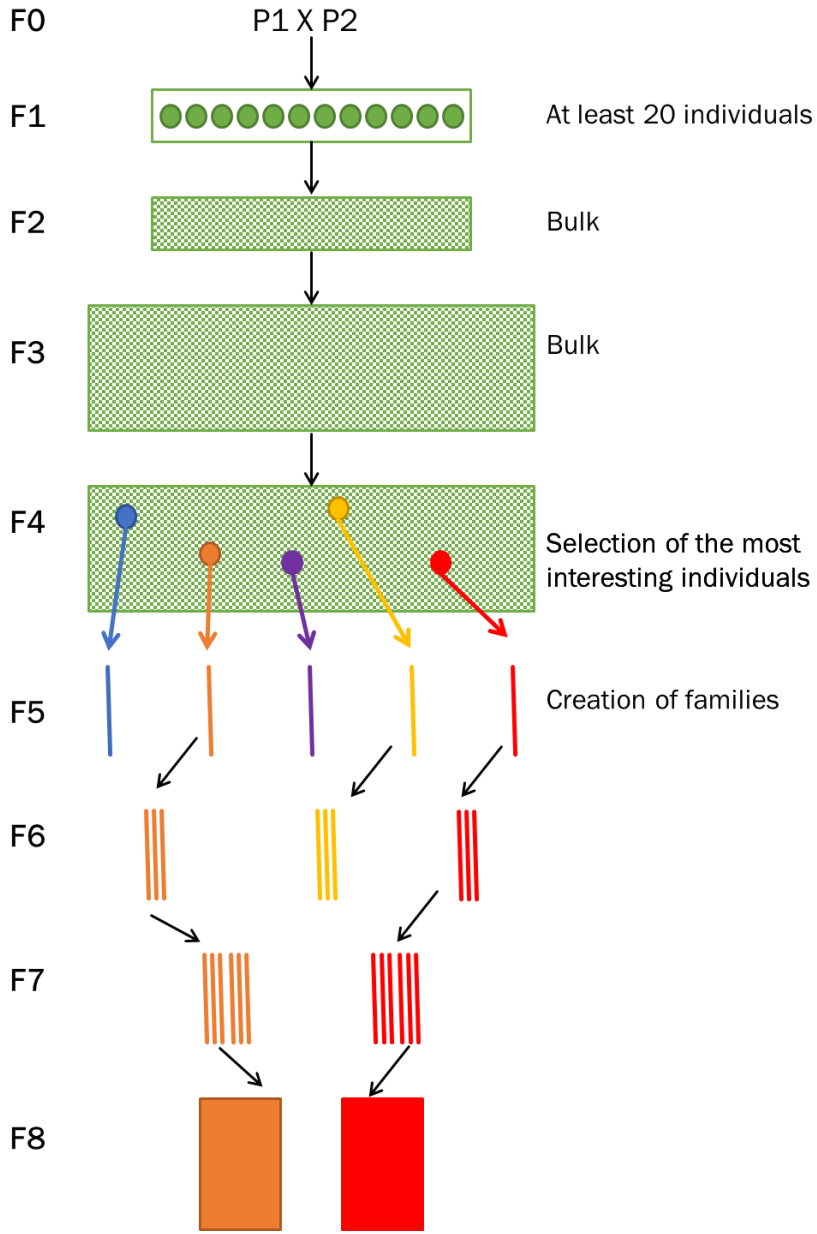


- **morphology, qualitative disease resistances, lodging, maturity,**
- **MAS possible** (shorten, secure the selection)

- **grain quality, uniformity/stability,**
- **Some MAS possible** (shorten, secure the selection)

- **Yield**
- **Drought, frost, … ,**
- **Genomic Selection** (speed, increase selection intensity, GxE)

BULK SELECTION



thx.

Спасибо за внимание!

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