

FINAL REPORT

PROJECT NO.:

CH-01-17

TITLE:

Clonal Rootstock Performance/Evaluations

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OBJECTIVES:

Comprehensive rootstock research is necessarily a long-term project. However, various components of the objectives will be completed annually.

1. Continue evaluation of the NC-140 regional project trial ('Bing' on 17 new rootstocks) established in 1998 for horticultural and physiological evaluations and fruit quality. Projected trial duration is 10 years.
2. Continue evaluating vigor and cropping performance of other orchard trials with key PNW cultivars on various rootstocks: e.g., 'Bing' on 5-6 different Gisela rootstocks in grower trials representing diverse production locations (planted in 1994-95); 'Chelan', 'Tieton', 'Cashmere', 'Selah', and 'Benton' on Mazzard, Mahaleb, 'Colt', 'Edabriz', and various Gisela and Weiroot rootstocks (planted in 1998).
3. Analyze the physiology of interactive rootstock/scion horticultural traits (e.g., canopy leaf area, yield efficiency, precocity, graft compatibility). On-going as personnel allows.

SIGNIFICANT FINDINGS:

1998 NC-140 Trial Rootstocks Training and growth of the 1998 NC-140 trial trees continued and 2003 represented the second significant cropping season for most trees. There existed tremendous variability in fruit yield, fruit quality, and growth in 2003.

In addition, by vigor category from the 1998 NC-140 rootstock trial in 2003:

- the following are **dwarfing** rootstocks (i.e., exhibit vigor reduction of 40 – 50% compared to Mazzard): W53, W72, W154, Edabriz, Gi209/1, and Gi473/10
 - yield was greatest in Gi209/1, Gi473/10, W72, and Edabriz (24 – 29 kg/tree), and lowest in W154 and W53 (13 - 15 kg/tree)
 - W72 exhibited the best combination of yield and quality - over 24 kgs of fruit were harvested averaging 7.7 g with 50 % 10.5-row and larger
- the following are **semi-dwarfing** (i.e., 70 –80% of Mazzard): Gi195/20, Gi5, Gi7, and W158
 - yield was greatest in the Gisela series Gi7, Gi5 and Gi195/20 (34 - 40 kg/tree) and lowest for W158 (19 kg/tree)
 - Gisela 5 exhibited the best combination of yield and quality - over 34 kgs of fruit were harvested averaging 7.2 g with 49 % 10.5-row and larger

- the following are **vigorous** (i.e., $\geq 90\%$ of Mazzard): W13, W10, Gi6, Mahaleb, Gi318/17, and P-50
 - yield was greatest for Gi6 (39 kg/tree) and Gi318/17 (37 kg/tree), intermediate for Mahaleb, W10, W13 (20 – 31 kg/tree), and lowest for Mazzard and P-50 (5 - 6 kg/tree)
 - Gi 318/17 exhibited the best combination of yield and quality - over 37 kgs of fruit were harvested averaging 7.8g with 58 % 10.5-row and larger

Summarizing data from all rootstocks over the 2003 growing season:

- there is no clear relationship between scion vigor and fruitfulness among these rootstocks
- trunk expansion is negatively related to tree yield efficiency (Fig. 2)
- a slight negative relationship ($r^2 \approx 0.1 - 0.5$) existed between fruit yield and quality (e.g., °brix, fruit weight)
- a slight positive relationship ($r^2 = 0.4 - 0.55$) existed between tree vigor and quality
- yield efficiency was closely and negatively related to fruit quality ($r^2 = 0.46 - 0.88$, Fig. 3)
- fruit quality was best on Mahaleb (8.3 g/fruit, 24.4 °brix) and worst on Gisela 7 and 195/20 (6 g/fruit, 17 °brix)

‘Chelan’ Rootstock Trial The 1998 ‘Chelan’ rootstock trial continued to exhibit differential reactions between rootstocks in 2002/2003. One complete replication (4 trees) on Mahaleb have been lost to gopher damage during the winter; no trees on other rootstocks were damaged. Although growth was generally excellent on all rootstocks, the trees on Mahaleb died. About 6% of the trees on Mazzard exhibit a health problem and only 2% of the trees on Colt. None of the trees on Edabriz, Gisela 6, GI 209/1, or GI 195/20 have exhibited any unusual symptoms. All of the trees on Gisela 5 exhibit a minor degree of premature leaf coloration and/or premature defoliation. These results with Mahaleb confirm several grower observations of tree mortality on Mahaleb.

WSU Variety Rootstock Trial Varieties included in this trial are: Chelan, Tieton, Benton, Selah, Rainier, and elite selections PC 8011-3, PC 7147-9, and PC 7903-2. 2003 represented the second crop on most rootstocks. Rootstock impacted scion precocity and fruit quality tremendously. In general, fruit quality was excellent, particularly compared to similar aged ‘Bing’ trees of the NC-140 trial, with a high percentage of fruit being 10.5-row and larger.

Across all scion varieties:

- fruit soluble solids were highest on Edabriz and Gisela 209/1 (~ 22 °brix) and lowest on Gisela 6 (~ 19 °brix)
- individual fruit mass was lowest for Edabriz (9.5 g), and highest on Gisela 195/20 and Gisela 6 (> 11 g)
- yields were highest on Gisela 6 and 5 (22 and 19 kg/tree, respectively), 50% less on Edabriz, and 70% less on Gisela 209/1
- fruit row-size distribution was excellent from all rootstocks but best on Gisela 195/20 (97% 10.5-row and larger) and worst on Edabriz (71% 10.5-row and larger)
- fruit firmness was excellent on all rootstocks (>290 g/mm) but highest from Gisela 5-rooted trees

METHODS:

The 1998 NC-140 plot was planted at WSU-Prosser’s Roza Experimental Unit, with ‘Bing’ as the scion cultivar and ‘Van’ as the pollinizer, on the German rootstock series Gisela 4 (GI 473/10), Gisela 5 (GI 148/2), Gisela 6 (GI 148/1), Gisela 7 (GI 148/8), GI 195/20, GI 209/1, and GI 318/17;

the German rootstock series Weiroot 10, W13, W53, W72, W154, and W158; Edabriz (France); P-50 (Japan); and Mazzard and Mahaleb seedlings as controls. There are 8 replications/rootstock, with guard tree around the plot perimeter, and tree spacing of 19.5 x 19.5 ft (6.0 x 6.0 m) to reduce the potential influence of neighboring trees. Irrigation by microsprinklers and frost protection by wind machine were installed. A duplicate plot was planted for potentially destructive analyses, such as physiological stress treatments. Improved estimates of rootstock influence on canopy vegetation (a key measure of potential fruit sizing capability) will be made with a non-destructive, portable, microprocessor-based leaf area meter to be obtained in 2002.

A new plot of 'Chelan' on Mazzard, Mahaleb, 'Colt', 'Edabriz', and various Gisela rootstocks was planted in 1998 to document whether industry concerns of certain graft incompatibilities with this important new variety are warranted. A small plot of 'Lapins' on Mazzard and Mahaleb was also planted to examine graft incompatibility potential. If and when evidence of incompatibilities arise, tissue samples will be taken from respective graft unions for biochemical analysis and investigation of the potential for developing a screening test for other incompatible rootstock/scion combinations.

Two new plots of WSU-Prosser varieties (including Benton, Selah, Glacier, and Tieton) and elite selections (including 8011-3, 8011-7, 8012-9, 8014-1, 7217-2, 7306-1, 8007-2, and 8005-1) on the new PiKu series (selections 1 and 3) of rootstocks, the Gisela series (including 5, 6, and 12), Mazzard, and Mahaleb were planted in 2002. Growth, fruiting, fruit quality, graft compatibility will be monitored in these plots.

RESULTS & DISCUSSION:

Sweet cherry varieties grown on standard seedling rootstocks like Mazzard are slow to bear fruit and particularly vigorous. These are not desirable traits in a rootstock. However, fruit quality from mature Mazzard-rooted trees can be excellent and hence, despite the inefficiencies of production systems based on this rootstock, it continues to be widely planted. Growers have utilized various horticultural (*e.g.*, deficit irrigation, limb bending) and chemical (*e.g.*, Ethrel, Apogee) strategies to overcome the lack of precocity and excessive vigour of Mazzard-rooted trees, with limited success. A potentially more sustainable and reliable solution to these production problems may lie in the use of genetics to achieve scion size control and/or precocity.

This research project has documented the effects of about 20 rootstocks on scion growth, fruiting, fruit quality, and compatibility. Rootstock genotype affected each of these parameters. In 2003, Mazzard was the least productive and most vigorous. Weiroot 53 was the least vigorous (25% of Mazzard) and several Gisela selections (Gi 7, Gi 6, Gi 318/17, Gi 195/20) were the most productive (35 – 40 kg/tree, 5-7 fold greater than Mazzard). Cumulatively since planting, the Gisela series of rootstocks have been the most productive (Fig. 1) as seven of the eight highest-yielding rootstocks were Giselas. Edabriz and Mahaleb were intermediate and the Weiroot series and Mazzard were even less productive. Precocity was not related to vigor. For example, Gisela 6 was very productive (~ 93 kg/tree) and Mazzard was unproductive (~ 17 kg/tree), both are vigorous rootstocks. In addition, Weiroot 53, the least vigorous rootstock, has been unproductive (~ 39 kg/tree) while other dwarfing rootstocks have been quite productive (*e.g.*, Gi 209/1, 69 kg/tree).

However, of greater relevance is the cumulative yield of premium quality fruit (*i.e.*, 10.5-row and larger). Such an analysis reveals again, tremendous variability among rootstocks (Fig. 1). Gi 318/17, Gi 6, W10, and Gi5 yielded the greatest amount of premium quality fruit. In the case of Gi 6, this was accomplished through high fruit yields per tree of which only about 42% was 10.5-row and larger. In contrast, W10-rooted trees were much lower yielding (*ca.* 43 kg/tree) but had a higher percent, almost two-thirds, of 10.5-row and larger fruit.

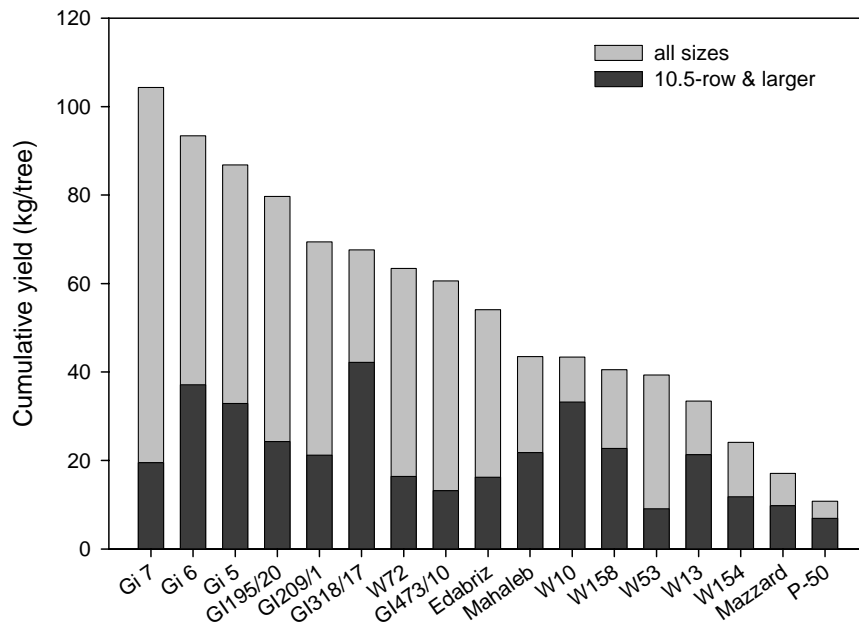


Figure 1. The effect of rootstock on the cumulative yield of all fruit and 10.5-row and larger ‘Bing’ fruit (kg/tree) between 1998 and 2003.

Among all rootstocks a close negative relationship existed between tree yield efficiency and annual growth (Fig. 2). This shows that secondary growth of sweet cherry trees is not a strong sink. Moreover, this relationship demonstrates a degree of competition between radial expansion of the trunk and fruit growth because expansion is restricted when trees exhibit high yield efficiency. Therefore, high crop load on trees of limited canopy can inhibit tree growth and canopy development, imparting a dwarfing effect. This effect suggests that the use of yield efficiencies based upon TCSA (*i.e.*, kg fruit/cm²) for comparative germplasm evaluations may be misleading without reference to this potentially confounding factor. A similar relationship occurs within a scion/rootstock combination (Whiting and Lang, 2003).

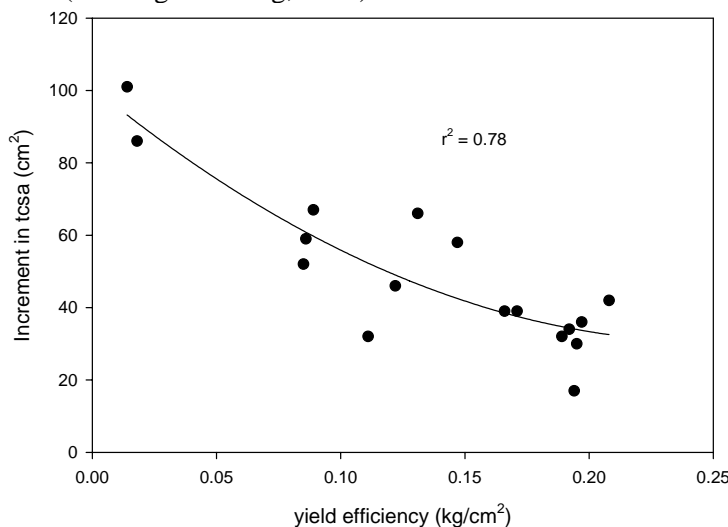


Figure 2. Relationship between ‘Bing’ tree yield efficiency (kg fruit per cm² trunk cross-sectional area (tcsa)) and the annual increment in tcsa (cm²).

Not surprisingly, fruit quality, whether measured as soluble solids or weight, is negatively related to tree yield efficiency (Fig. 3). This trend has been more precisely described for ‘Bing’/Gisela 5 trees in another project (see report ‘Quantifying Limitations to Balanced Cropping’). This is the first report of such a relationship across rootstock genotypes however. This result underscores the need to

balance crop load with canopy size to produce high quality fruit from size-controlling and precocious rootstocks. Fruit soluble solids are more closely related to tree yield efficiency than fruit weight ($r^2 = 0.88$ and 0.46 , respectively) because sugar accumulation occurs during stage III of fruit development and is therefore dependent upon metabolism during 2003. In contrast, fruit weight is determined, to some degree, during the previous season and therefore less dependent upon tree factors during the season of actual fruit growth and development.

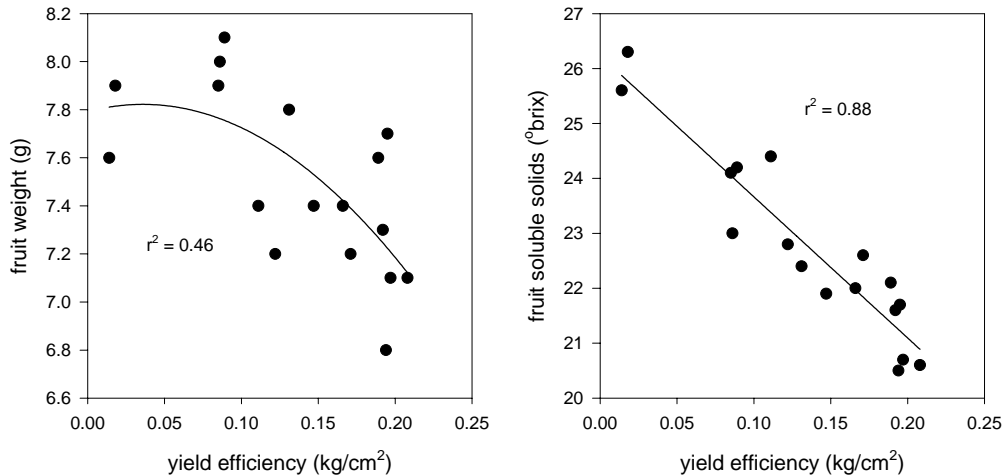


Figure 3. Relationships between ‘Bing’ tree yield efficiency (kg/cm^2 tcsa) and fruit weight (g) and soluble solids ($^{\circ}\text{brix}$) on 17 different rootstocks.

Fruit yield and quality were evaluated in a plot of WSU selections (Cashmere, Chelan, Tieton, Benton, Selah, Rainier, PC 8011-3, PC 7903-2, and PC 7147-9) planted also in 1998 on Edabriz and several Gisela rootstocks. Tree anchorage was weak for Tieton/Gisela 6 trees and a support structure (likely a single wire trellis) is recommended for that combination. All other combinations exhibited good growth and anchorage. No incompatibilities are apparent at this early stage.

Compared to Bing, fruit quality from this trial was far superior, with the majority of fruit being 10.5-row and larger (Table 1). This is attributable to the improved genetic potential for large fruit in these selections and suggests that, unlike Bing, new varieties on precocious and/or dwarfing rootstocks are less likely to bear heavy crops of poor quality fruit. Gisela 195/20 produced the highest yields and best quality fruit. This is a somewhat size-controlling rootstock that was a particularly good match with Tieton (>40 lbs/tree, 12.2 g, 99% 10.5-row and larger), a variety renowned for bearing light crops.

Rootstock	Yield (lb)	Fruit Weight (g)	Soluble solids	smaller than 12-row (%)	11 and 12-row (%)	10.5-row and larger (%)
Edabriz	25	9.5	22.1	2	27	71
Gi 195/20	44	11.2	21.5	0	3	97
Gi 209/1	20	10.4	22.7	1	18	81
Gi 5	29	10.4	20.6	0	16	84
Gi 6	36	11.1	19.8	1	14	86

Table 1. Effect of rootstock on fruit yield and quality. Data are means across 9 scion varieties (Cashmere, Chelan, Tieton, Benton, Selah, Rainier, PC 8011-3, PC 7903-2, and PC 7147-9).

This project has generated critical clonal rootstock/scion performance information that is providing new strategies for early-producing, high-yielding, efficiently-harvested PNW sweet cherry orchards. The screening for incompatibilities may help prevent economic losses due to unforeseen graft incompatibility of new rootstocks, and screening for adaptability to environmental extremes may help prevent catastrophic economic losses in new or mature orchards. The analysis of rootstock influence on important horticultural characteristics assists in developing management strategies for maintaining productivity in high-density orchards. In addition to annual NC-140 project reports on vigor and yield, 5-year cumulative studies will be compiled after 5 and 10 years in the 1998 trial. Information transfer will occur through research reports at industry meetings (e.g., Cherry Institute, IDFTA), on-site grower evaluations of IAREC and industry cooperator research plots, and publication of results and recommendations in industry (e.g., Good Fruit Grower) and scientific periodicals (e.g., Fruit Varieties Journal, HortScience, etc.).

Literature cited

Whiting, M.D. and G.A. Lang. 2003. Bing Sweet Cherry on the Dwarfing Rootstock Gisela 5: Crop Load Affects Fruit Quality and Vegetative Growth but not Net CO₂ Exchange. J. Amer. Soc. Hort. Sci. In press

Project no.: CH-01-17

Current year request: n/a

Project total: \$ 52,706

Year	2001	2002	2003
Total	\$15,580	\$19,380	\$17,746

Current year breakdown

Item			
Salaries ¹	5,897	5,797	6,083
Benefits (28%)	2,123	1,623	1,703
Wages ²	3,500	6,000	6,000
Benefits (16%)	560	960	960
Equipment		2,000	
Supplies ³	3,000	2,500	2,500
Travel ⁴	500	500	500
Miscellaneous			
Total	\$15,580	\$19,380	\$17,746

¹ 1/6 annual salary for Mr. Efrain Quiroz

² Time slip wages for harvest, data collection, and fruit quality and laboratory analyses.

³ Supplies for fruit evaluations

⁴ Travel to plots