Cherry breeding projects and new rootstocks

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Abstract: The most important advance in rootstock breeding for sweet and sour cherry occurred near the turn of the century, with the commercialization of the Gisela series of interspecific *Prunus* hybrids that conferred precocity, productivity, and a range of vigor levels to scion varieties. This stimulated horticultural and physiological research that led to innovations in sweet cherry orchard production systems, resulting in improved yields, fruit quality, and labor efficiencies. Consequently, Michigan State University sour cherry breeder Amy Iezzoni began evaluating dozens of sour cherry crosses and collected germplasm for their potential as cherry rootstocks, resulting in the Corette® series of precocious and productive dwarfing to semi-dwarfing rootstocks (Cass, Clare, Clinton, Crawford, Lake) and several semi-vigorous, less precocious rootstocks (Lincoln, King). Sweet and sour cherry scions grafted onto the dwarfing to semi-dwarfing rootstocks exhibit relative vigor levels that vary from site to site, based on results thus far from the NC140 coordinated research trials across North America. Relative yields also have varied by site and by year (given some significant impacts of extreme climatic events in some locations). In general, vigor levels and productivity are comparable to those exhibited by trees on Gisela®3 and Gisela®5. In several sites, suckering has been excessive on Clare and significant on Cass and Lake, with minimal suckering generally observed on Clinton and Crawford (similar to Gisela®3 and 5). At least three more years of data from these trials, and other observations, is needed before strong grower recommendations can be made.

Key words: *Prunus avium*, *Prunus cerasus*, interspecific hybrids, intensive training systems, high density, planar canopy architecture

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1. Introduction

Rootstock breeding and selection for sweet (*Prunus avium*) and sour (*P. cerasus*) cherry made a giant leap forward during the final decades of the 20th century, when the research group led by Professor Werner Gruppe at Justus Liebig University in Giessen, Germany, took a methodical approach to creating a series of interspecific *Prunus* hybrids that conferred a range of vigor levels (and other traits) to scion varieties. Until this time, cherry rootstock improvement had been relegated largely to selection of *P. avium*, *P. mahaleb,* or *P. cerasus* seedlings or clones that had slightly improved graft compatibility and/or soil adaptability traits, but little to no vigor reduction nor significantly improved precocity or productivity. Early hybridizations with a broader range of species included the crossing of *P. avium* with *P. pseudocerasus* (resulting in Colt) and with *P. mahaleb* (resulting in the MxM [Mahaleb x Mazzard] rootstock series). Ostensibly, Colt was initially thought to be vigor-limiting, but under well-irrigated (or frequent rain-fed) conditions, it promoted growth as vigorously as standard seedling rootstocks.

Some later use of additional *Prunus* species and interspecific crosses, such as those from the University of Gembloux, Belgium, that utilized *P. canescens*, *P. dawyckensis*, *P. incisa* and *P. serrula*, did achieve significant vigor reduction (resulting in Inmil, Damil, and Camil). However, it was the Giessen program that created the rootstock series commercialized under the name Gisela® that provided a broad range of relatively successful rootstocks from dwarfing (Gisela®3) to semi-dwarfing (Gisela®5) to semi-vigorous (Gisela®6 and 12). Of the various interspecific crosses made in the Giessen program, those that ultimately were released for commercial use were all *P. cerasus* x *P. canescens* or the reverse cross. More recently, two additional precocious, productive rootstocks, semi-vigorous Gisela®13 (*P. cerasus* x *P. canescens*) and nearly full vigor Gisela®17 (*P. canescens* x *P. avium*), have been released. Gisela®3, 5, and 6 have performed very well in temperate locations across Europe and North America; however, under hot, dry Mediterranean-climate locations like California, Spain, and Chile's V and VI regions, they tend to exhibit significant stress. Gisela®12, 13, and 17 have been reported to perform adequately in such conditions given well-managed irrigation.

The widespread availability of these Gisela® rootstocks subsequently stimulated significant innovation in sweet cherry orchard production systems, providing the appropriate plant materials for high density training techniques as well as catalyzing studies of cherry reproductive physiology that significantly advanced the potential for improved yields and fruit quality. In the United States, from the period 1995 to 2020, sweet cherry production increased by 97% and orchard productivity (as measured by average yield per acre) increased by 31%. Certainly, the concurrent genetic advances in self-fertile scion varieties have contributed to these accomplishments as well, but the advent of smaller, more labor-efficient trees opened to door to many more potential cherry growers worldwide.

Other interspecific cherry rootstock hybridization efforts during the late 20th century included the Pillnitz program in eastern Germany led by Brigitte Wolfram (ultimately resulting in the PiKu® rootstocks) and the prolific Russian stone fruit rootstock program led by Gennadiy Eremin (resulting in the Krymsk® cherry rootstocks). The Krymsk® rootstocks were selected under non-irrigated conditions and tend to develop more extensive root systems than Gisela®3, 5, and 6. They are a little less precocious than the Gisela® rootstocks, but they exhibit better anchorage and better growth under hot and dry conditions than Gisela®6 in the semi-vigorous class. In some soils, Krymk®5 tends to sucker excessively, while Krymsk®6 suckering is less but still more than the Gisela® rootstocks. Virus-free budwood should be used with Krymsk®5 and 6, which are hypersensitive to Prune Dwarf (PDV) and Prunus Necrotic Ringspot (PNRSV) viruses. Krymsk®7, a more recent introduction, confers nearly full vigor but reportedly less suckering and no sensitivity to PDV or PNRSV.

In the late 1990s, Michigan State University sour cherry breeder Amy Iezzoni began evaluating dozens of her sour cherry crosses and germplasm for their potential as cherry rootstocks. This resulted in the Corette® series of rootstocks that have recently been released for widespread evaluation and potential commercialization. There are other on-going international cherry rootstock improvement programs, such as the WeiGi® rootstocks that are essentially "next generation" efforts based on plant materials from both the Giessen and the Weihanstephan ("Weiroot") rootstock programs, and certainly major interspecific breeding efforts in China (for which is it difficult to obtain good information, much less plant materials for international evaluation). However, this presentation will primarily provide an update on what is currently known about the Corette® series.

2. The Corette® rootstocks from Michigan State University

The current accessions in the series include Cass, Clare, Clinton, Crawford, Lake, Lincoln, and King. These are licensed to North American Plants, Inc. and Sierra Gold Nursery in the United States; the Agromillora Group in the European Union, the United Kingdom, and South America; and Global Plant Variety Administration Ltd in New Zealand. Although ease of propagation by cuttings was one of the selection criteria for these clonal rootstocks, today they are propagated by tissue culture, and they are graft compatible with sweet and sour cherry. They are also tolerant of PDV and PNRSV. The heritage of each rootstock is as follows (O.P. = open-pollinated):

Cass (aka Corette®1) – O.P. (presumed natural hybrid of *P. cerasus*, *P. avium*, and/or *P. fruticosa*), seed collected in Hungary

Clare (aka Corette®2) – O.P. (presumed natural hybrid of *P. cerasus*, *P. avium*, and/or *P. fruticosa*), seed collected in Hungary

Clinton (aka Corette®3) – O.P. seed of Gisela 5 (*P. cerasus* x *P. canescens*)

Crawford (aka Corette®4) – *P. cerasus* 'Balaton' (aka 'Ujfehértói Fürtös') x 'Gisela 6' (*P. cerasus* x *P. canescens*)

Lake (aka Corette®5) – O.P. (presumed natural hybrid of *P. avium*, and *P. fruticosa*), seed collected in Hungary

Lincoln (aka Corette®6) – *P. cerasus* ('English Morello' x 'Sumadinka') x *P. cerasus* 'Akastoi Korai'

King (aka Corette®7) – *P. cerasus* ('English Morello' x 'Maliga Emléke') x *P. cerasus* (O.P. seedling)

The Corette® rootstocks have only been tested in several sporadic grower trials in Michigan, Oregon, and Washington, plus sweet and sour cherry research trials planted in 2017 that are coordinated across the U.S. in the NC140 Regional Research Project, for which data are expected to be collected for at least 10 years. Consequently, no comprehensive conclusions about each rootstock's various traits have yet been determined to provide strong recommendations for specific production circumstances, but some general conclusions are apparent. Trees on Cass, Clare, Clinton, Crawford, and Lake range in vigor between dwarfing (similar to Gisela®3) and semi-dwarfing (similar to Gisela®5); trees on Lincoln and King are semi-vigorous (similar to Gisela®6). The vigor that trees grafted onto the first five rootstocks exhibit, relative to each other, varies from site to site, and possibly among scion varieties as well. Consequently, soil type and/or water management may significantly influence the relative vigor of each rootstock.

Michigan has two NC140 trial sites with 'Benton' sweet cherry as the scion (near Sparta [SP] and in the northwest [NW] near Traverse City). The SP soil is loamy clay with excellent fertility and water-holding capacity, while the NW soil is very sandy and prone to water stress conditions during periods of drought. The root systems develop under both periodic rainfall throughout the season (promoting more spreading root systems) and drip irrigation during droughts (limiting root system activity to that near the emitters). After seven years, trees on Lake are almost identical in size at the two sites, while trees on Cass, Clare, and Gisela®3 are 50% larger at SP and those on Gisela®5 are 140% larger at SP. This suggests that Lake may be more tolerant of water stress and/or low nutrient availability than Gisela®5, Cass, Clare, or Gisela®3; there are insufficient trees of Clinton or Crawford with 'Benton' to make similar comparisons. At SP, trees on Lake were smaller than trees on Gisela®5, Cass, and Clare, and larger than trees on Clinton or Gisela®3. At NW, trees on Lake were the largest, followed by those on Cass, Gisela®5, Clare, and Gisela®3.

The Michigan sites with 'Montmorency' sour cherry are the same northwest location (NW) but the second site is a similarly sandy southwest (SW) location. At both, the largest 'Montmorency' trees were on Lake; at SW, trees on Clare were similar to Lake in size, followed by Clare, Cass, Gisela®5, Crawford, and Clinton. However, at NW after trees on Lake, those on Gisela®5, Cass, and Clare were similarly slightly smaller, followed by Crawford and Clinton. In the NC140 trials in Wisconsin, 'Montmorency' trees on Lake were the smallest, while they were intermediate among the rootstocks in Utah and New York. Trees on Gisela®5 were the largest in Wisconsin, Utah, and New York.

In Michigan, Cass, Clare, Clinton, Crawford, and Lake also all tend to promote precocity and productivity equal to or greater than Gisela®5, and similar to Gisela®3; precocity and productivity are much lower on Lincoln and King. With 'Benton' sweet cherry, Clinton thus far has the highest yield efficiency in Michigan (SP) and New York, and in Michigan (NW) with 'Montmorency'. However, 'Montmorency' yield efficiency is highest thus far on Lake in Michigan (SW) and on Clare in New York. Those comparisons are based on only 2 to 4 years of data due to spring freeze crop losses. At least three years remain for these trials before strong yield conclusions can be made. In several of the NC140 sites (Michigan, New York, Utah), it is clear that suckering can be excessive on Clare and significant on Cass and Lake, but minimal on Clinton and Crawford (similar to Gisela®3 and 5), which are progeny of Gisela®5 and 6, respectively..

3. Other relatively new cherry rootstocks: the WeiGi series

When the Giessen breeding program ceased upon the retirement of Werner Gruppe, some of the breeding selections were moved to the German University at Freising-Weihenstephan where there had already been some rootstock selection from open-pollinated sour and sweet cherries that resulted in several commercial rootstock releases as the Weiroot® series (e.g., W10, W13, W53, W72, W158, etc.). This collection of materials formed the basis of the eventual rootstock selection program of a grower in the region, Peter Stoppel, which has generated three cherry rootstocks for commercialization in the United States over the past decade:

WeiGi®1 (aka 'STO1') - *P. cerasus* O.P. (presumed to be *P. avium*)

WeiGi®2 (aka 'STO2') - *P. cerasus* x (*P. avium* x *P. canescens*)

WeiGi®3 (aka 'STO3') - *P. cerasus* x (*P. avium* x *P. canescens*)

All three rootstocks are purported to be well-adapted to hot and dry conditions, but have yet to be tested widely in the U.S. WeiGi®1 is considered to be semi-dwarfing to semi-vigorous, similar to Gisela®6; WeiGi®2 is considered to be dwarfing to semi-dwarfing, between Gisela®3 and Gisela®5; WeiGi®3 is considered to be semi-vigorous, similar to Gisela®12. The purported precocity, productivity, and adaptability traits listed in the patents have yet to be confirmed in U.S. trials.

4. Conclusions

Cherry rootstock breeding over the past 40 years has achieved a complete range of vigor control, as well as precocity and productivity. This has been particularly important for sweet cherries produced for fresh markets, since *Prunus avium* is genetically a large, non-precocious, apically dominant forest tree with small delicate fruit, and therefore inherently labor-inefficient for hand-harvesting. With smaller trees and higher productivity, more intensive horticultural management is required to achieve the necessary balance in leaf area-to-fruit ratios for desirable fruit size and quality. Dwarfing precocious rootstocks made it possible to simplify sweet cherry canopies to better estimate, quantify, and manage crop loads to produce good yields of large fruit, leading to unprecedented increases in production worldwide over the past 30 years.

During this time, innovations in canopy training techniques, such as the pedestrian Kym Green Bush (KGB) and planar Upright Fruiting Offshoots (UFO) cordon-based fruiting wall have also achieved less vigorous, simplified, highly structured canopy architectures even on semi-vigorous to vigorous rootstocks. Consequently, future rootstock breeding efforts should build upon the current foundations of 1) precocity, 2) productivity, and 3) various levels of vigor to further advance traits such as adaptation to specific soil conditions (such as higher pH), more efficient uptake of key nutrients (such as calcium), and greater resilience to climatic stresses (such as drought, high summer or low winter temperatures, etc.) as the impact of a changing climate, with greater incidence of extreme events, becomes ever more evident.

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References:

Long, L.E., G.A. Lang, and C. Kaiser. 2020. Sweet cherries. CAB International, Wallingford, U.K., 404 pp. ISBN-13: 9781786398284.

Quero-Garcia, J., A. Iezzoni, J. Pulawka, and G. Lang. 2017. Cherries: botany, production and uses. CAB International, Wallingford, U.K. ISBN: 978-1-78064-837-8.

U.S.P.P. 2015. Cherry rootstock plant named 'STO1'. USPP #25,891.

U.S.P.P. 2015. Cherry rootstock plant named 'STO2". USPP #25,892.

U.S.P.P. 2015. Cherry rootstock plant named 'STO3'. USPP #25,912.

U.S.P.P. 2019. Cherry tree rootstock named 'CRAWFORD'. USPP #30,473.

U.S.P.P. 2019. Cherry tree rootstock named 'CLINTON'. USPP #30,538.

U.S.P.P. 2019. Cherry tree rootstock named 'CASS'. USPP #30,553.

U.S.P.P. 2021. Cherry tree (rootstock) named 'LAKE'. USPP #32,813.

U.S.P.P. 2021. Cherry tree (rootstock) named 'CLARE'. USPP #32,852.

U.S.P.P. 2022. Cherry tree (rootstock) named 'KING'. USPP #34,682.

U.S.P.P. 2022. Cherry tree (rootstock) named 'LINCOLN'. USPP #34,683.

Wertheim, S.J. 1998. Rootstock guide. Fruit Research Station, Wilhelminadorp, The Netherlands, 144 pp. ISBN 90-803462-2-5.