Experiences from 'NOVAFRUITS' : an apple trans-border organic participatory breeding program based on robust and disease tolerant old local cultivars

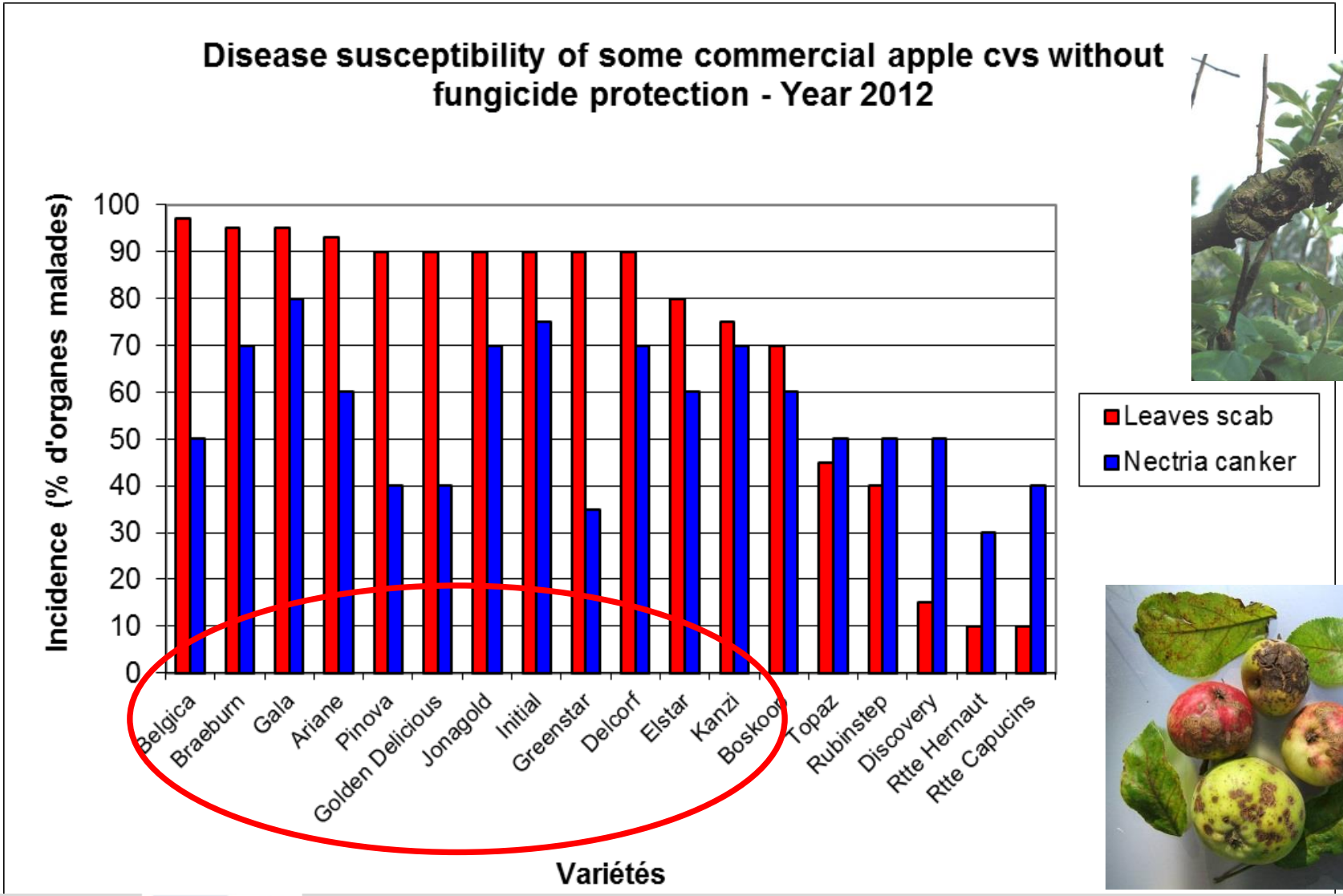
M. Lateur, J-B Rey, T. Donis, A. Rondia, R. Stiévenard

Wallonie recherche CRA-W

espaces naturels régionaux
Centre régional de ressources génétiques NORD-PAS DE CALAIS

Centre wallon de Recherches agronomiques – Unité Amélioration & Biodiversité
Répondre aux questions d'aujourd'hui et relever les défis de demain
www.cra.wallonie.be

1. Why should we still do breeding ? – Creating/looking for new combinations ?



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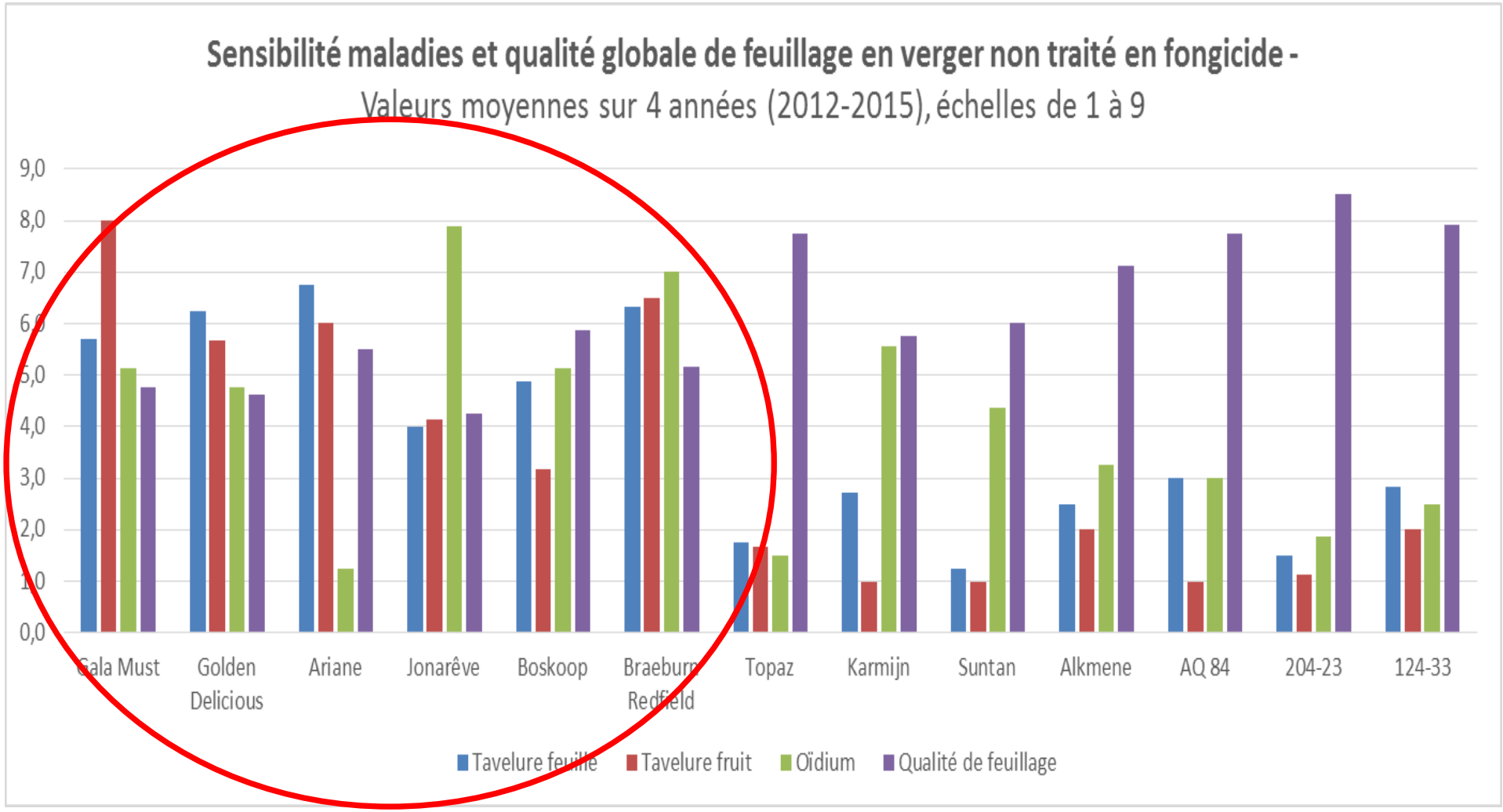


1. Why should we still do breeding ? – Creating/looking for new combinations ?

Example of cv. 'Pinova': very susceptible to scab

'Pinova' 6th leave : Control

32 tonnes / ha

Less than 10 % fruit marketable

'Pinova' : 6th leave : Organic scheme

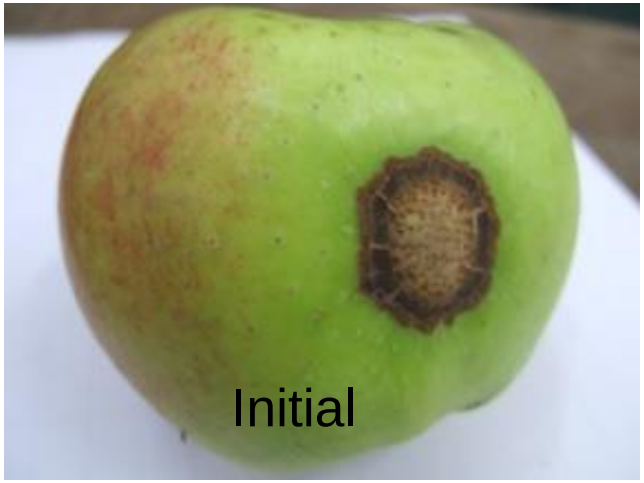
67 tonnes /ha

1. Why should we still do breeding ? – Creating/looking for new combinations ?

Big difference between high density
mono cv commercial orchards
& orchard meadows - agroforestry

1. Why should we still do breeding ? – Creating/looking for new combinations ?

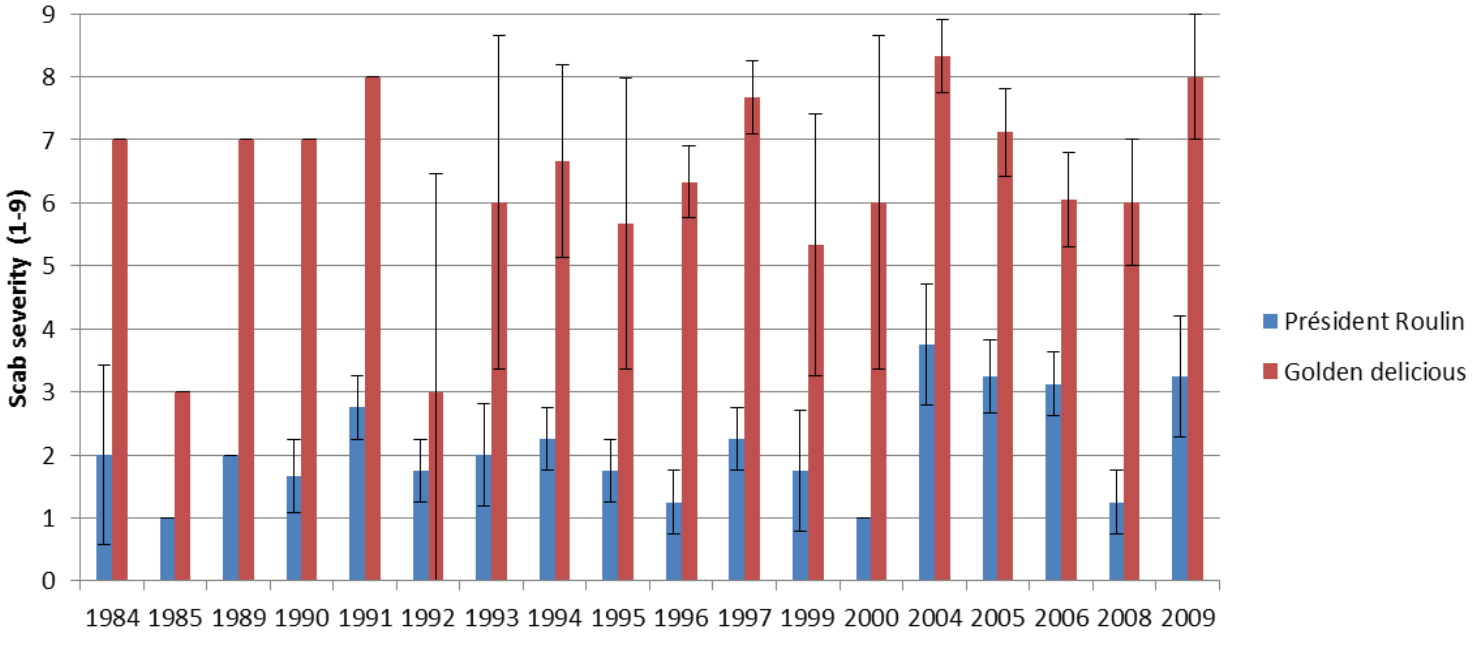
DURABLE SCAB monogenic resistance genes???



1. Why should we still do breeding ? – Creating/looking for new combinations ?

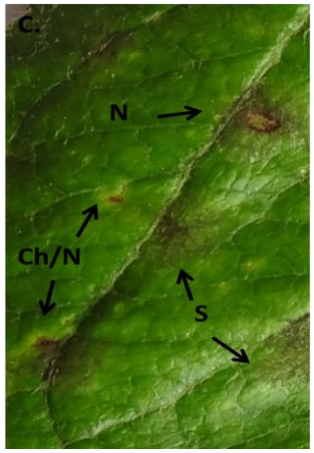
Due to the strategy to **not spray at all** our evaluation orchards :
very large diversity of scab inoculum and nearly all monogenic resistance genes are overcome

Example of old Belgian cv. 'Président Roulin' RFG-Gblx



'Président Roulin'

'Gala'



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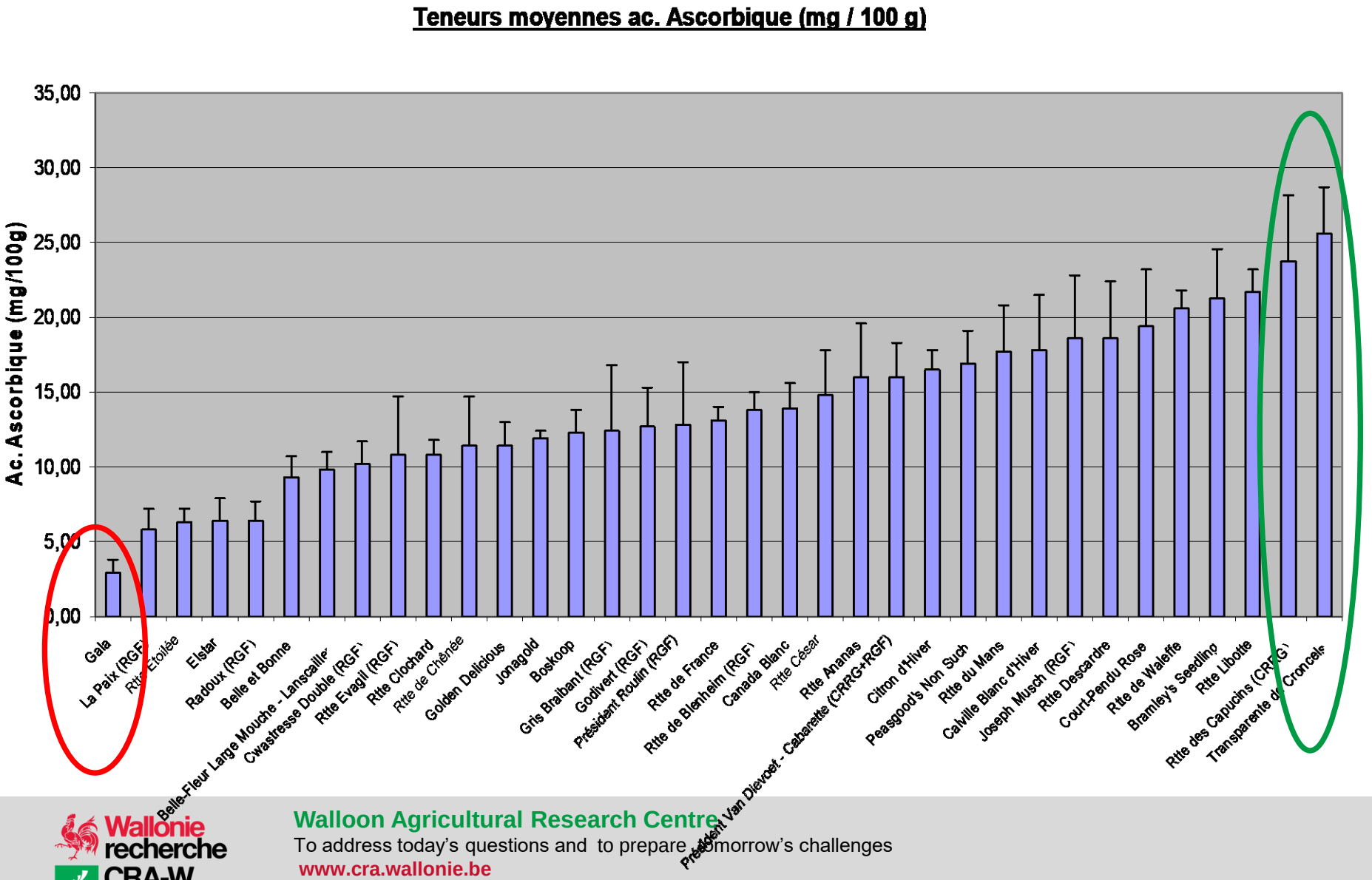

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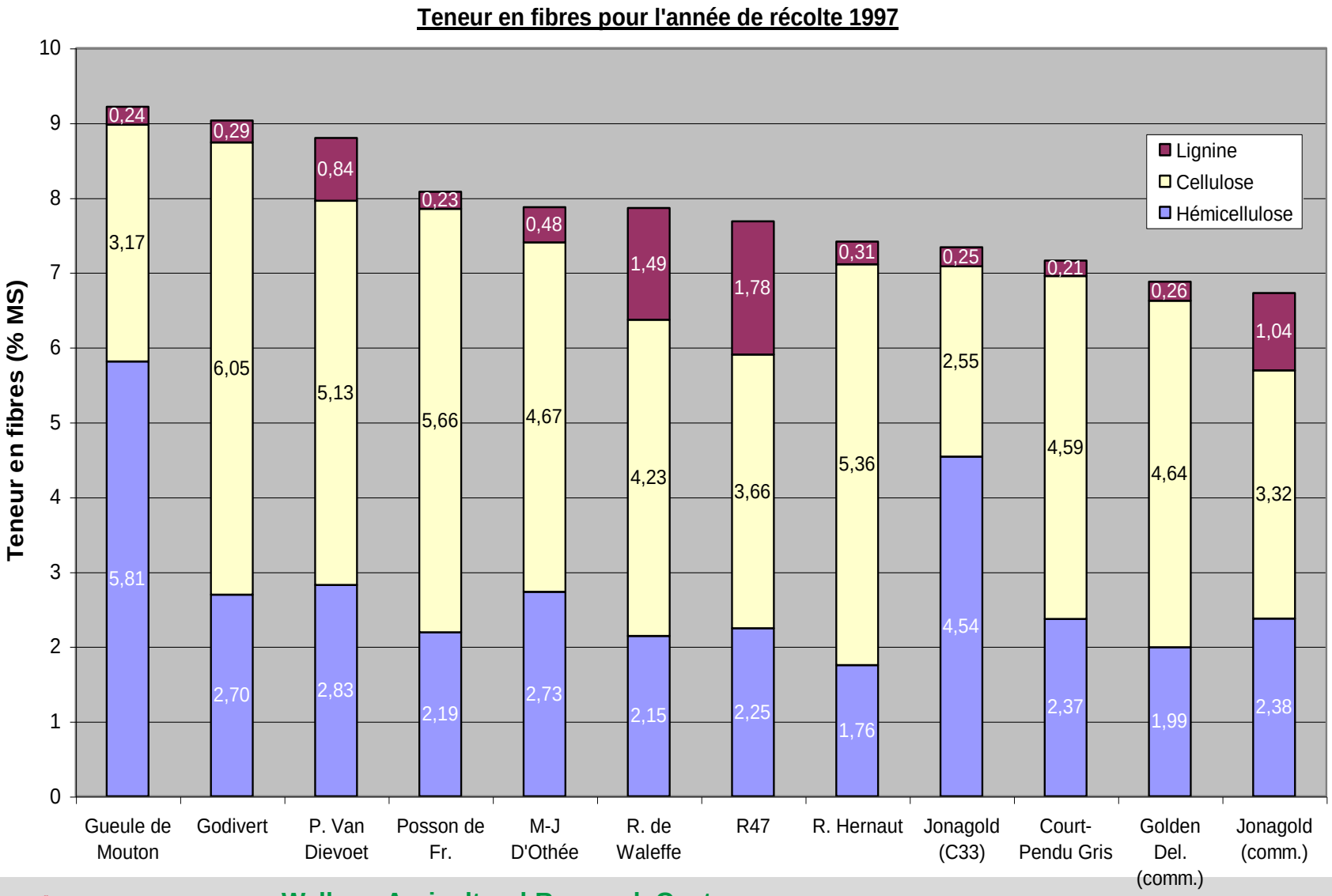


2. Breeding : definition of global goals

Boosting Research for a Sustainable Bioeconomy
A Research Action Plan to 2020

Plants for the Future
European Technology Platform

BRIEFING

EU agricultural research and innovation

European Parliament

Quel progrès génétique pour une agriculture durable ? [1]

Jean-Marc Meynard et Marie-Hélène Jeuffroy
UMR d'Agronomie INRA – INA-PG, 78850 Thiverval-Grignon ; *meynard@grignon.inra.fr ; jeuffroy@grignon.inra.fr*

01/2019

4 main topics	**Diversity**	**Low input farming systems – Lower risks**			**Climatic Resilience**	**Quality**
6 objectives	1. ↗↗ Use of GenRes – genetic diversity	2. ↗↗ Resistance &/or tolerance to disease	3. ↗↗ Resistance &/or tolerance to pests	4. ↗↗ Nitrogen *(& fertilizers)* efficiency Rootstocks & Cvs	5. ↗↗ Flexibility to abiotic stresses (drought,…) Rootstocks & Cvs	6. ↗↗ Differential Quality – New healthy products

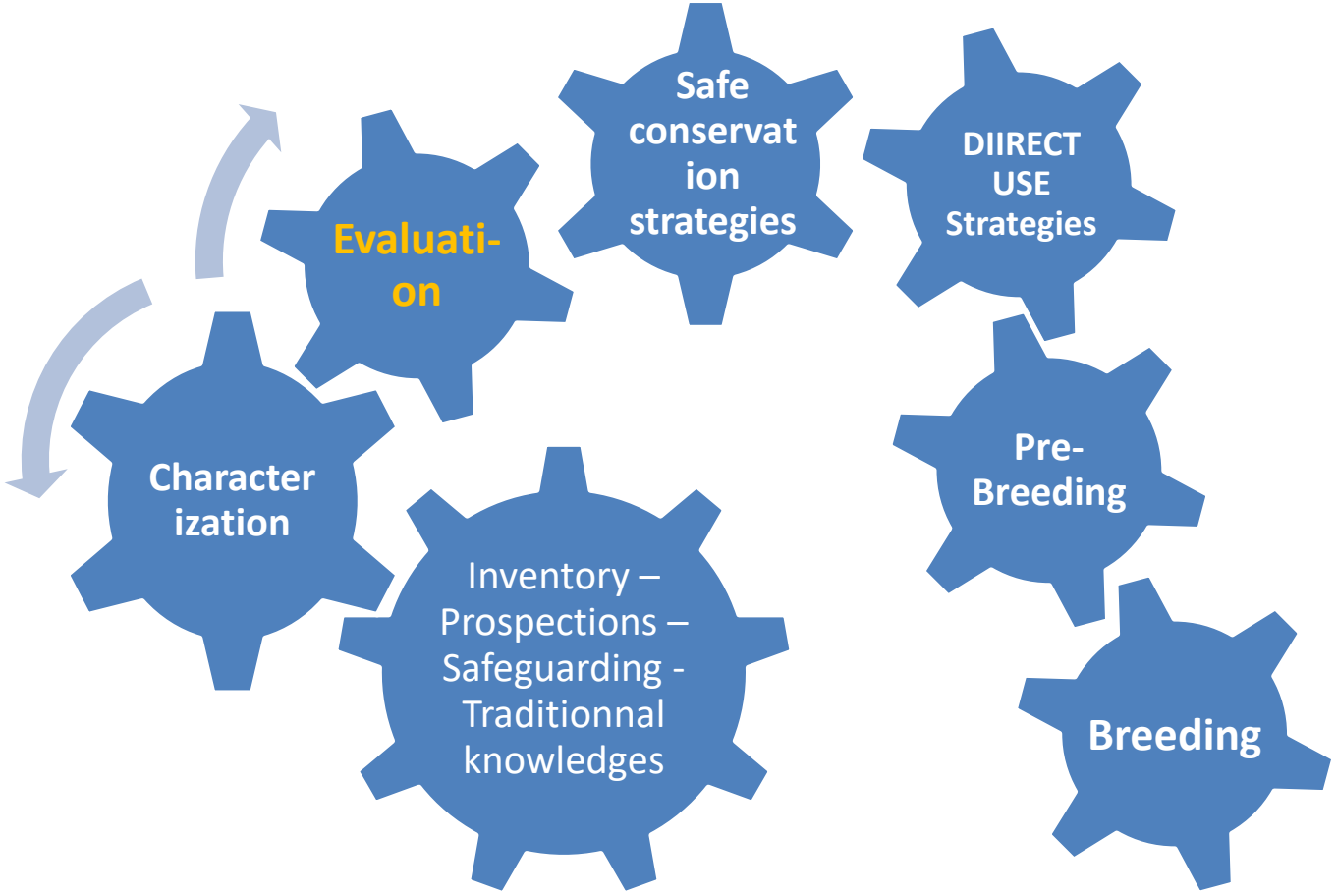
3. Our apple breeding: definition of more specific goals

Definition of breeding objectives:

1. Adaptation to low input growing systems (mostly Organic)
2. Disease tolerance, robustness, resilience : combination of many minor genes + *Vf*
3. Broadening genetic bases using best performing local neglected old cvs
4. Quality and originality – Dessert & processing uses
5. Better nutritionnal quality
6. Easy tree architecture, good yield, no specific post harvest “problems”
7. Collaborative breeding approaches

Very important to make a good choice of parents:

4. *Use of Fruit Genetic Resources in breeding – a chain of actions…*

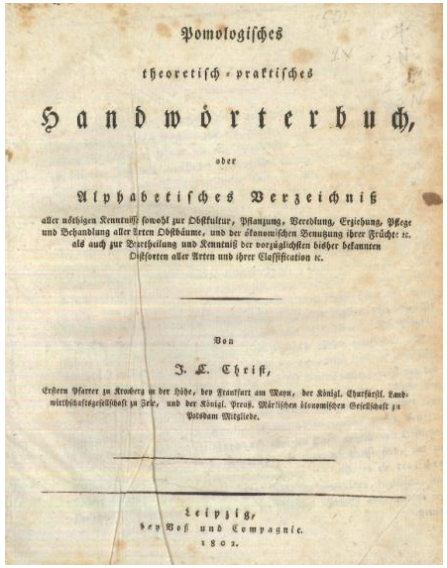


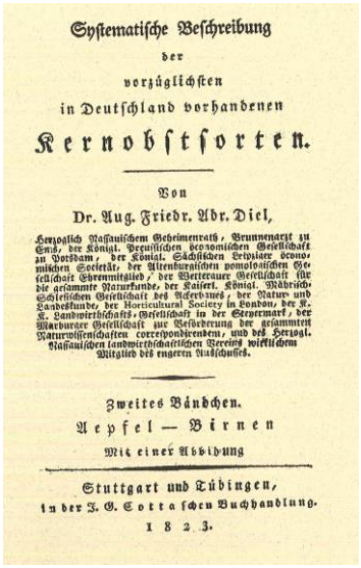
Back to the roots…many interesting traits identified in the large diversity of old and new cultivars through priority work of long term scientific evaluation activities in unsprayed orchards.

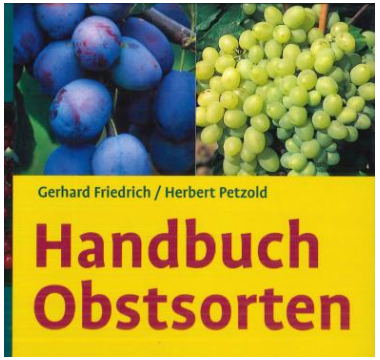
Key role of unsprayed EVALUATION orchards = natural co-evolution of pest & disease populations with environmental stresses

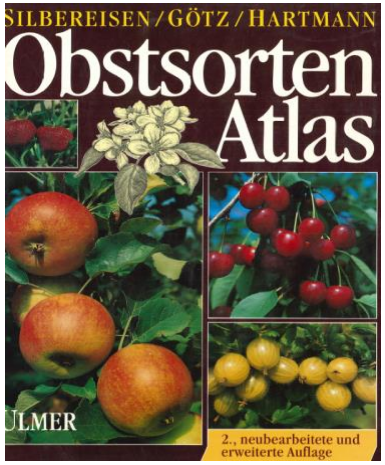
⇒ **Rusticity and tolerance to abiotic stresses : robustness**
⇒ **Tolerance to pest and diseases**
⇒ **Long keeping ability without sophisticated cold systems**
⇒ **Large diversity of forms, colours, tastes, uses, healthy nutriments…**

Germany: country of historical famous pomologists…


Pomologisches
theoretisch-praktisches
Handwörterbuch,
oder
Alphabetisches Verzeichniß
J. L. Christ,
Leipzig,
bey Voß und Compagnie.
1802.


Systematische Beschreibung
der
vorzüglichsten
in Deutschland vorhandenen
Kernobstsorten.
Von
Dr. Aug. Friedr. Adr. Diel,
Zweites Bändchen.
Aepfel — Birnen
Mit einer Abbildung
Stuttgart und Tübingen,
in der J. G. Cotta'schen Buchhandlung.
1823.





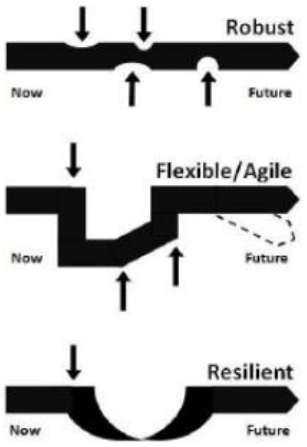
4. *Use of Fruit Genetic Resources in breeding – a chain of actions…*

- ❑ Lempe *et al.* (2013) **Molecular mechanisms of robustness in plants**. *Curr Opin Plant Bio.*
- Robustness is a **quantitative trait**.
- Robustness is **trait-specific** and may not be predictive of robustness in other traits.

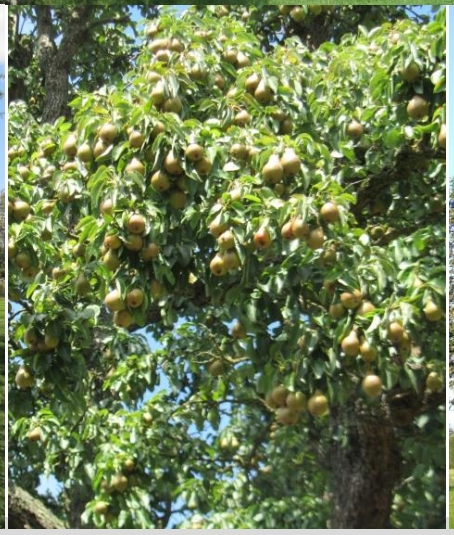
A more 'robust' cultivar has

- **a higher adaptive capacity to biotic & abiotic stresses**
- **a higher adaptive capacity to optimize its yield under low input farming systems**

- ❑ Husdal *et al.* (2010)
- ❑ Lachowier et al. (2016)



Some old cvs have robustness, disease tolerance, capacities of adaptation, low fertilizing needs…



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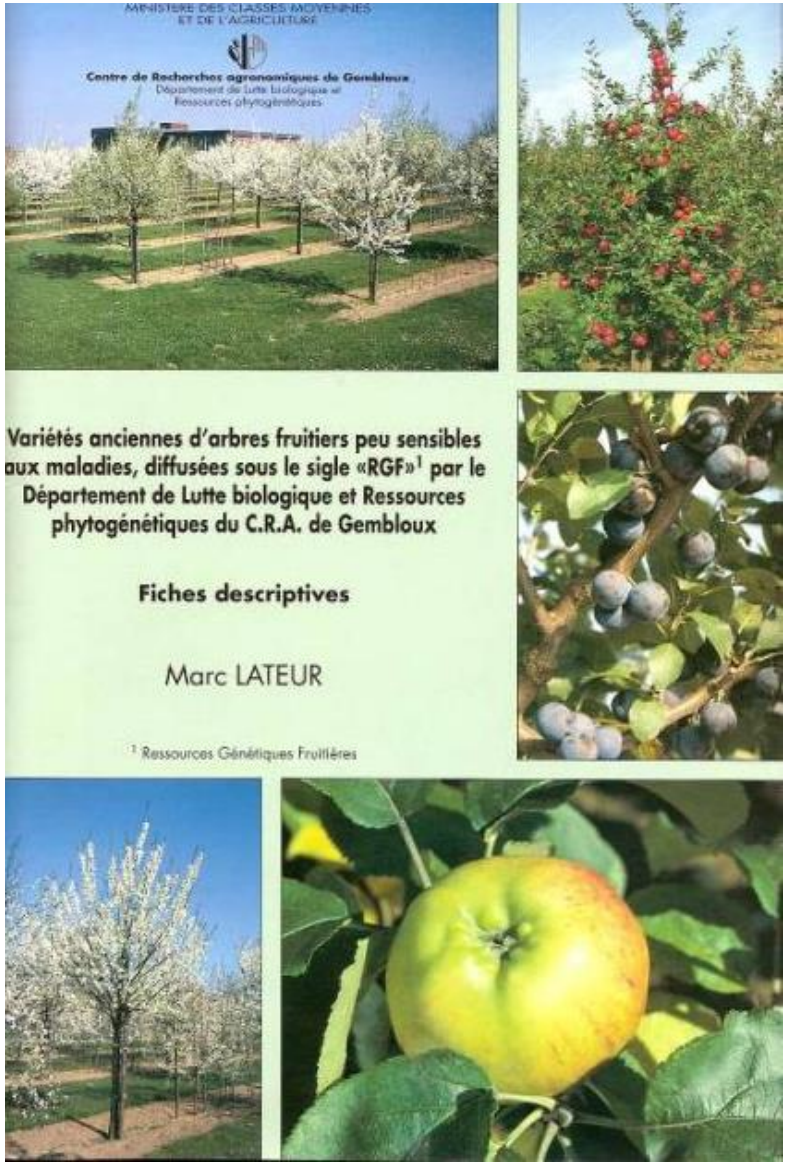
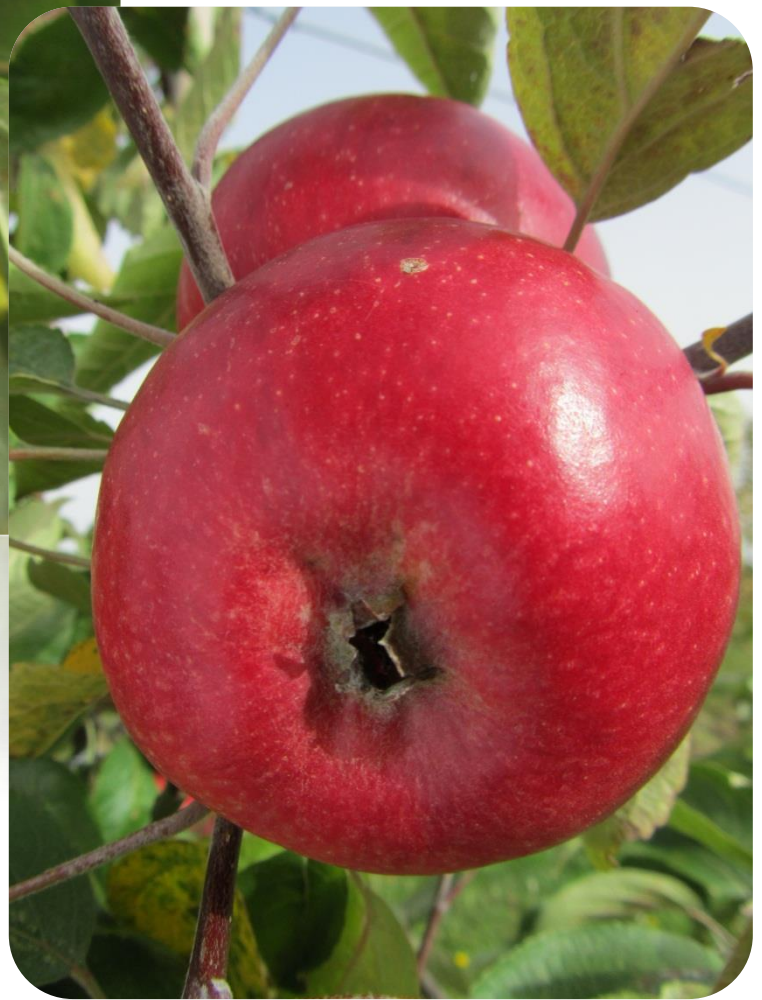
Reinette Dubois *RGF-Gblx*

Ancienne variété belge du pays de Herve, mentionnée pour la première fois en 1858 ; issue d'un semis de hasard, arbre quasi unique trouvé chez Monsieur Franssen à la ferme 'Du Bois', au lieu-dit 'La Fabrique', a été sauvé durant l'été 1984 par MM. Charles Populer de Gembloux et Claude Guiot de Retinne. Fruits à cueillir première moitié d'octobre ; de forme assez variable et le plus souvent globeuse aplatie ; épiderme lisse, coloré majoritairement de rouge brillant sur vert – virant au jaune ; mouche fermée à mi-ouverte ; pédoncule moyennement long inséré dans une large cavité très profonde ; chair très blanche, fine et bien ferme de type 'Reinette' qui se fripe sans devenir farineuse, sucrée-acidulée et de très bon goût; véritable fruit de dessert de fin d'automne et d'hiver, très bonne conservation en cave jusqu'en avril. Arbre peu vigoureux et bien adapté aux petits jardins ; de faible croissance en pépinière ; feuilles large et en cuvette; arbre très facile à conduire donnant une bonne production régulière, très bien adapté à toutes les formes mais à greffer de préférence sur des porte-greffe semi-vigoureux et vigoureux, très bonne adaptation en haute tige; très peu sensible à la tavelure, peu à moyennement à l'oïdium mais suivant les endroits, assez sensible au chancre. Très bon pollinisateur pour les variétés fleurissant assez tardivement (Groupes 5 et 6 de floraison).

M. Lateur : Variété « RGF-Gblx » diffusée par le CRA-W, GEMBLOUX, saison 2011

Wallonie





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Centre régional de ressources génétiques du Nord – Pas de Calais
Ferme du Héron, Chemin de la Ferme Lenglet
59650 -VILLENEUVE D'ASCQ
FRANCE
www.enrx.fr

Président Henry Van Dievoet *RGF-Gblx*
Cabarette *CRRG*

Ancienne variété belge obtenue en 1878 par M. Camille De Clercq de Poperinge, très connue dans le Nord de la France sous le nom de 'Cabarette', diffusée par le Centre Régional de Ressources Génétiques (CRRG) de Villeneuve d'Ascq. Fruits verts, virant au beau jaune clair qui présentent parfois une légère joue rose-orangé ; chair très blanche, très ferme, acidulée-sucrée; véritable fruit d'hiver tant de table que pour cuire et dont ses qualités gustatives s'améliorent à partir de la Noël, très bonne conservation en cave jusqu'en mai-juin. Arbre vigoureux, facile à conduire, très productif mais alternant, très bien adapté à toutes les formes et à tous les porte-greffes; dans nos régions, assez peu de problème d'oïdium et moyennement sensible à la tavelure et au chancre ; très bon pollinisateur pour les variétés fleurissant en moyenne saison (Groupes de floraison 4, 5 et 6).

Variété « CRRG & RGF - Gblx » diffusée par le CRA-W, GEMBLOUX et le CRRG, VILLENEUVE d'ASCQ, Saison 2006.

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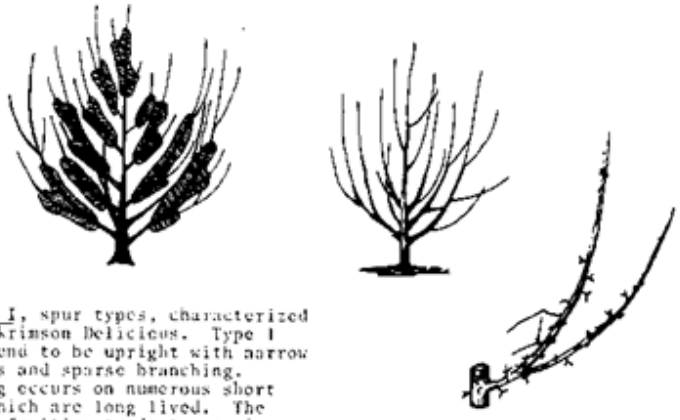
Transparente de Lesdain *RGF-Gblx*

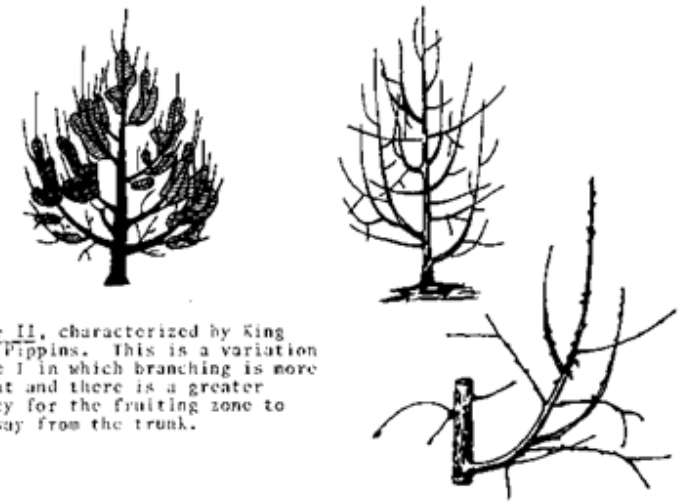
Nouvelle variété issue des travaux de création variétale du CRA-W qui valorise nos anciennes variétés comme parents – sélectionnée grâce à notre étroite collaboration avec le Centre Régional de Ressources Génétiques du Nord Pas-de-Calais, dans le cadre du projet INTERREG IV – '*BIODIMESTICA*'. Fruit d'automne, doit se cueillir bien mûre vers la mi-septembre et se conserve plus d'un mois. Fruit allongé, lisse, jaune lavé de rose-orangé ; de bonne à très bonne qualité : croquante, ferme, sucrée-acidulée et d'un bon arôme. Bon pollen, floraison en moyenne saison (Groupe 3-4). Arbre très facile à conduire en axe central, très rapide à se mettre à fruits, très fertile et très peu alternant. Jusqu'à présent, très faible sensibilité aux principales maladies.

M. Lateur, T. Donis, A. Rondia, L. Delpierre, R. Stiévenard : Variété « RGF-Gblx » diffusée par le CR GEMBLOUX, saison 2011

Four main fruit bearing habits



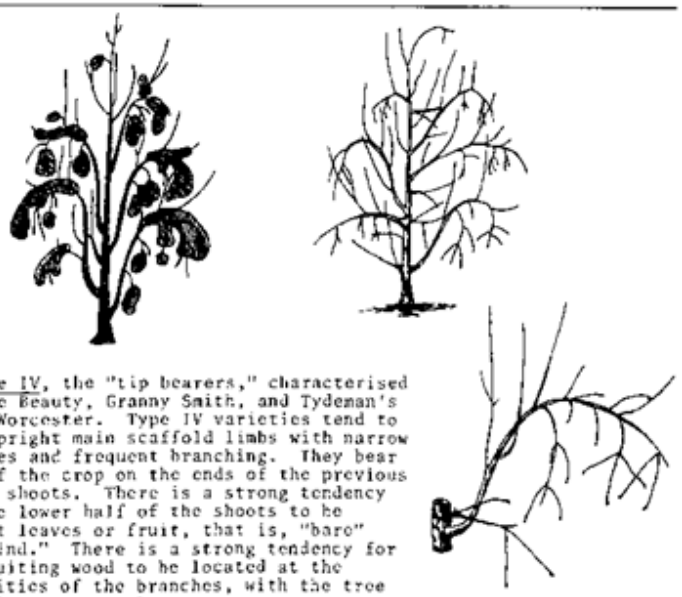
Type I, spur types, characterized by Starkrimson Delicious. Type I trees tend to be upright with narrow crotches and sparse branching. Fruiting occurs on numerous short spurs which are long lived. The zone of fruiting tends to remain close to trunk.



Type II, characterized by King of the Pippins. This is a variation of type I in which branching is more frequent and there is a greater tendency for the fruiting zone to move away from the trunk.

Figure 1. Bearing habit, based on the IXBA system used by Lespinasse

Type III, characterized by ("standard") Golden Delicious. Type III varieties tend to be spreading with wide crotches and frequent branching. They bear on spurs and shoots which are generally 1 to 3 years of age. The fruiting zone tends to move rapidly away from the trunk to the outside of the tree.



Type IV, the "tip bearers," characterised by Rome Beauty, Granny Smith, and Tydeman's Early Worcester. Type IV varieties tend to have upright main scaffold limbs with narrow crotches and frequent branching. They bear much of the crop on the ends of the previous year's shoots. There is a strong tendency for the lower half of the shoots to be without leaves or fruit, that is, "bare" or "blind." There is a strong tendency for the fruiting wood to be located at the extremities of the branches, with the tree spreading as a result.

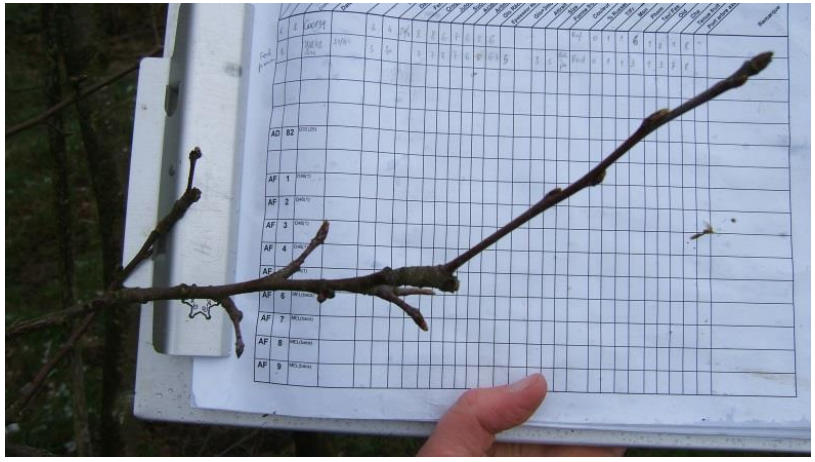
Figure 1. Bearing habit (continued)

Table 27. Main types of fruit bearing habits (Watkins and Smith 1982)

Type	Fruit bearing type	Main fruit position	Reference cultivars
1	Columnar	On spurs only; very few branches.	Wijcik, Bolero, Waltz
2	Type I	On spurs of older twigs only; fruit zone close to the trunk. Upright tree shape.	Starkrimson
3	Type II	On spurs mainly, branching more frequent; fruit zone move slightly away from trunk. Upright tree tendency at the youngest stage, later spreading.	King of the Pippin (Reine des Reinettes), Cox's Orange Pippin, Blenheim Orange, Schone van Boskoop
4	Type III	Fruit zone mostly on 1, 2, 3 years twigs; tendency of moving the fruit zone to the outside of the tree. Spreading tree tendency.	Golden Delicious, Jonagold, Pinova
5	Type IV	Mostly on youngest twigs at the end of long shoots; strong tendency to having zones at the base of branches without fruits or leaves; high tendency of drooping trees.	Granny Smith, Tydeman's Early, Idared

Example of choice of parents

Parents	Maturity	Type fruit bearing	Keeping ability	Acidity	Sugar	Firmness/Crunchy	Scab	Pow. Mild.	Canker	Quality	Robustness
Van Dievoet	Mid 9	II	10-11	8	5	7	Polyg ++	3	4	5	8
Rubinola	Mid 10	IV	05	5	5	8	Vf	4	4	6	4



Strategy : close trans-border collaboration

The *Centre Régional de Ressources Génétiques Hauts de France - CRRG*

BIODIMESTICA
Nord-Pas-de-Calais/Wallonie

INTERREG IV
France • Wallonie • Vlaanderen

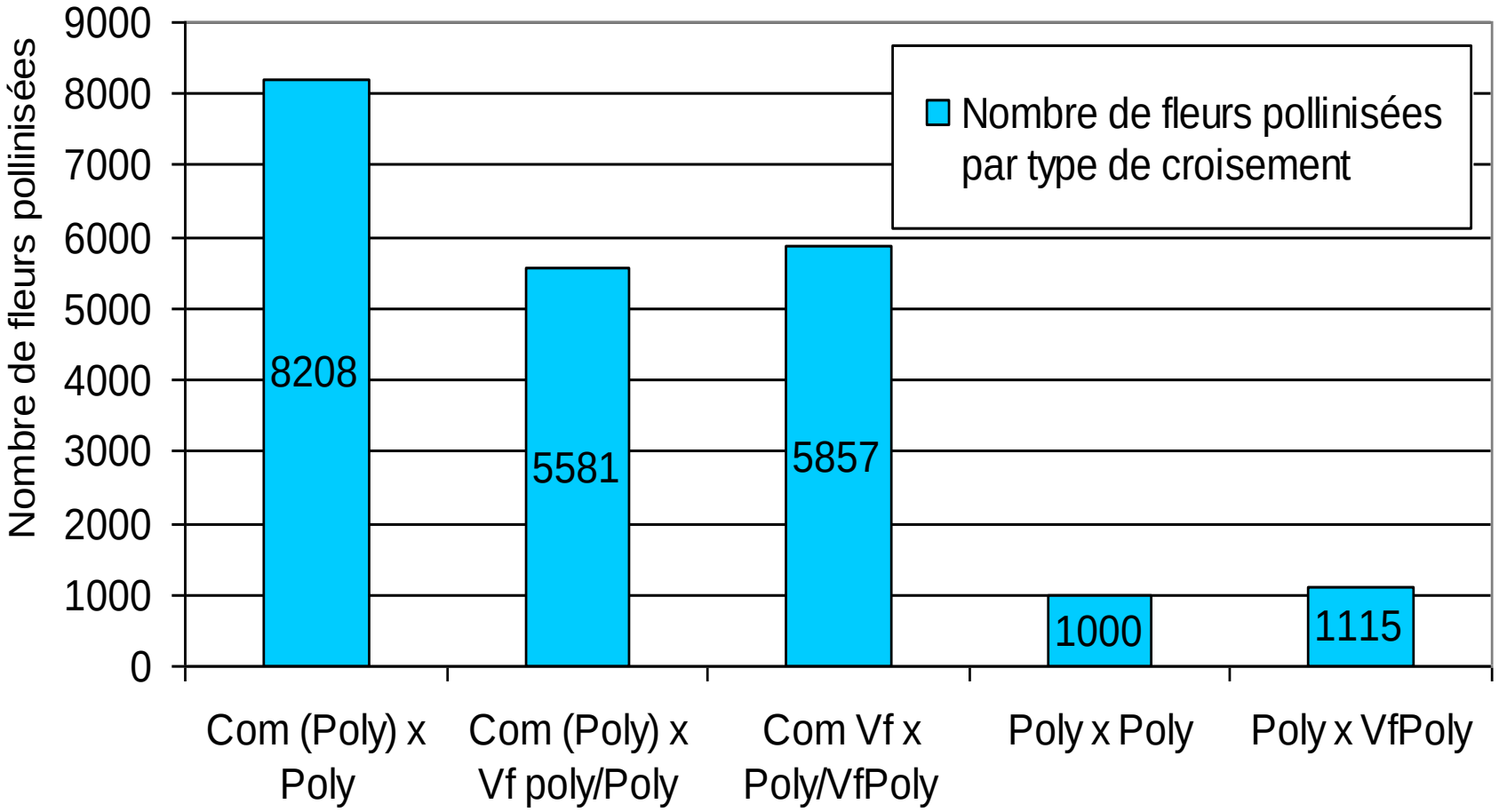
The *Centre Wallon de Recherches Agronomiques - Gembloux - CRA-W*

SYNERGIES & sharing ideas, material, expertises…

Hand-Pollinination - *Beefly*

4. *Use of Fruit Genetic Resources in breeding – a chain of actions…*

Different strategies of crosses



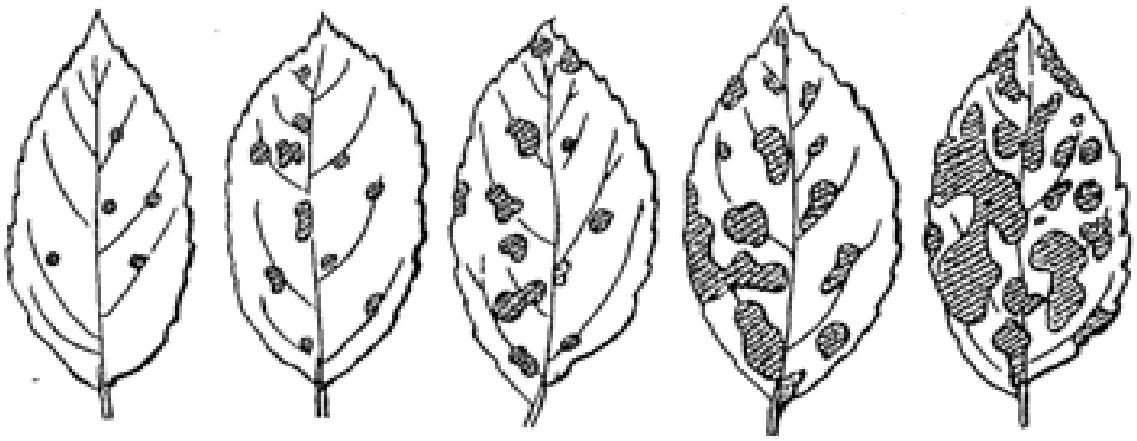
5. Screening methods adapted to polygenic resistance

- Mix of d**iversity of local wild scab strains + specific Rv virulent races**

- **Standardization of inoculum doses:**
  - Rv genes = 3. 10^5 conidia viables/ml
  - Polyg resistance = 1,5. 10^5 conidies viables/ml
- **Standardization of the inoculation** : QUANTITAIVE INOCULATION

5. Screening methods adapted to polygenic resistance

➢ **Using a QUANTITATIVE assessment scale:**



Evaluation de la surface atteinte

0%	1% – 5%	±10%	±25%	25-50%	>50-75%	>75%
0	1	2	3	4	5	6

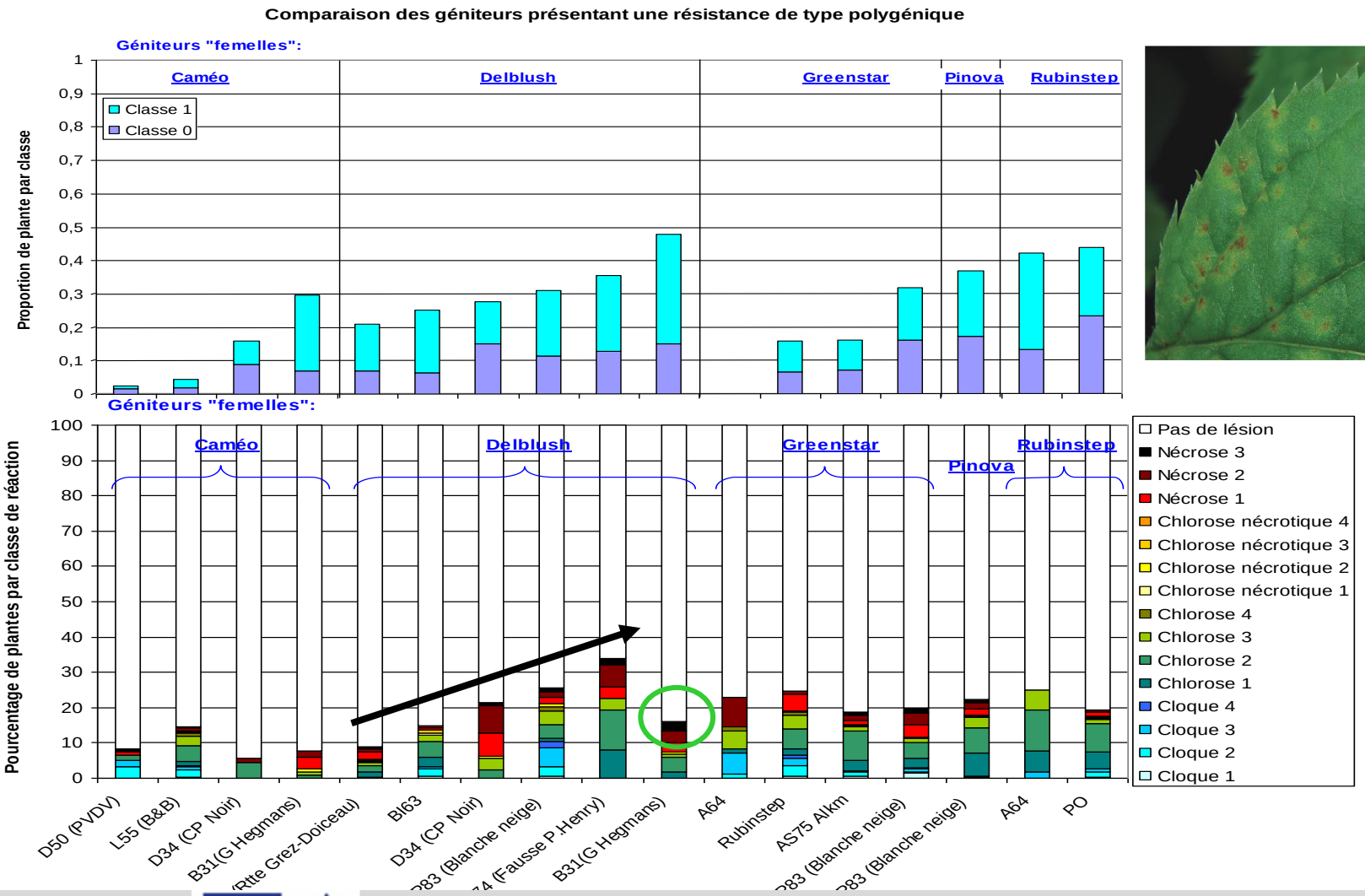
Classe de sévérité

Selection

Elimination

5. Screening methods adapted to polygenic resistance

In specific crosses = leaves defense reactions : necroses & chloroses



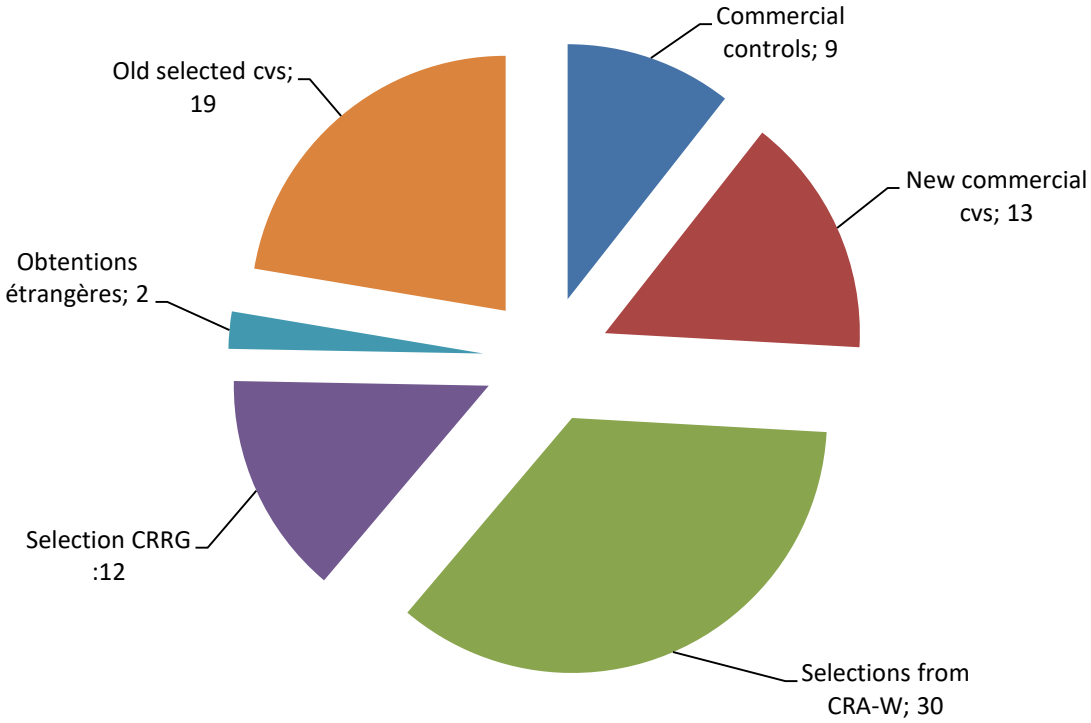
6. Participatory Breeding Program (PB) - Results

Transborder participatory breeding (PB) programme with private growers (Organic) - 2014

6. Participatory Breeding Program (PB) - Results

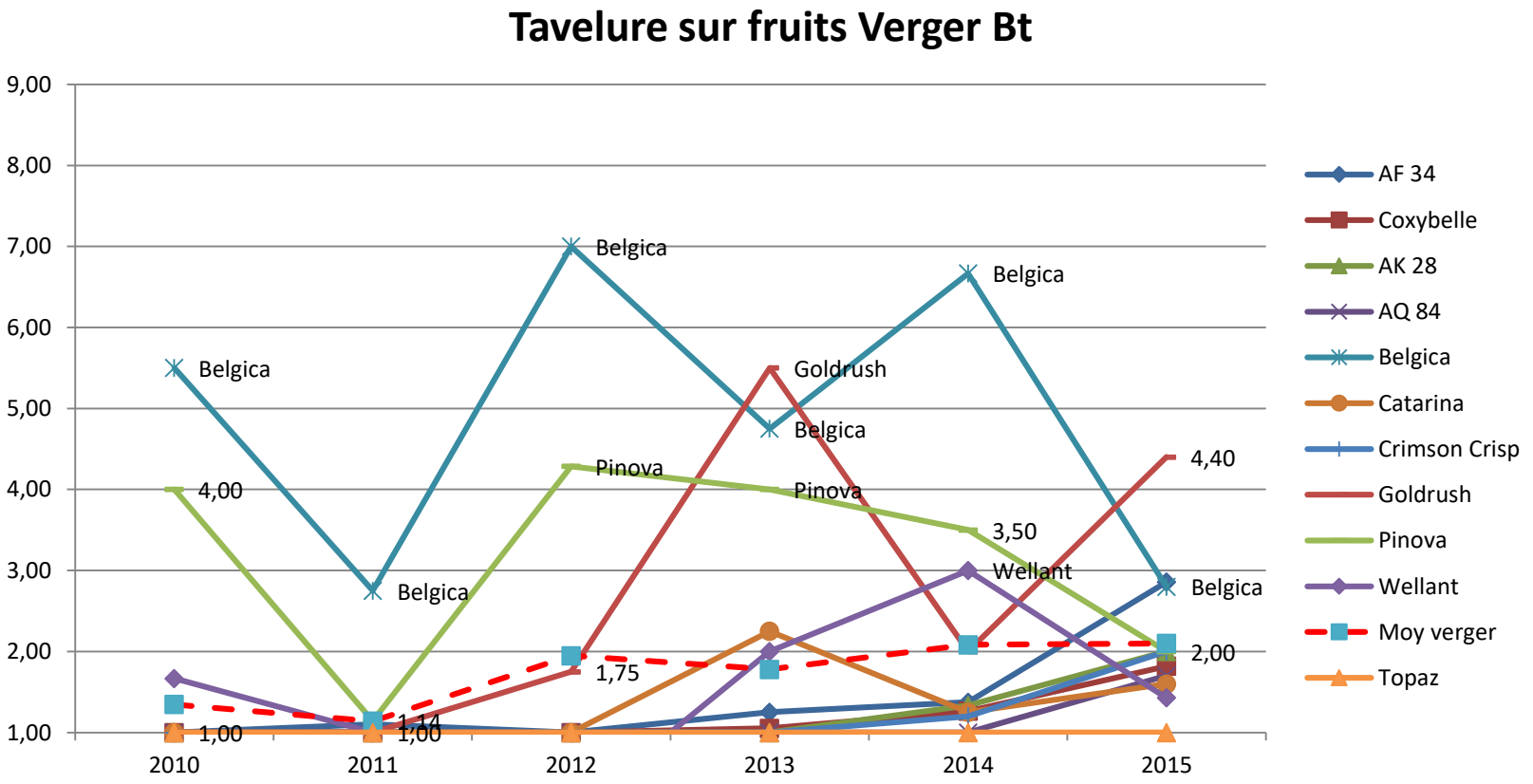
Trans-border selections & cvs organic trials evaluated with growers

- Organic trials on 2 sites



6. Participatory Breeding Program (PB) - Results

Scab cvs susceptibility in organic trials



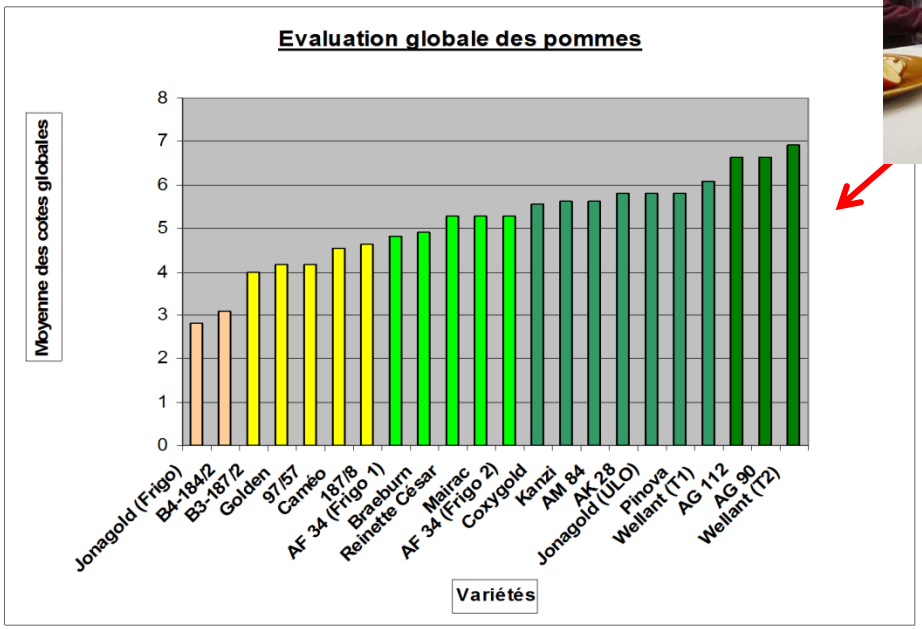
6. Participatory Breeding Program (PB) - Results

Network of growers for testing new cvs

- **'Coxybelle' - AG 90**

- Combination of **Vf** gene & polygenic quantitative genes from the old cv **'Président Van Dievoet' x 'Rubinola'**
- **Good size, average yield**
- **Tendency to biennal yield!**

Very good taste and aroma but variability in quality – much better quality in low input orchards!!!!
Automn – early winter cv



6. Participative Breeding Program (PB) - Results

Selection CRA-W – Ma-AQ 84

‘Reinette Libotte’ *x* **‘Rubinola’** (Polyg x Rvi6)

- Easy tree training
- Type III - IV
- Low susceptibility to scab
- Fruit with high firmness & very long shelf life
- Acidic/sweet
- **Very regular quality!**
- Keeping ability up to April-July in a +5°C cold chamber
- Average size = 160 - 190 g

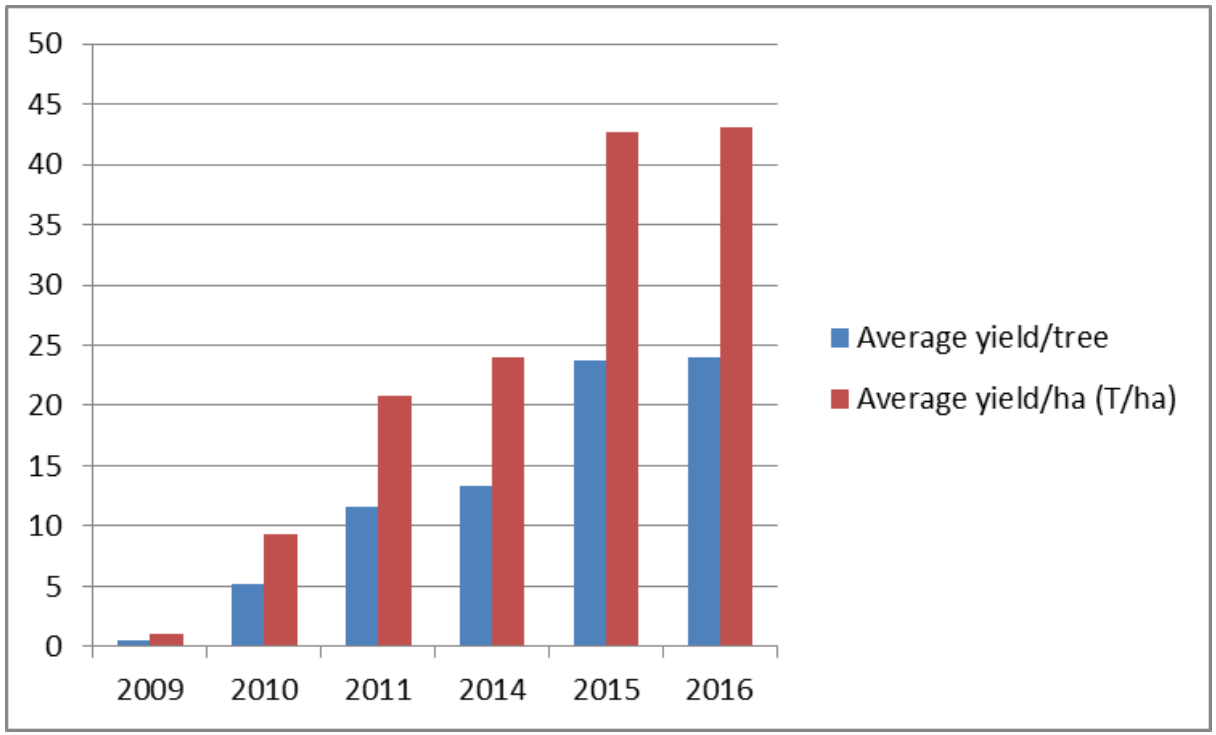
6. Participative Breeding Program (PB) - Results

Selection CRA-W – Ma-AQ 84

WAGENINGEN UNIVERSITY & RESEARCH

Résuls from The Netherlands

Plantation 2008 – 3,5 x 1,25 m – M 9/ Golden D. (n=5)



6. Participative Breeding Program (PB) - Results

Transborder participatory breeding programme with private growers (Organic)

« NOVAFRUITS – Heritage & sharing innovation »

- **Transborder participatory breeding association**
- **29 organic regional growers**
- **2 public Regional Institutes**
- **Collaboration Agreements**

espaces naturels régionaux
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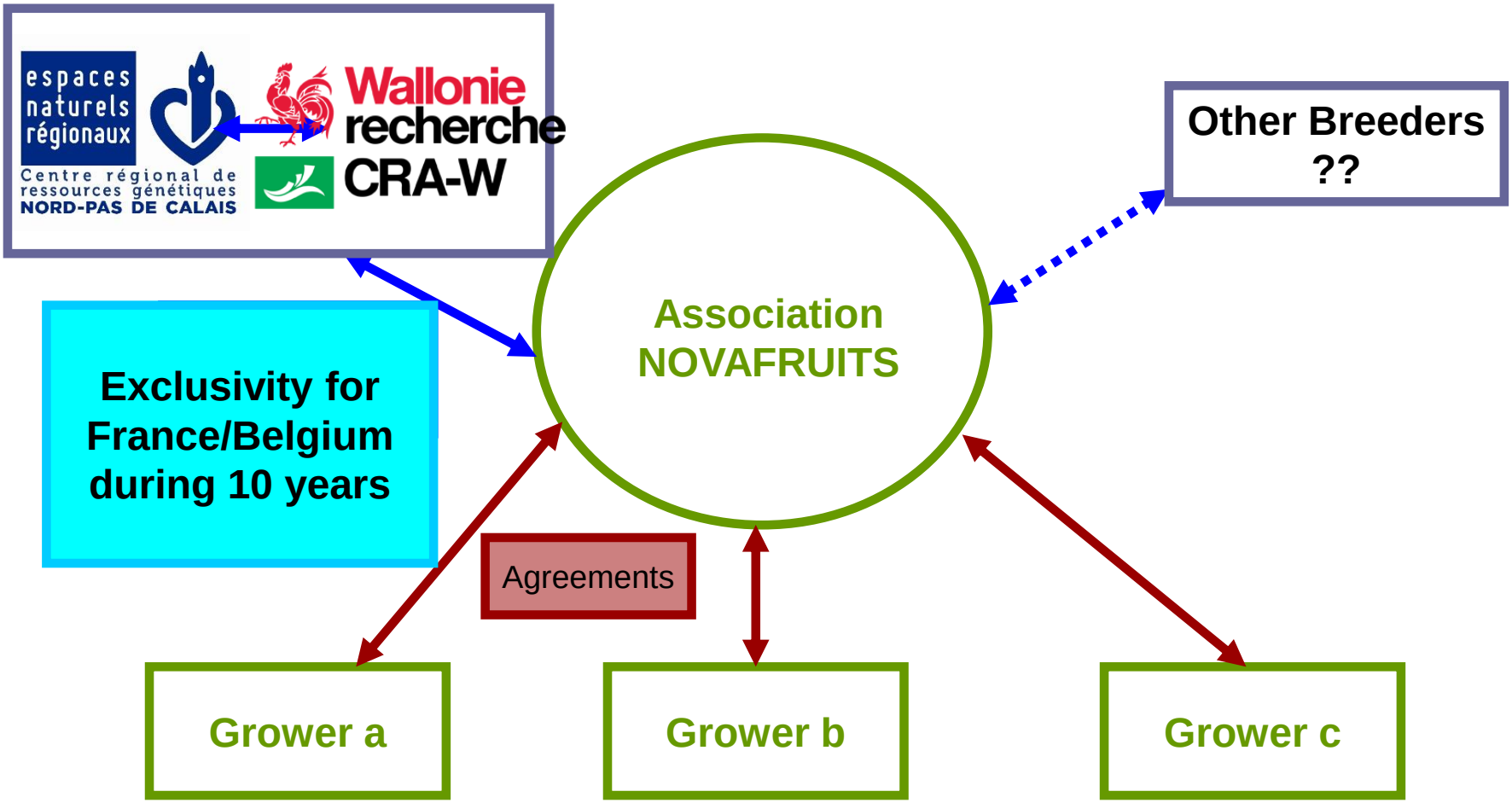
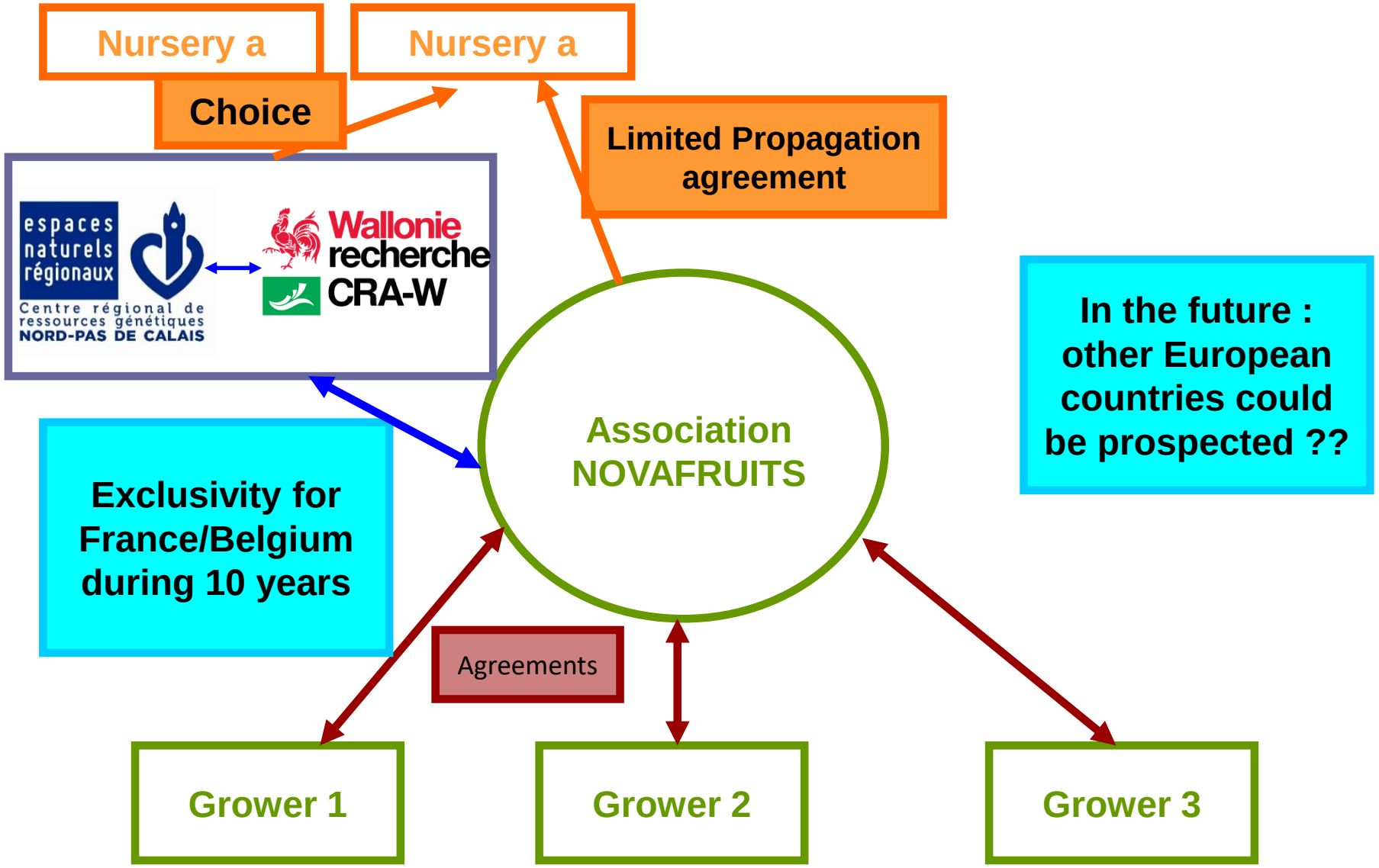
Nord-Pas-de-Calais/Wallonie

« NOVAFRUITS – Heritage & sharing innovation »



« NOVAFRUITS – Heritage & sharing innovation »



11 selections under trial by growers associated to NOVAFRUITS

•187 / 02

204 / 23

187 / 05

124 / 33

Coxybelle

BK 75

AK 28

AQ 84

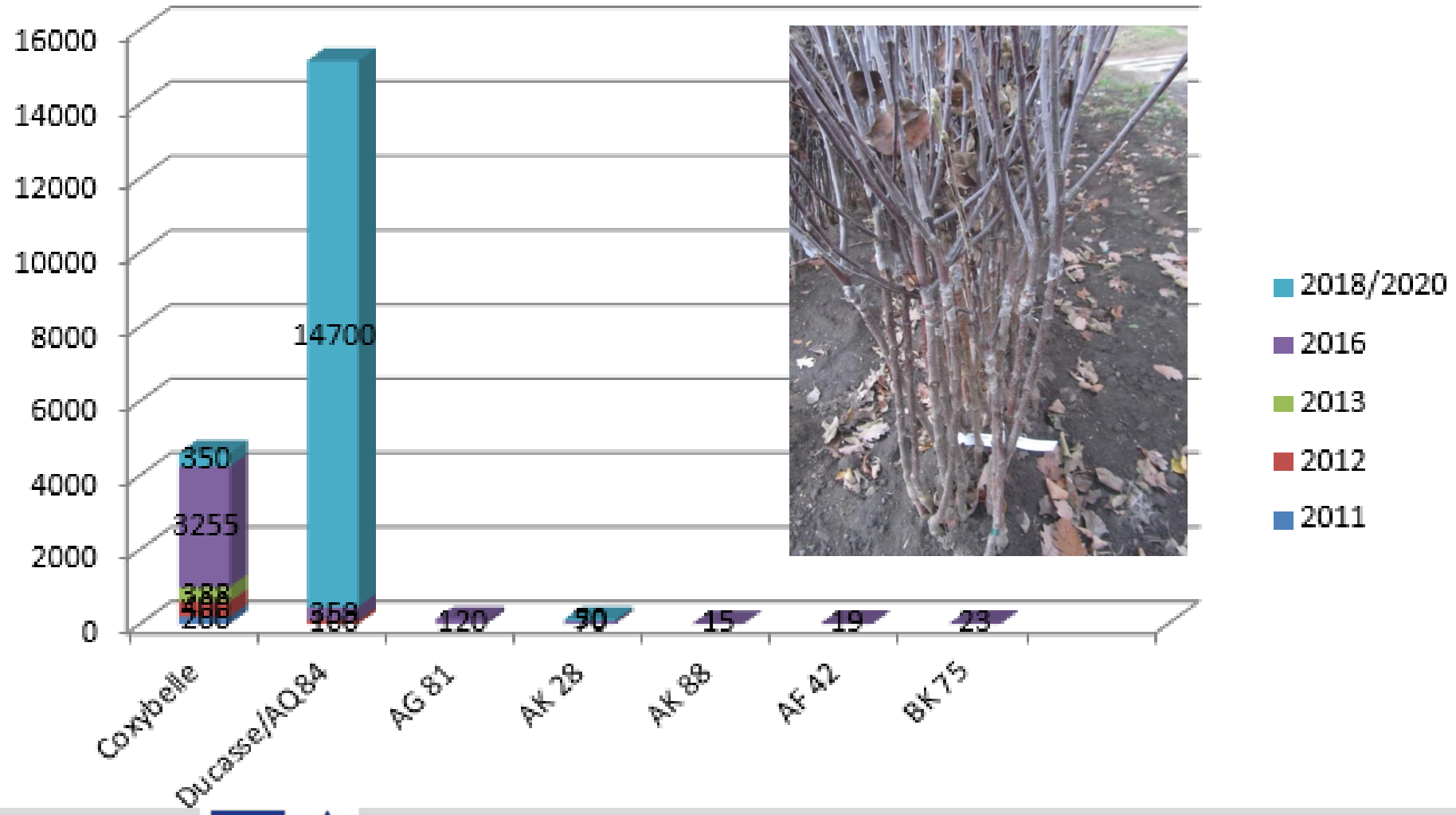
AG 81

AK 88

AF 42

Current situation - # trees planted &/or ordered…

21% in IFP **13% on MM 111 rootstock**



7. Experiences on PB efficiency

- Collaboration with private partners boost efficiency : more precise and short time objectives + rich & complementary expertises,
- Scientific public Institutes offer confidence to local citizens and is an added value for private enterprises
- One key is transparent networking with clear agreements definition
- Such succesful utilization of FTGR is a clear demonstration of usefulness of PGR conservation for both citizens and decision makers – it boosts public awareness!
- A key corner is to develop elaborated process of EVALUATION - long term non-sprayed evluation orchards = co-evolution between host and pathogens diversity strains
- Practical organization with private sector needs to be at a professional level – high threshold of efficiency + high quality propagation material!
- Such relationship with commercial nurseries is surely not obvious at all!
- Scientist/private partners need to speak same language: time consuming, always looking for innovation and enhancement – and with fair and democratic processes.

8. Perspectives…

To go ahead in our breeding work…

In 1946 started in US the “COOP” co-breeding programme between :

Purdue University
Rutgers University ‘Prima’, ‘Priscilla’, …
Illinois University
New York Experimental Station Geneva

Why not creating together a EUROPEAN Network of participatory breeding regional NOVAFRUIT associations???

“European Cooperative Network for Participatory Fruit Breeding” ?????