**FINAL REPORT**
**PROJECT NO.:** CH-01-16

**TITLE:** Intensive Sweet Cherry Orchard Management

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**OBJECTIVES:**

1. Plant a new orchard for the development and evaluation of management practices (e.g., specific training/pruning strategies and growth regulator applications) that facilitate mechanical harvest of sweet cherries for the fresh market.
2. Continue to evaluate the interactions between high density pruning/training systems and trees on various rootstocks for precocity, yield efficiency, fruit quality and other horticultural characteristics. Remaining trial duration is two to three years.
3. Refine high density orchard management techniques (e.g., pruning/training systems) for 'Bing' and 'Rainier' trees established in 1995 on dwarfing and non-dwarfing rootstocks. Remaining trial duration is two to three years.
4. Develop and apply cultural techniques, such as developmental bud and branch management, growth regulator applications, to achieve smaller trees on non-dwarfing rootstocks in new WSU or cooperators' orchards.

**Significant findings:**

*Rootstock x Training System:*

In 2003 we compared vegetative characteristics and fruit quality of 'Bing' trained to 4 distinct systems: the free-standing central leader (C) and Spanish bush (B) with the trellised palmette (P), and Y-trellis (Y).

- Among training systems and across rootstocks:
    - fruit quality was lowest for P-trained trees (6.6 g/fruit, ~ 31% ≥ 10.5-row), and similar among the other systems (7.7 g/fruit, ~ 51% ≥ 10.5-row)
    - fruit quality was negatively related to tree yield
    - fruit yield was highest from C and P trees, intermediate from Y trees, and significantly lower (ca. 35%) from SB trees
    - trees trained to B and Y were the most vigorous and CL and P trees were the least vigorous
    - yield efficiency (kg/cm$^2$ TCSA) was lowest for SB trees, intermediate from Y trees and highest from C and P

- Among rootstocks and across training system:
  - fruit quality was best on Mazzard and worst on Gisela 5
  - yield was highest on Gisela 6 (~ 27 kg/tree, 9 tons/acre) and ca. 21 and 70% less from Gisela 5 and Mazzard, respectively
  - despite producing less than half of the total yield of Gisela 5 trees, Mazzard-rooted trees yielded a similar quantity of ≥ 10.5-row fruit per tree
  - Mazzard was the most vigorous followed by Gisela 6 (20% less) and Gisela 5 (45% less)
  - yield efficiency was greatest on Gisela 5, 17% less on Gisela 6, and 70% less on Mazzard
- Across all rootstock/training system combinations, yield efficiency and fruit size were correlated closely ($r^2$=0.83) and negatively
- The top three system/rootstock combinations for yield and quality were: Gisela 6 trained to either Spanish Bush or Central Leader, and Gisela 5 trained to Spanish Bush

*Fundamental Cropping Components:*
In 2002 and 2003 we studied how canopy architecture affects fundamental components of cropping and fruit quality including number of spurs per tree, flower buds per spur, length of wood per tree, and trunk cross-sectional area. From these data, spur/bud density (spurs/buds per cm wood) and potential cropping density (fruit per tree) were estimated. With this knowledge, we will better understand the effects of training system on tree productivity and be able to develop system-specific management techniques.

- Across all rootstocks, Y-trellis had the highest number of spurs per tree (~750), SB and P were similar (~700), and CL had the fewest (~650)
- CL trees had the highest number of buds per spur (3.2) and SB had the fewest (2.1)
- Therefore, potential fruit per tree was highest for CL (due to high buds/spur), intermediate for P and Y, and lowest for SB (due to low # buds/spur)
- Y trees had the most wood, SB was intermediate, and P and CL had the least
- Spur density was therefore highest for P and the lowest was for Y trees
- Among all combinations, CL Gisela 6 is potentially the most productive and Mazzard trained to SB was the least productive

**Methods**:
A new high-density orchard (3 acre) will be designed and planted specifically to facilitate mechanical harvest of fruit. Several cultivar/rootstock combinations will be planted including Bing, Chelan, Columbia, Liberty Bell, Sweetheart, and Tieton on Gisela 5, 6, and 3 (209/1), Edabriz, Weiroot 72 and 158. Different high density orchard strategies will be applied, including training (e.g., variations of the Y-trellis, non-trellised) and the use of plant bioregulators. These orchard system variables will be studied for their influence on tree/system precocity, fruit quality, ease/cost of maintenance, efficiency of harvest, and long-term productivity.

A 4-acre (2ha) high density orchard (360tress/acre) of ‘Bing’ and ‘Rainier’ on Mazzard (full size), and Gisela 5 (50% size), Gisela 6 (Full size), Gisela 7 (55% size), and Gisela 11 (75% size) was established in 1995 at WSU-Prosser’s Roza Experimental Unit with microsprinkler irrigation and wind machine frost protection. Eight training systems, four trellised (single-plane palmette, double-plane “Y”, single-plane oblique leader, and single-plane central leader) and four self supporting (multiple leader bush, central leader spindle, central leader axe, and standard multiple leader), were imposed in a randomized block design. Size control, precocity, yield efficiency, fruit quality and other horticultural characteristics are being evaluated relative to both rootstock/scion combinations and rootstock/training system interactions.

Several smaller high density orchards have been planted at the Roza Experimental Unit for short-term studies of specific intensive management practices as trees have been available. These include: 'Bing' and 'Rainier' on Mazzard and Gisela 5, Gisela 6, Gisela 7, and Gisela 11 rootstocks, planted in 1995 on a single plane trellis at trunk angles that vary by 15° increments from 30° to 90°, to examine specific training vs. cropping responses (precocity, fruit quality, and flower bud development vs. shoot growth); a very high density orchard of 'Bing' on Gisela 1 (GI 172/9), planted in 1996 and trained to a central leader spindle to examine canopy architecture as influenced by selected bud or shoot removal, as well as renewal pruning on fruit quality since Gisela 1 is prone to severe overcropping and poor vigor. In addition, high density orchard plots of 'Chelan', 'Attika', 'Lapins', and 'Regina' planted in 1998 on standard rootstocks and trained to either a multiple leader bush or central leader spindle training system to examine growth and precocity responses of these new cultivars to high density training systems. Selective bud removal strategies on young trees in these, and in grower/cooperator orchards will continue to examine the potential for non-Promalin branch development, enhancement of precocity on standard rootstocks, and balancing of reproductive vs. vegetative vigor on precocious rootstocks.

**Results and Discussion:**

Sweet cherry orchards are being planted at higher tree densities to improve orchard efficiencies (labour in particular) and economic returns. Very little research has investigated the interaction between canopy architecture and rootstock in high density sweet cherry production systems. In addition, the prospect of mechanical harvest of sweet cherries for sale in a premium, fresh market, creates the need for novel orchard systems trials to better understand key growth and cropping components (*e.g.*, cultivar, rootstock, and training system and their interactions). This project provides critical, practical information relating sweet cherry cropping performance to specific intensive training and orchard management decisions under PNW conditions.

Our results show that training system (across all rootstocks) can significantly affect yield and fruit quality (Table 1). Spanish Bush-trained trees were less productive (total tree yield) and yielded the best quality fruit compared to the other architectures. This training system yielded fruit with the highest weight, soluble solids, firmness, and % premium quality. Indeed, almost 56% of fruit from B trees were in the largest category compared to 52% from Y, 46% for CL, and 31% from P trees. However, despite producing a lower % premium quality fruit, other systems with higher total yields (e.g., C and Y) produced significantly more 10.5-row and larger fruit per tree. Central leader trees yielded the most premium quality fruit at 8.6 kg per tree. This is roughly equivalent to 3.25 tons per acre of 10.5-row and larger fruit.

Rootstock (across all training systems) significantly affected fruit quality and yield (Table 1). These results support data from previous years. In general, trees on Mazzard were larger and yielded fewer, higher quality fruit compared to Gisela 6 and 5. In 2003 individual fruit weight from Mazzard trees was about 1 g higher than Gisela 6 trees whose fruit were about 1 g heavier than fruit from Gisela 5 trees. Fruit soluble solids were similar among rootstocks (e.g., 21.1 – 22.8 $^{o}$brix). Trees on Gisela 6 yielded significantly more fruit of slightly better quality than trees on Gisela 5. Clearly the implementation of 'standard' management practices in 'Bing'/Gisela 5/6 trees can lead to high yields of poor quality fruit. In 2003, less than 45 and 20% of harvested fruit were 10.5-row or larger for Gisela 6 and 5, respectively. In 2002 fruit were slightly better quality. These general trends reflect the negative relation between fruit quality and crop load (see report on Quantifying Limitations to Balanced Cropping) because tree yields were lower for Mazzard-rooted trees and in 2002.

Tremendous interaction exists between training system and rootstock (Table 1). Trees on Mazzard rootstock performed the best when trained to a central leader system. For Mazzard, this combination produced the highest yields and the best quality fruit (12.5 kg/tree, 85% 10.5-row and larger).

Palmette trained trees were the second highest-yielding but they only produced about half the quantity of premium quality fruit as C. For trees on Mazzard, B was the worst training system because yields were low and fruit quality was poor in comparison to other architectures. In contrast, trees on Gisela 6 rootstock performed the worst when trained to P and were similar among the other systems. However, best individual fruit quality was harvested from B trees but the C and Y systems yielded the most premium quality fruit. The Spanish bush was the best training system for trees on Gisela 5 because yields were lower and fruit quality was better. Similar to Gisela 6, the palmette system was the worst for Gisela 5, yielding just over 1 kg of premium quality fruit per tree.

| **Rootstock** | **Training System** | **Fruit yield (kg)** | **Yield ≥ 10.5-row (kg)** | **Fruit mass (g)** | **Soluble solids (°brix)** | **Firmness (g/mm)** |
|---|---|---|---|---|---|---|
| **Central Leader** | | | | | | |
| | **Mazzard** | 12.5 | 10.8 | 8.6 | 22.6 | 369 |
| | **Gisela 6** | 29.9 | 12.0 | 7.2 | 20.6 | 285 |
| | **Gisela 5** | 25.7 | 3.1 | 6.5 | 21.0 | 295 |
| | **Mean** | 22.7 a | 8.6 a | 7.43 a | 21.4 b | 316 b |
| **Spanish Bush** | | | | | | |
| | **Mazzard** | 4.5 | 2.6 | 7.8 | 23.3 | 383 |
| | **Gisela 6** | 19.0 | 9.7 | 8.2 | 22.4 | 313 |
| | **Gisela 5** | 16.1 | 4.8 | 7.1 | 23.8 | 319 |
| | **Mean** | 13.2 c | 5.7 b | 7.7 a | 23.17 a | 338 a |
| **Palmette** | | | | | | |
| | **Mazzard** | 10.7 | 5.6 | 7.8 | 22.3 | 358 |
| | **Gisela 6** | 31.4 | 6.7 | 6.5 | 20.1 | 284 |
| | **Gisela 5** | 20.1 | 1.1 | 5.6 | 20.4 | 308 |
| | **Mean** | 20.73 ab | 4.5 b | 6.63 b | 20.93 b | 317 b |
| **Y-Trellis** | | | | | | |
| | **Mazzard** | 4.3 | 4.0 | 9.6 | 22.8 | 332 |
| | **Gisela 6** | 27.7 | 12.2 | 7.5 | 21.3 | 287 |
| | **Gisela 5** | 23.3 | 4.5 | 6.7 | 21.3 | 308 |
| | **Mean** | 18.43 b | 6.9 ab | 7.93 a | 21.8 ab | 309 b |

Table X. Effect of training system and rootstock on fruit yield and quality of 9-year-old Bing sweet cherry trees. Means followed by different letters are significantly different by LSD ($P < 0.05$).

Fruit row-size distribution also was tremendously variable among training systems and rootstocks (Fig. 1). Among all combinations, the worst quality fruit were harvested from palmette-trained Gisela 5 rooted trees (>30% smaller than 12-row, <10% 10.5-row and larger) and the best quality were harvested from y-trellised Mazzard rooted trees (0% smaller than 12-row, 90% 10.5-row and larger). In general, Gisela 5 rooted trees had the highest percent of smaller than 12-row fruit and the lowest percent of 10.5-row and larger fruit. For Gisela 5, P was the worst with about 30% in the smallest size category. Bush was clearly the best system for Gisela 5 yielding about 40% in both the 11 and 12-row category and the 10.5-row and larger category. Gisela 6 and Mazzard trees yielded fewer cull fruit (smaller than 12-row) than Gisela 5, generally 5 percent or less. Mazzard produced a higher proportion of premium quality fruit compared to Gisela 6 though. For all rootstocks, palmette was the worst system by yielding the lowest proportion of premium quality fruit and highest proportion of cull fruit.

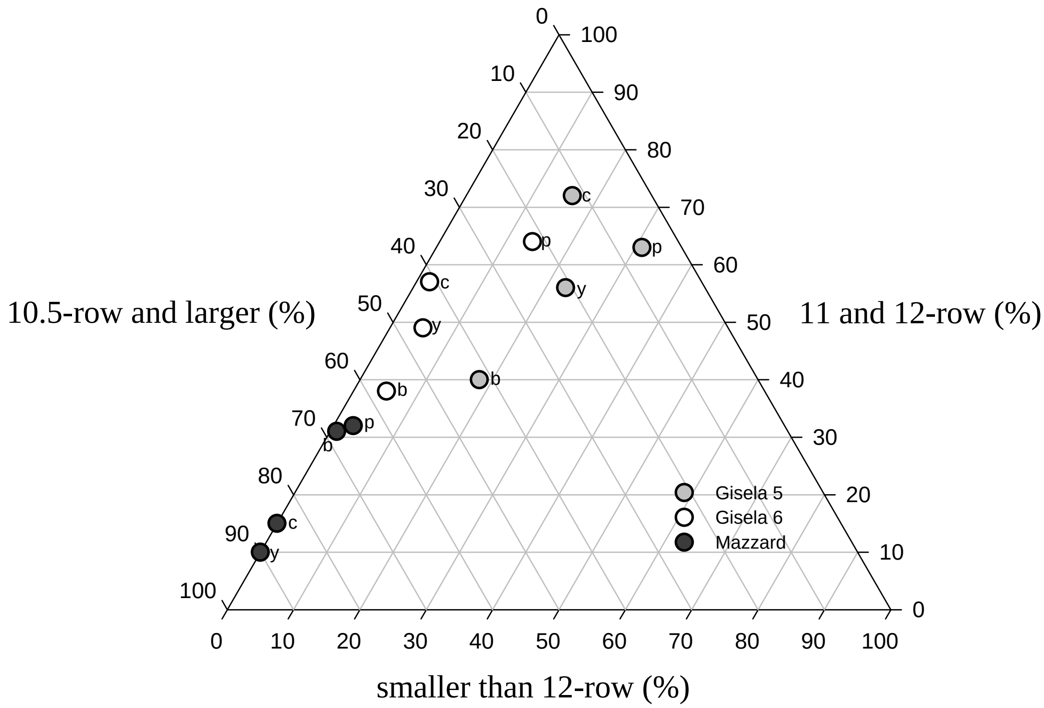


Figure 1. Effect of training system and rootstock on row-size distribution from 9-year-old Bing sweet cherry trees. c = central leader, p = palmette, y = y-trellis, b = bush.

**Vigor and yield since planting**

Rootstock genotype affected tree vigor (Fig 2). Gisela 5 was the most vigor-controlling rootstock reducing tcsa to 54% of Mazzard-rooted trees. Gisela 6 was intermediate reducing tcsa to 80% of Mazzard-rooted trees in 2002. Very little research has examined the cause of dwarfing in sweet cherry but in apple, restricted conducting tissue may play a role. The size-controlling properties of the Gisela rootstocks did not become apparent for several years after planting. Not until 1999, in the trees' five year in the orchard, did significant variability in tcsa manifest. Gisela 6 and Mazzard-rooted trees exhibited similar vigor until 2000 after which point trees on Gisela 6 were about 20% less vigorous. Differences among rootstocks became more pronounced thereafter as crop load increased significantly. Whiting and Lang (2003) showed that crop load was related negatively to trunk radial expansion. It is not known whether a similar relationship would hold across rootstock genotypes.

Differences in tree vigor among training systems were less pronounced than rootstock. Only subtle differences were evident in the years following planting. Significant trends began to emerge in 2000 as CL and P trained trees were less vigorous than B and Y trees which were similar. However, by 2002, CL and P trees were only about 15% less vigorous than B and Y. Early training of both B and Y involved more branch heading cuts which may have caused greater trunk expansion in these systems.

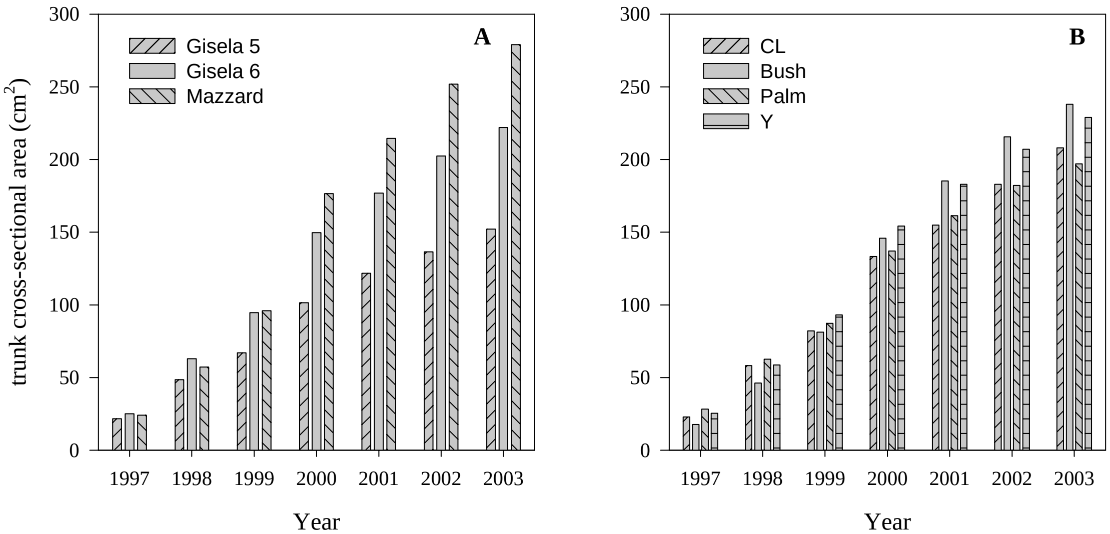


Figure 2. Effect of training system and rootstock on tree vigor (tcsa, $cm^2$) of Bing sweet cherry trees. Trees were planted in 1995 at 8.5' x 14'.

Rootstock had a tremendous effect on fruit yield (Fig. 3). Overall, Gisela 6 was the most productive rootstock yielding between 12 and 25% more fruit than Gisela 5-rooted trees and 50 to 85% more than Mazzard-rooted trees, depending on the year. Both Gisela 5 and 6 were significantly more precocious than Mazzard and induced fruiting two years after planting. Early yields of Gisela series rootstocks were about 4.5 to 6-fold higher than Mazzard-rooted trees. This trait is of particular interest to sweet cherry growers because the revenue from early fruit sales allows growers to pay off the high costs of orchard establishment. Preliminary estimates indicate that due to the precocious nature of Gisela 5 and 6 rootstocks, growers may break even 7 years before they would with Mazzard-rooted trees (Seavert, pers. comm.).

Training system exhibited less of an effect upon fruit yield compared to rootstock (Fig. 3). Through the first 3 years of production, P was the most productive system and B was the least. In the past 3 years, B remains the least productive system (~ 20 – 25% lower yields) while the other three are similar. However, by mitigating the precocity of the Gisela series rootstocks with repeated heading cuts, the B system yielded higher quality fruit at full production (Fig. 1).

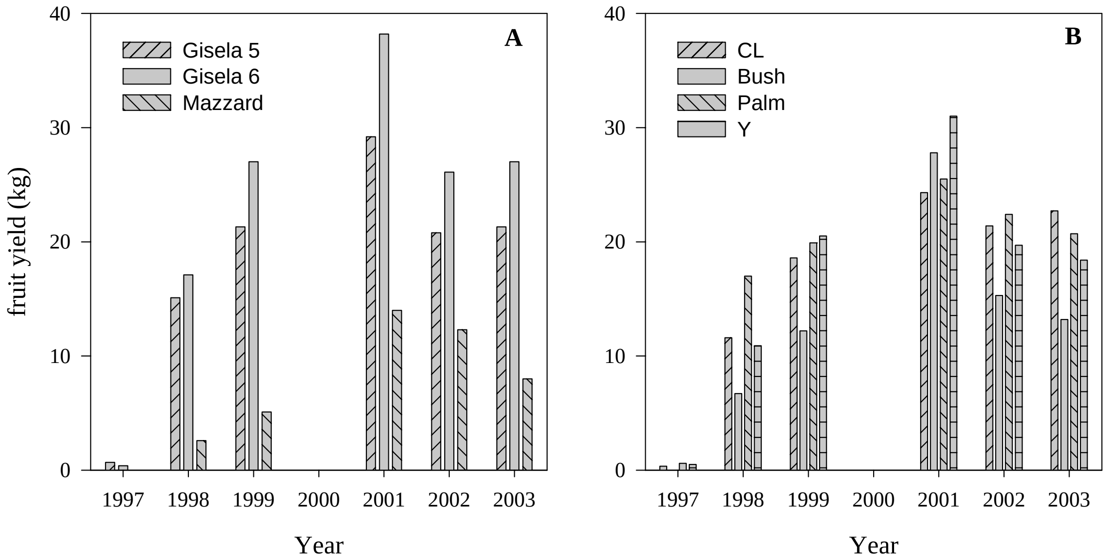


Figure 3. Effect of training system and rootstock on tree yield (kg) of Bing sweet cherry trees. Trees were planted in 1995 at 8.5' x 14'.

**Budget**:
**Project duration: 2001-2003**
**Project total: $47,926**
**Current year request: n/a**

| **Year** | 2001 | 2002 | 2003 |
|---|---|---|---|
| **Total** | $10,500 | $19,180 | $18,246 |

| **Item** | | | |
|---|---|---|---|
| Salaries[1] | | 5,797 | 6,083 |
| Benefits (28%) | | 1,623 | 1,703 |
| Wages[2] | 6,000 | 6,000 | 6,000 |
| Benefits (16%) | 960 | 960 | 960 |
| Equipment | | 1,800 | |
| Supplies[3] | 3,000 | 2,500 | 2,500 |
| Travel[4] | 540 | 500 | 1000 |
| Miscellaneous | | | |
| **Total** | $10,500 | $19,180 | $18,246 |