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Accelerated generation cycle “Fast Track” used for stacking *R*-genes in apples

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Introduction

Reducing juvenility allows an acceleration of the generation cycle which is crucial in breeding perennial fruit tree species such as apple (*Malus domestica* Borkh.). This becomes even more important when wild *Malus* species are used for the introgression and stacking of new resistance genes (*R*-genes) against the same or different diseases. In such a case, at least four to five pseudo backcross generations in the pre-breeding process are necessary to improve fruit quality up to a commercial level.

Results

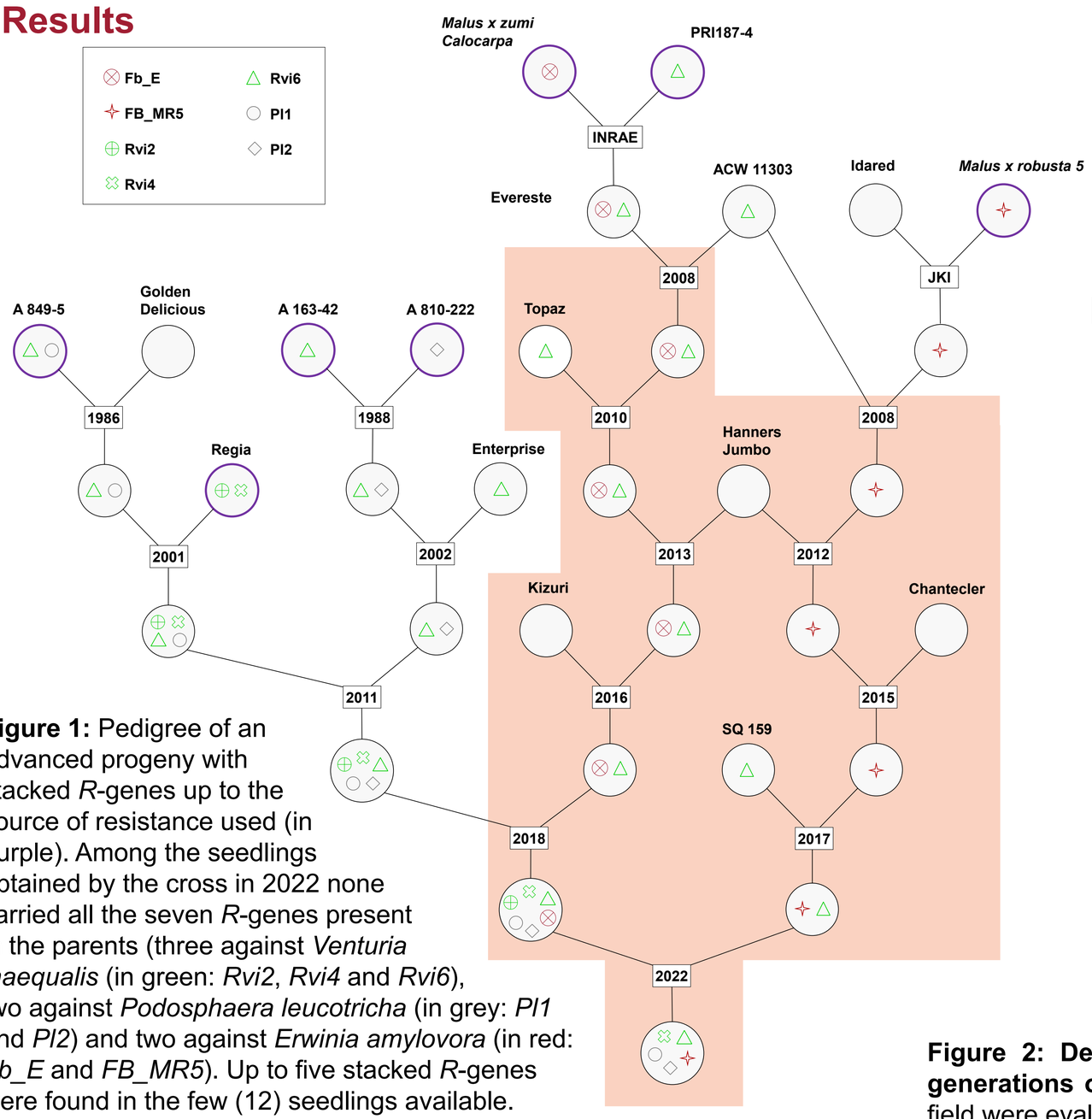

Figure 1: Pedigree of an advanced progeny with stacked *R*-genes up to the source of resistance used (in purple). Among the seedlings obtained by the cross in 2022 none carried all the seven *R*-genes present in the parents (three against *Venturia inaequalis* (in green: *Rvi2*, *Rvi4* and *Rvi6*), two against *Podosphaera leucotricha* (in grey: *Pl1* and *Pl2*) and two against *Erwinia amylovora* (in red: *Fb_E* and *FB_MR5*). Up to five stacked *R*-genes were found in the few (12) seedlings available. Crosses made using the “Fast Track” method are indicated in the orange box.

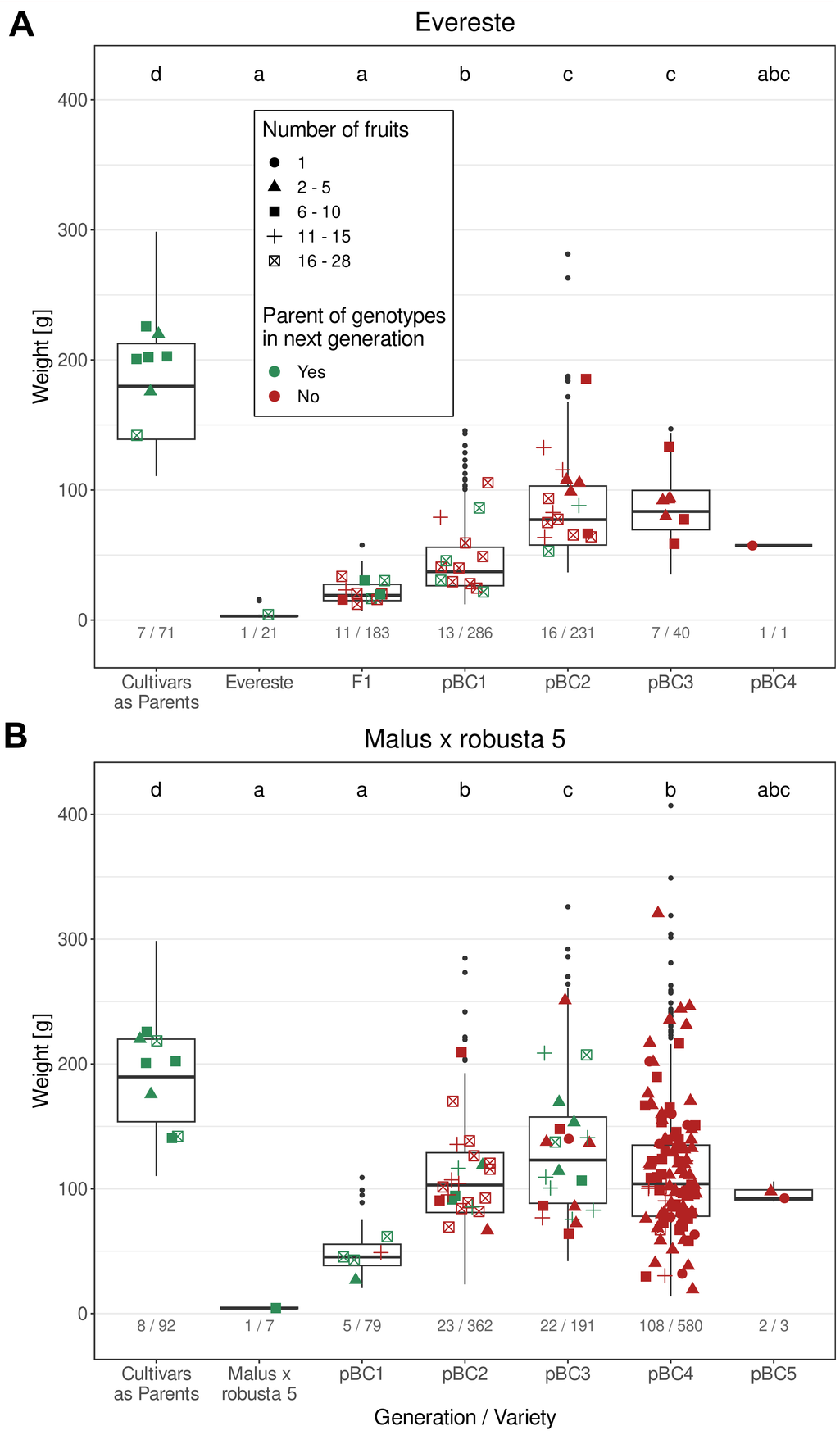

Figure 2: Development of single fruit weight across pseudo backcross (pBC) generations of Evereste (A) and *Malus x robusta 5* (B). Only fruits harvested in the field were evaluated. The different symbols show the mean fruit weight per genotype. The shape indicates the number of fruits measured and the colour indicates whether a genotype was used as a parent for the next generation. The numbers below the boxes indicate the number of genotypes and fruits considered, respectively. Letters indicate significant differences between generations according to a post-hoc Tukey test ($p < 0.05$).

Method

“Fast Track”, a cost-effective speed breeding approach, has been continuously developed and used in breeding at Agroscope in Waedenswil since 2008. "Fast Track" is a non-GMO based method that uses special growth conditions, including non-limiting irrigation and fertilization, for apple seedlings on their own roots in a standard greenhouse in combination with the application of growth regulators and artificial winter simulation in a cold store. Parents for new introgression cycles are selected based on marker-assisted selection (MAS) for known resistance genes and fruit quality traits, fruit evaluation and phenotypic disease resistance screening (apple scab - *Venturia inaequalis* (Bühlmann-Schütz et al. 2023a) and fire blight - *Erwinia amylovora* (Bühlmann-Schütz et al. 2023b)).

Conclusion

Since the establishment of "Fast Track“ in 2008, six generation cycles in 15 years have been achieved. This leads to an approx. halving of the generation time compared to normal crossing in the field. Targeted parental selection allowed stacking of up to six *R*-genes over the years. Fruit quality (i.e. fruit weight) has been steadily improved over the generations.
In the future, the combination of “Fast Track” and genomic selection for fruit and tree quality traits will allow more rapid improvement in the general quality of this precious pre-breeding material.

References
[a] Bühlmann-Schütz, S., Hodel, M., Dorfmann, E., Jung, M., Broggini, G.A.L., Patocchi, A. and Kellerhals, M. (2023). Forty years of scab resistance breeding in apple at Agroscope. Acta Hortic. 1362, 253-262. DOI: 10.17660/ActaHortic.2023.1362.34 | [b] Bühlmann-Schütz, S., Hodel, M., Dorfmann, E., Vonmetz, L., Lussi, L., Patocchi, A. (2023).Comparison between artificial fire blight shoot and flower inoculations in apple. Manuscript submitted for publication.

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