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Breeding apples with broad genetic basis

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Outline

- Apple breeding targets at Wädenswil
- The challenge to broaden the genetic basis
- Project ‘Use of apple genetic resources for organic growing’
- Description of Swiss apple genetic resources
- Selection of top candidates for breeding
- Breeding for durable disease resistance with broad genetic background
- Conclusions and outlook

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Apple breeding targets

- **High fruit quality**
- **good tree features (yield, self thinning, etc.)**
- **Disease resistance**

a) combined resistances

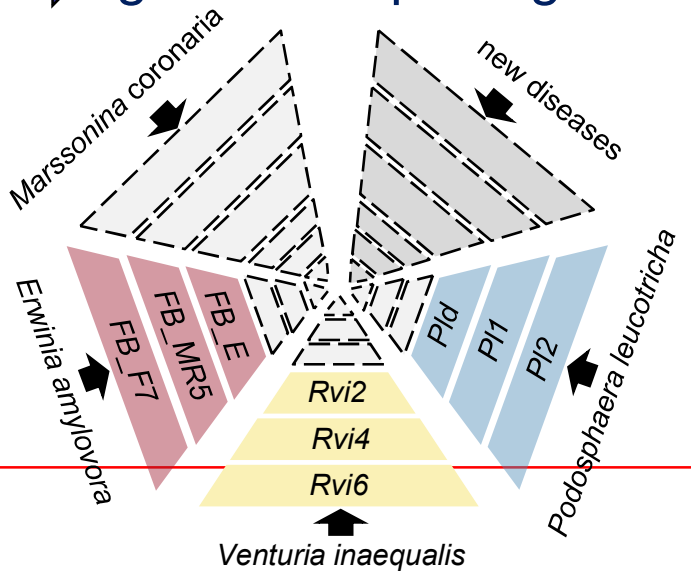
'major genes' and 'polygenic'

→ against different pathogens

- Fire blight (*E. amylovora*)
- Apple scab (*V. inaequalis)*
- Powdery mildew (*P. leucotricha)*
- Leaf blotch (*Marssonina*)
- Canker (*Nectria)*
- Storage diseases
- …

b) pyramided resistances

→ against one pathogen



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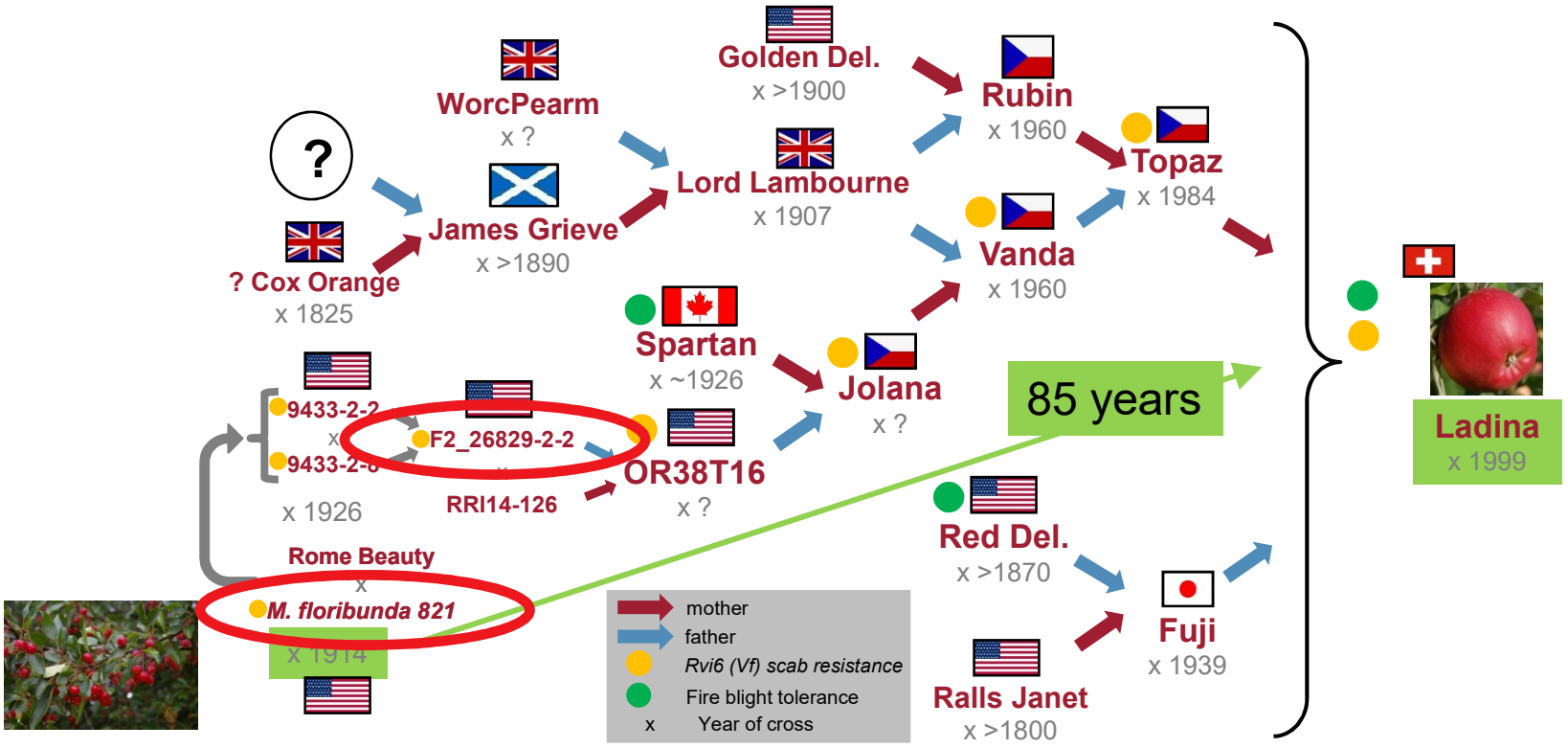
The challenge

- Genetic basis in apple breeding is relatively narrow. 6 founders are predominant: Golden Delicious, Cox Orange, Jonathan, McIntosh, Red Delicious, James Grieve (Bannier, 2011).
- Scab resistance (*Rvi6, Vf*) is also based on a few founders



Use of apple genetic resources for breeding (NAP-project 2016-2019, funding FOAG, Swiss Federal Office for Agriculture)

Project partners

- Agroscope www.agroscope.ch
- Poma Culta (organic dyn.) www.pomaculta.ch
- FiBL (project coordination) www.fibl.org

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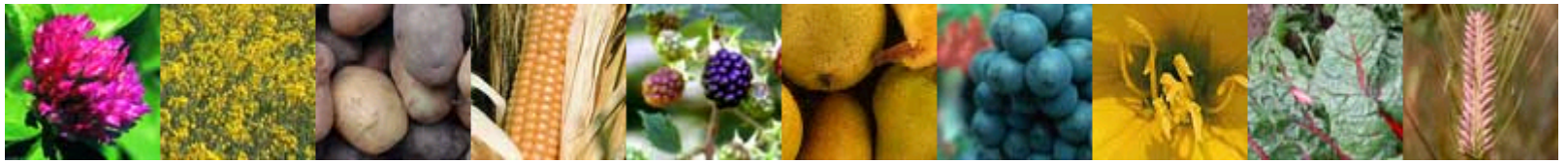
Swiss National Plan of Action on Plant Genetic Resources for Food and Agriculture (NAP-PGRFA)

„aims at the long term conservation and sustainable use of **P**lant **G**enetic **R**esources for **F**ood and **A**griculture“

Concerns agricultural species and their wild relatives

www.bdn.ch



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NAP PGRFA – Projects of Fructus/Agroscope to describe the Swiss apple genetic resources

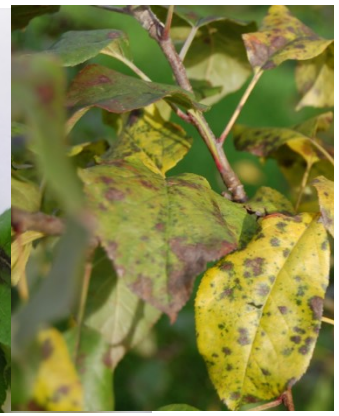
- 2007 - 2010 BEVOG
- 2011 - 2014 BEVOG II
- 2015 - 2018 BEVOG III, NUVOG, WEBEVOG, NEVA
- 2019 - 2022 BEVOG IV and NUVOG II

1308 *Malus* accessions in field for disease evaluation

2 series with accessions to test for *V. inaequalis,*

P. leucotricha, partially E. amylovora and *M. coronaria susceptibility:*

- 608 accessions from 2009 (2nd leaf) - 2014
- 735 accessions from 2017 (2nd leaf) - 2023
- Two trees on M27, no fungicide treatments except in first leaf
- Golden Delicious and Gravensteiner as susceptible references



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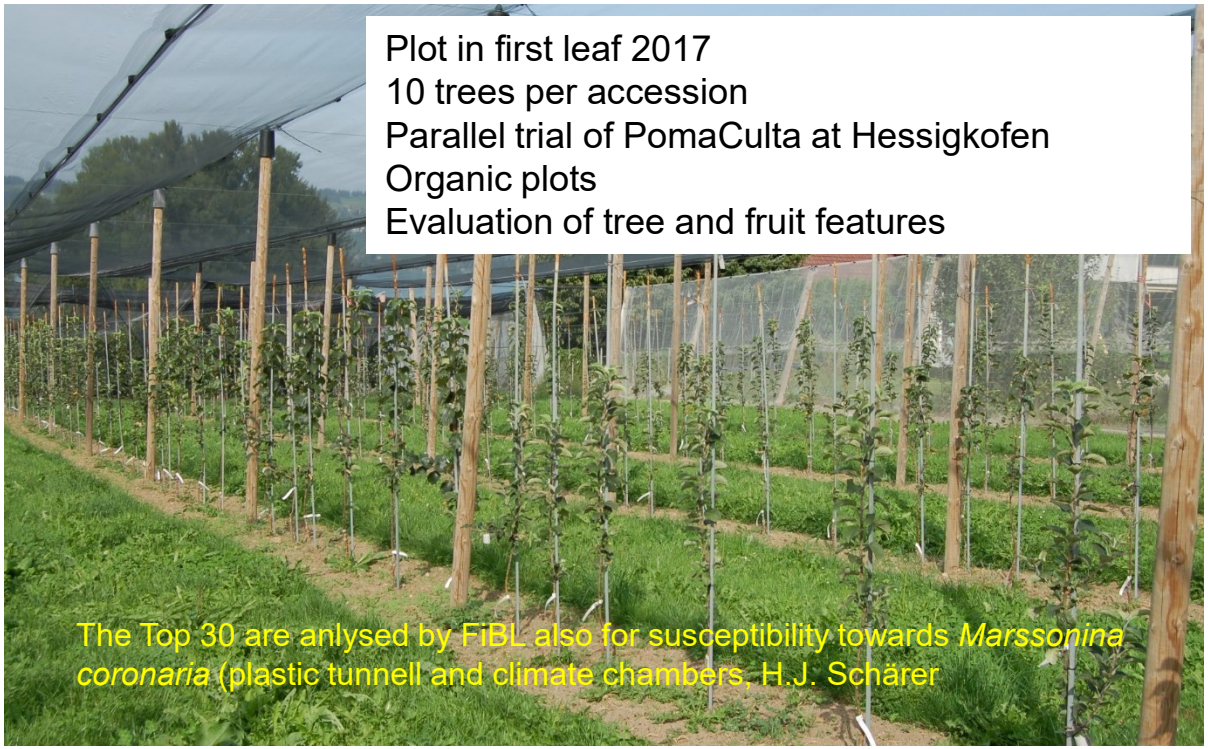
The ‘Top 30’ for scab and powdery mildew tolerance out of 600



Plot in first leaf 2017
10 trees per accession
Parallel trial of PomaCulta at Hessigkofen
Organic plots
Evaluation of tree and fruit features

The Top 30 are anlysed by FiBL also for susceptibility towards *Marssonina coronaria* (plastic tunnell and climate chambers, H.J. Schärer

Schorenapfel
Midonette
Lanterne
14-001-2226 unbekannt
Süsser Zila
Brunnerapfel
Zimtapfel
Sonnenwirts
Nägelimalzer
Kaister Feldapfel
Gulielmo / Glanzreinette
Siebensüss
Seegässler
Gurwolfer
Erdbeerapfel
31058 unbekannt
Brienzer
Ohnegleichen
Batschueli
unbekannt
82297 unbekannt
Gruniker
Chleisler
Eierapfel
103951 unbekannt
Büppiapfel
Züsigärtner
105480 unbekannt
Boskoop Schmitz-Hübsch (NUK, Kontrolle))
Empire (NUK, Kontrolle)
105722 Eierapfel

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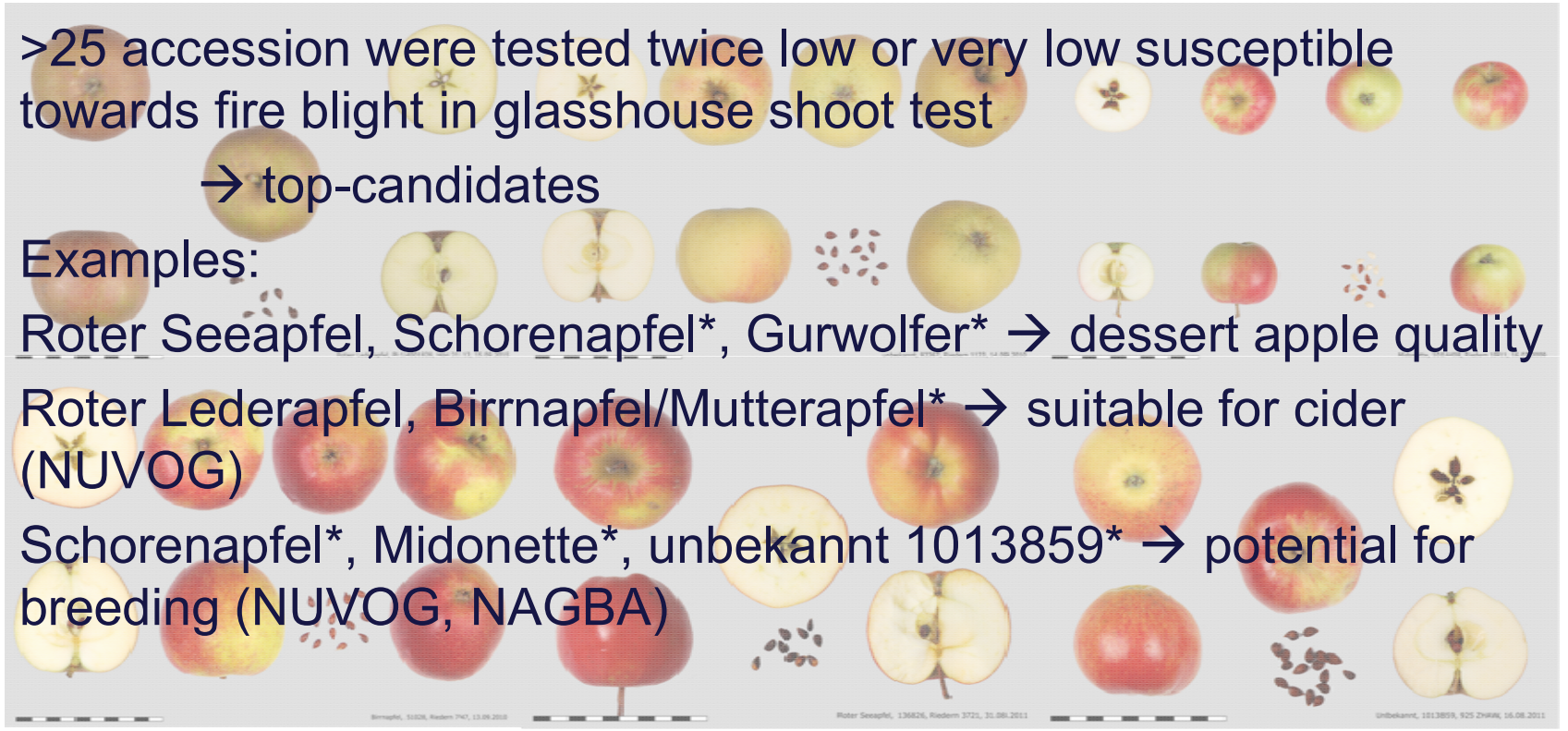
Apple accessions with potential for breeding



>25 accession were tested twice low or very low susceptible towards fire blight in glasshouse shoot test

→ top-candidates

Examples:

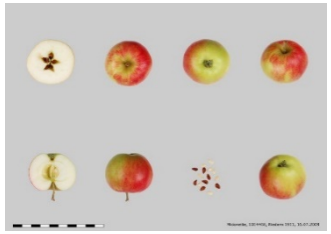
Roter Seeapfel, Schorenapfel*, Gurwolfer* → dessert apple quality

Roter Lederapfel, Birrnapfel/Mutterapfel* → suitable for cider (NUVOG)

Schorenapfel*, Midonette*, unbekannt 1013859* → potential for breeding (NUVOG, NAGBA)

* Additionally highly tolerant towards scab and powdery mildew

Accessions used as parents in the NAP-PGRFA project NUVOG


Midonette

Wehntaler Hagapfel

Bovarde

Brienzer

Schorenapfel

Züsigärtner

unbekannt 105538

unbekannt 103951

Heimenhofer

unbekannt 1013859

Mutterapfel (Birnapfel)

Kaister Feldapfel

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Scale for scoring macroscopic scab symptoms (based on Lefrancq et al., 2004)

Class	Symptoms
0	No visible symptoms
1	1 to < 5 % sporulation leaf surface
2	5 to < 10 % sporulation leaf surface
3	10 to < 25 % sporulation leaf surface
4	25 to < 50 % sporulation leaf surface
5	50 to < 75 % sporulation leaf surface
6	75 to < 100 % sporulation leaf surface

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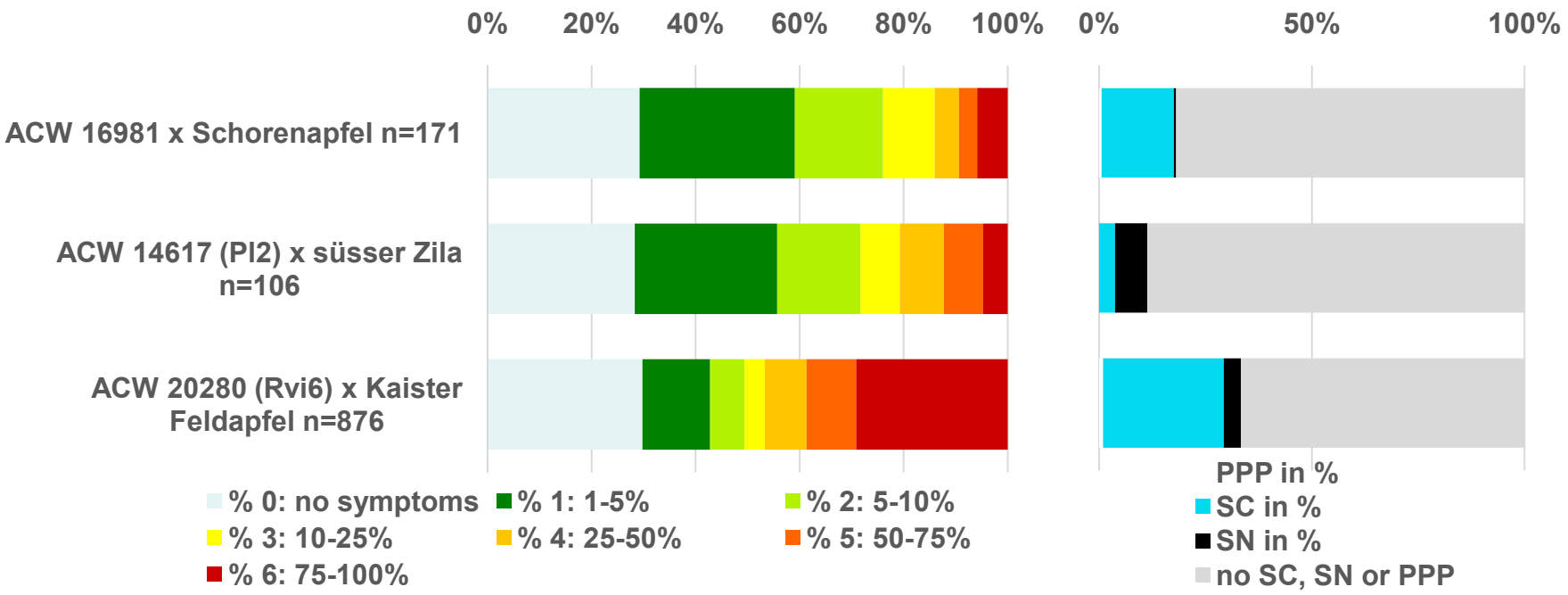
Scab classification of three progenies of the project



0-25 % considered “resistant”, more than 25% considered “susceptible” and discarded pinpoint pits (PPP), stellate chlorosis (SC) and stellate necrosis (SN), n = number of seedlings

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Molecular analyses of parents used in the joint NAP-project

Accession (Parents)	SSR Markers present for
ACW 14617 (Champagner Reinette x A 810-390)	*Pl2*
ACW 16981 (La Flamboyante x Milwa)	*Md-ACS1*
ACW 20280 (Ariane x Topaz)	*Rvi6, Md-ACS1*
Kaister Feldapfel	-
Schorenapfel	*Md-PG1*
Süsser Zila	*Md-PG1*

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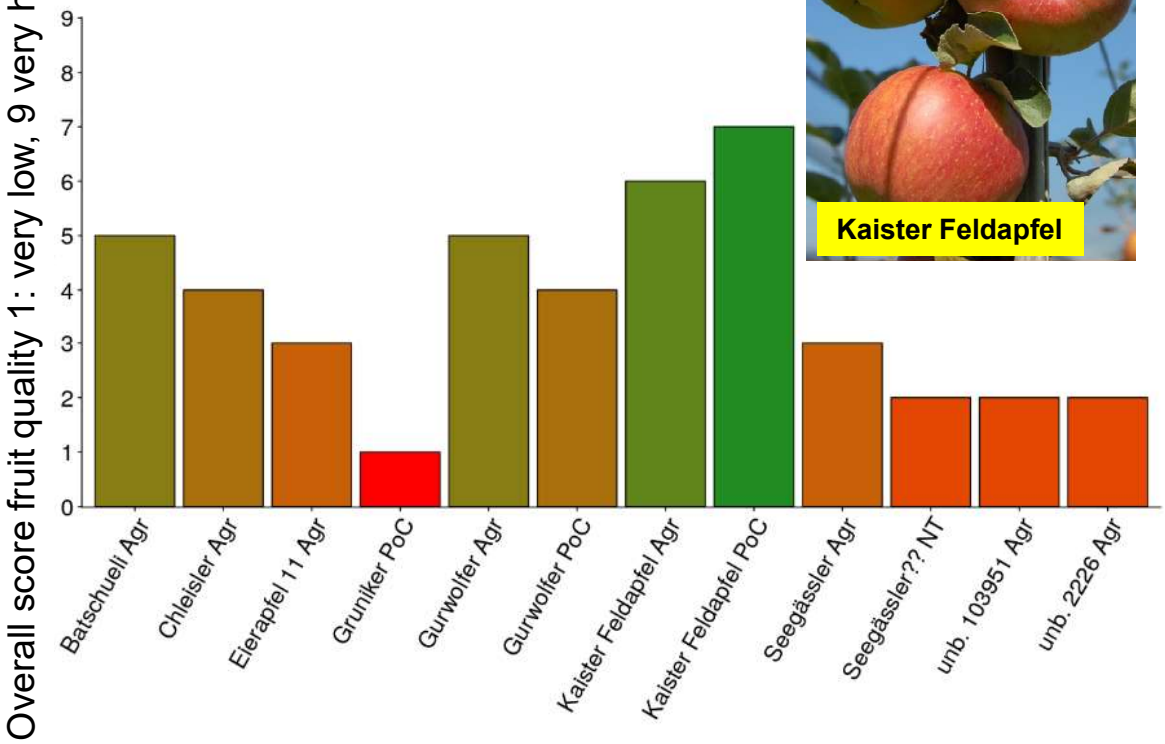
Molecular Analyses – Progeny plants

After pre-selection in container plot:

Cross	Parents	n	Rvi6	PI2	Md-ACS1 (1/2)	Md-PG1	Share of (combined) genotypes
1635	ACW 16981 (Md-ACS1) x Schorenapfel (Md-PG1)	21	-	-	-	38%	38% Md-PG1
1636	ACW 14617 (PI2) x süsser Zila (Md-PG1)	48	-	92%	54%	-	52% PI2, Md-ACS1 (1/2)
1637	ACW 20280 (Rvi6, Md-ACS1) x Kaister Feldapfel (-)	176	81%	-	-	17%	13% Rvi6, Md-PG1

Markers for resistance: scab, mildew, fruit quality

Sensory evaluation (20.11.18, n=4)



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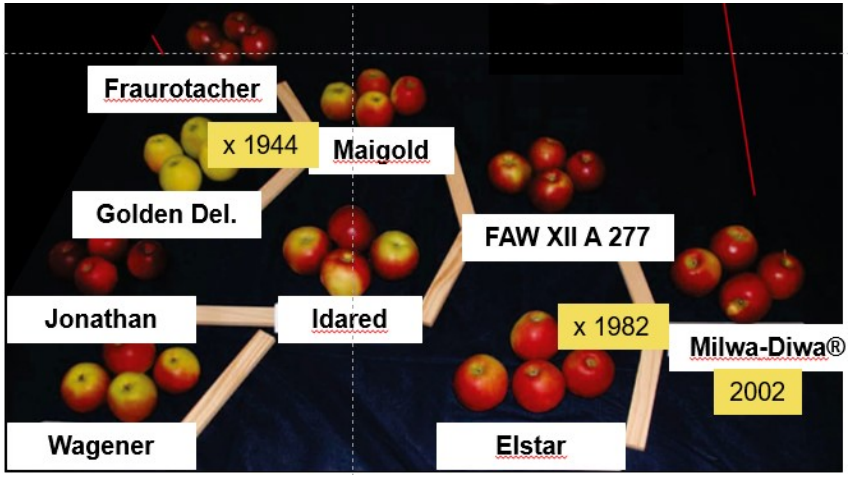
What is in the pipeline?

ACW 16981: Milwa x La Flamboyante
ACW 19978: ACW 12556 x Sternapi (Top 3 NAGBA)
ACW 21578: Opal x Ohio Reinette (Top 3 NAGBA)
ACW 25831: ACW 13340 (Discovery x Durello di Forli) x CH-Alant (Top 3 NAGBA)



Conclusions and outlook

- Selected apple accessions (genetic resources) are potentailly interesting breeding parents that allow for a broader genetic basis
- The better the accessions are charcterized the more useful these data are for breeders
- Joint efforts of Agroscope, FiBL and Poma Culta allow for a breeding think tank and for coordinated progress
- Marketers and consumers should be open for more diversity and it's added value

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Thank you for your attention

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