

'Hedelfingen' Sweet Cherry Fruit and Tree Growth Responses to Thinning and Five Rootstocks

CHEOL CHOI* AND ROBERT L. ANDERSEN

Abstract

Four dwarfing and one traditional, full-vigor, sweet cherry rootstocks; and several hand thinning vs. unthinned treatments were studied for their effects on horticultural characteristics of 'Hedelfingen' scion cultivar. Tree sizes, expressed in terms of TCSA (Trunk Cross Sectional Area), of 'Gisela 1' and 'Damil' were about 1/3 to 1/4 that of trees on 'Mazzard'. 'Gi 196/4' and 'Gisela 6' were about 1/2 of 'Mazzard', with 'Gi 196/4' being slightly bigger than 'Gisela 6'. Fruit diameter was also influenced by rootstocks. 'Mazzard' and 'Gi 196/4' had relatively large fruit size among rootstocks. Hand thinning increased fruit size when averaged across rootstocks. Its effect on fruit size depended on rootstocks. Semi-dwarfing rootstocks with high crop density responded well to thinning. The photosynthetic resource limitation began to be shown in the beginning of phase III of development because it was at this point that the difference in fruit size between the thinned and unthinned treatments was manifested.

Introduction

Seedlings and full-vigor clonal rootstock cultivars of *P. avium* and *P. mahaleb* have been the most commonly used rootstocks for sweet cherry and sour cherries in most countries of the world (4). Cherries grafted on 'Mazzard' and 'Mahaleb' seedling rootstocks are classified horticulturally as vigorous and relatively slow to begin cropping (10). In recent years, dwarfing sweet cherry rootstocks have been introduced to overcome the shortcomings of existing rootstocks (9).

Exotic cherry species and interspecific hybrids have been introduced as rootstocks from Gemblous, Belgium (11, 12, and 13) and Giessen, Germany (5). Some have excellent potential and have recently been distributed for commercial sale in Europe and in the United States (8). Several of these new rootstock cultivars have shown greater precocity, heavier blossom density, and a range of dwarfing. However, some of these dwarfing rootstock cultivars have generally imparted smaller fruit to the scion (6). It is not fully understood if this is a crop load or genetic effect or a combination of both.

There are several ways of reducing crop load such as pruning, hand thinning or

chemical thinners. Currently, no commercial chemical thinning agents are available for sweet cherry; thus hand thinning is a logical option for reducing crop load. Hand thinning is precise and devoid of side effects. Little data exists on the effect of thinning on the fruit produced on dwarfing cherry rootstocks.

The purpose of the present investigation was to evaluate the effect of new dwarfing rootstocks on 'Hedelfingen' and to evaluate the interaction of rootstock and hand thinning. This information will be useful in understanding the culture of trees on new cherry rootstocks and whether it is possible to improve fruit size and quality of cherries grafted to them through cultural manipulation of crop load.

Materials and Methods

The study was conducted on trees in the North Central Regional Project Number 140 (NC-140) sweet cherry rootstock trial established in 1987 in an orchard at the New York State Agricultural Experiment Station (NYSAES) in Geneva, New York. The trees were spaced 5.2 m apart in the row with 6.6 m between rows and trained as free standing central leaders. 'Hedelfingen' was used as the primary

Department of Horticultural Sciences, New York State Agricultural Experimental Station, Cornell University, Geneva, NY 14456, USA

*Current address: Agriculture and Agri-Food Canada, Pacific Agriculture Research Centre Summerland, B.C. Canada, V0H 1Z0

scion cultivar on all rootstocks and 'Emperor Francis' was the pollinizer. Trees on the following rootstocks were used in this analysis: 'Mazzard', 'Damil' ('GM 61/1'), 'Gisela 6' ('Gi 148/1'), 'Gisela 1' ('Gi 172/9') and 'Gi 196/4'.

The two levels of hand thinning (+/-) were applied to whole trees on five rootstocks. In 1992, trees were hand-thinned to one flower per cluster, regardless of cluster type or position at petal fall stage. Thinning in 1993 involved leaving one fruitlet from every cluster (fruitlet thinning) at 14d after full bloom (DAFB).

To determine the effect of thinning on fruit growth at different phenological stages, fruit diameter (mm) was measured every 7 days until harvest beginning 2 weeks after full bloom in 1992 and 3 weeks after full bloom in 1993. A random sample of 40 fruits per tree was used for determination of fruit size. Prior to measurement of fruit diameter, four branches were chosen and tagged. Two branches were randomly chosen out of the four tagged branches and 20 fruits from each branch were chosen and measured. Diameter was determined using an electronic vernier calipers and was measured at the widest point at the equator of the fruit.

To determine thinning response, fruit set (number of fruits per flower cluster) was measured. Three limb units per tree were selected by the method suggested by Lombard et al (7). Limbs uniformly spaced around the tree were chosen and each had no less than 100 flower buds. Selected limbs were 1 to 2 cm in basal diameter, well exposed to light, at a uniform height, and had a horizontal to slightly upright attitude.

At harvest, weight of all fruit from each tree was determined in the field. Fruit number of each tree was estimated as follows: fruit number per tree = total yield / mean weight of a fruit based on 100 sample fruits per tree at harvest time. Crop density (total fruit number per tree / TCSA) was the component used to describe yield.

For fruit size distribution analysis, 'sector sampling' was used to gather represen-

tative fruit samples from each tree. Each fruit sample consisted of at least 200 fruit. Fruit were then separated into eight size classes: smaller than 14.5, 14.5-16.4, 16.5-18.4, 18.5-20.4, 20.5-22.4, 22.5-24.4, 24.5-26.4, and larger than 26.5 mm in diameter. Frequency (%) and cumulative numbers on each of the classes were calculated to determine the fruit size distribution.

Harvested fruits were analyzed for soluble solids content (%) of expressed juice (SSC) and cracking percentage. SSC (%) of expressed juice was determined by a hand-held refractometer for a combined 30 cherry sample per tree.

Results and Discussion

Rootstock Performance

Tree sizes, expressed in terms of TCSA, were significantly different among the rootstocks (Table 1). In comparison to 'Mazzard' seedlings, the size of trees on GM and Gi clones ranged from 31% to 64% less in the 5th year (1992) and 26% to 53% less in the 6th year (1993). In addition, the smallest trees were on 'Gisela 1' and 'Damil'. The results with trees on Gi clones when compared to 'Mazzard' are almost identical to the comparison of Gisela clones to 'F 12-1' of Gruppe (5). According to Gruppe (5), size control effects may be caused by an earlier cessation of shoot growth, shorter shoots, and shorter side branches.

Among the 5 rootstocks in this study, trees on 'Gi 196/4' and 'Gisela 1' rootstocks had higher fruit set than other rootstocks (Table 1). The rootstock with the highest fruit set was 'Gi 196/4', while the lowest was found in trees on 'Damil'. Fruit set of trees on 'Gi 196/4' and 'Gisela 1' was almost twice that of trees on 'Damil'. This study suggests that the fruit set may vary in sweet cherry during the early years of an orchard life due to not only to physiological phenomena induced by seasonal and cultural environments, but also to different genetic factors inherent in different rootstocks. Although Alston and Tobutt (1) concluded that fruit set is dependent on scion variety, the current study

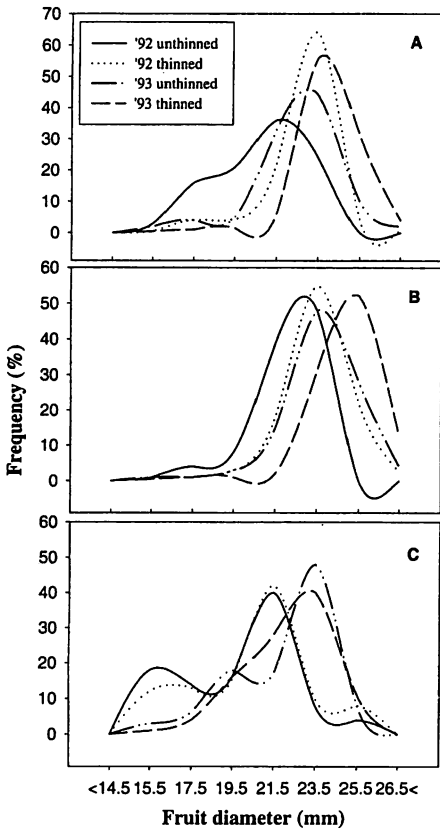


Figure 1. Frequency distribution of fruit size classes of 'Hedelfigen' on 'Gisela 6' (A), 'Gi196/4' (B) and 'Gisela 1' (C) as related to thinning treatments.

suggests rootstock is also an important factor. The need to study fruit set as influenced by rootstock on a long-term basis is evident.

Rootstock influenced fruit diameter in both years (Table 2). 'Mazzard' and 'Gi 196/4' had relatively large fruit size among rootstocks when averaged over the 2 years. Surprisingly, trees on 'Gi 196/4' not only had high crop loads but also produced fruits equal to those on 'Mazzard' which had lower yields in 1992. These results conform with those of Gruppe (5). He suggested 'Gi 196/4' is inherently more efficient in producing more large fruit per unit of vegetation growth. Compared with trees on 'Gi 196/4', 'Mazzard', with its large

tree size, had relatively low crop loads and a good fruit size. The dwarfing rootstocks with high crop load generally yielded smaller fruits. For example, 'Gisela 6' and 'Gesela 1' which both had medium to small tree size, had relatively small fruit and high crop loads. This suggests that for certain rootstocks, it is not only in the culture, but the genetic properties of the rootstock that is also important in determining fruit size of scions grafted to them.

Even with the small fruit size and heavy crop load level, 'Gisela 1' had relatively high value in SSC (Table 2). Soluble solids were not significantly different among the other four rootstocks in either 1992 or 1993.

Thinning response

Although the thinning had been applied so as to achieve about 75% reduction in flower numbers per cluster by leaving one flower (in 1992) or one fruitlet (in 1993) in each cluster (comprised of three to five flowers), final fruit set on the treated trees was reduced by 52% (in 1992) and 48% (in 1993) compared to that on the control trees across all rootstocks (data not shown). This is thought to have happened because the thinning treatment was done before the completion of two natural fruit abscission periods: first drop and June drop.

Thinning treatments produced significant differences in fruit sizes for trees on 'Gi 196/4' and 'Gisela 6' that had relative-

Table 1: Tree size, final fruit set and crop density as influenced by 'Hedelfingen' sweet cherries on five different rootstocks.

Rootstock	Tree size ^Z (cm ²)		Fruit set ^Y (%)		Crop density ^X (fruits cm ⁻²)	
	'92	'93	'92	'93	'92	'93
Mazzard	171.1	245.1	40.3	59.1	4.4	8.1
Gi 196/4	110.1	147.9	89.5	96.4	21.7	14.7
Gisela 6	97.5	130.9	77.4	67.0	23.3	13.0
Gisela 1	55.4	62.8	83.1	85.4	36.7	13.5
Damil	56.2	62.5	24.1	38.4	5.1	16.6
LSD _{0.05} ^W	28.7	39.3	8.9	11.2	9.5	3.6

^ZTrunk cross sectional area (TCSA).

^YFruit set = number of fruits/100 blossom clusters.

^XCrop density = number of fruits/TCSA.

^WLSD values are provided for comparisons of means within columns when a significant difference was found. n = 4.

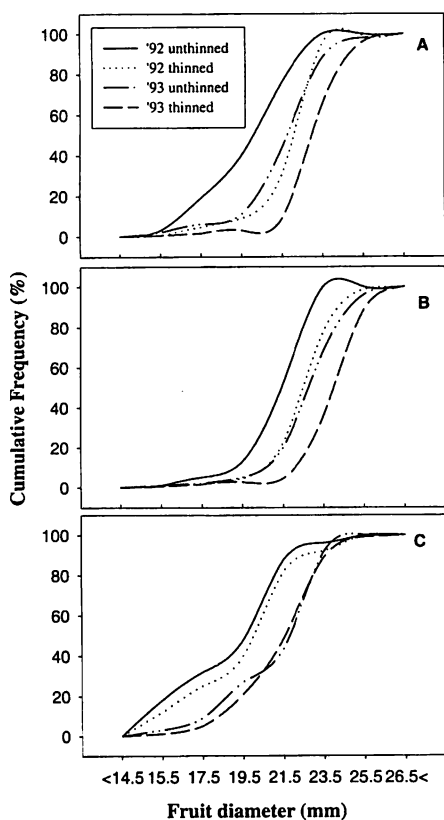


Figure 2. Effect of fruit thinning in cumulative frequency (%) of 'Hedelfingen' on 'Gisela 6' (A), 'Gi 196/4' (B) and 'Gisela 1' (C) fruits having diameters equal to or less than indicated values.

ly high crop loads. On the other hand, the thinning treatments did not produce a significant difference in fruit size of trees on 'Mazzard', 'Gisela 1' and 'Damil'. For 'Mazzard', the crop load in the unthinned trees was so low that probably little competition for resources occurred. Hence, it was expected that thinning treatments would have little effect on its fruit size. For 'Gisela 1', fruit size was not significantly different, even though its crop load was significantly greater than those of 'Mazzard' and 'Damil'. Gruppe (5) concluded that 'Gisela 1', which induces small scion trees with high crop loads, in general have smaller fruit size. We as-

sumed that because 'delayed genetic incompatibility' for 'Gisela 1' was very severe in 1993, the health of the 'Gisela 1' trees was so poor that they were unable to respond to fruit thinning (3).

Although thinning had no effect on SSC, a trend toward higher readings in thinned trees was present in both years. Soluble solids content of fruit from trees on all rootstocks were greater in 1993 than in 1992. A rainy season in 1992 may have led to lower SSC.

Fruit growth at phenological stages of fruit development

Seasonal fruit growth of 'Hedelfingen' sweet cherry on the five rootstocks showed a classical three distinct growth period pattern (Data not shown). For each of the rootstocks used in this study, no differences in fruit size were observed until the end of the second phase of fruit development in either season. In cherry, cell division is usually completed by 10 days after full bloom (14). In 1992, the thinning treatment was applied about a week after full bloom, so it might have helped to increase the cell number. In 1993, however, because the treatment was applied about two weeks after full bloom, it was less likely to influence cell number.

Fruit size from trees on 'Gi 196/4' and 'Gisela 6' in both years were both significantly larger than that of the unthinned trees from the beginning of the phase III of development (about 7 weeks after full bloom). For 'Mazzard', 'Gisela 1' and 'Damil' in both years, the thinning treatment appeared to fruit growth during phase III of development, but the increase was not significant. These results indicate that the competition for carbohydrates, water, and nutrients needed for cell enlargement was greatest during phase III of fruit development. In the case of low crop load trees on 'Mazzard' and 'Damil' such competition was not as strong. Even though trees on 'Gisela 1' had relatively high crop loads in both 1992 and 1993, thinning treatment did not influence fruit size. We believe this was probably due to overcropping manifested as severe symptoms of 'delayed genetic incompatibility.'

Table 2. Fruit yield, final fruit size and soluble solids of 'Hedelfingen' sweet cherries on five rootstocks in response to thinning treatment.

Rootstock	Thinning	Yield/Tree (Kg)		Final fruit diameter (mm)		Soluble Solids (%)	
		'92	'93	'92	'93	'92	'93
Mazzard	Unthinned	6.2	19.8	22.2	23.8	12.9	17.8
	Thinned	2.2	10.4	23.1	24.1	13.0	18.1
Gi 196/4	Unthinned	19.4	18.3	21.2	22.1	13.0	18.3
	Thinned	7.7	11.0	22.9	24.2	13.4	18.3
Gisela 6	Unthinned	11.1	11.7	20.5	22.9	13.6	19.2
	Thinned	9.5	7.7	22.7	24.1	14.7	19.7
Gisela 1	Unthinned	9.5	7.8	19.4	22.5	16.4	20.3
	Thinned	4.7	4.5	20.4	22.7	17.1	19.9
Damil	Unthinned	2.0	4.1	19.9	21.2	13.8	19.4
	Thinned	0.4	2.0	20.6	21.0	13.8	19.6
	LSD _{0.05}			1.3	0.8	1.3	1.0
Total	Unthinned	9.6	12.3	20.6	22.5	13.9	19.0
	Thinned	4.9	7.1	21.9	23.2	14.4	19.1
	LSD _{0.05} ²	3.5	5.1				

²Wherever main (thinning treatment) effect LSD values are not present, the rootstock X thinning interaction was significant at $P = 0.05$. $n = 20$ for thinning treatment means; $n = 4$ for cultivar X thinning treatment means.

Frequency and Cumulative Fruit Size Distribution

Data on fruit diameter were compiled into 8 categories of size in order to evaluate fruit size distributions and treatment effects. The fruit size distribution curves of thinned trees compared to unthinned trees on 'Gisela 6' and 'Gi 196/4' in both years demonstrated a distinct shift to larger size classes (Fig. 1 A and B, respectively). However, those of 'Gisela 1' (Fig. 1 C) and 'Damil' (Data not shown) had little shift due to thinning in either year. The value of these findings may lie in helping to understand that frequency distribution patterns for fruit sizes rather than mean fruit size is realized. If large fruit bring a higher price, size distribution is important. For example, fruits on 'Gisela 6' in 1992, unthinned trees had 20% of fruit in the 18.5-20.4 mm size category. While for thinned trees, only 4% of total fruits were within this class. In addition, 45% of fruit on thinned trees was 22.5-24.5 mm while the unthinned trees had 24% of total fruit in this size category.

The fruit size distribution threshold is important in finding out a percentage of

fruits that might have to be discarded to meet a given marketable fruit size. For instance, if the fruit size below 20.5 mm is not marketable, using cumulative numbers would show that about 40% of total fruit from the unthinned treatment would have to be discarded, while only about 5% of total fruit from thinned trees on 'Gisela 6' in 1992 would be unmarketable (Fig. 2 A). But if one compares mean fruit size, the mean difference between the thinned and unthinned trees on 'Gisela 6' for 1992 was only 2.2 mm. These two sets of information, frequency and cumulative number, are likely to be more important than mean fruit size when assessing the importance of thinning.

In summary, this study showed that dwarfing cherry rootstocks controlled tree size as well as fruit setting capacity and influenced fruit size. Among the dwarfing rootstocks, the trees on 'Gisela 6' and 'Gi 196/4', which had mid to large tree size produced larger fruit size than 'Gisela 1' and 'Damil', which produced small trees and which might have a scion incompatibility with 'Hedelfingen'.

Hand thinning improved fruit size and/or altered fruit size distribution on trees on 'Gisela 6' and 'Gi 196/4' rootstocks. However, fruits from 'Gisela 1' and 'Damil' trees were not as affected as those on 'Gisela 6' and 'Gi 196/4'. In young sweet cherry orchards, crop load manipulation on dwarfing rootstocks is suggested based on this research. In a practical sense, if dwarfing rootstocks with self-fertile scion cultivars are demanded by growers for their advantages in sweet cherry production, obtaining larger fruit size might be more problematic than with self-incompatibles on traditional (vigorous) rootstocks because many self-fertiles seem to overset in some environments compared to self-incompatible sweet cherries. To improve fruit size and/or its distribution, practical methods of crop load manipulation (i.e. chemical thinning agents or pruning) of self-fertiles on dwarfing rootstocks need experimental study.

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Identifying Apple Tolerance Limits for Visual Attributes

A 42 consumer panel preferred a fruit about 7.5 cm in diameter. Women and panelists over 55 preferred slightly smaller apples. There was no preference among apple shapes but leaticels were unacceptable when they exceeded 1.0 mm in diameter. Tolerance for stem bowl russet resembled acceptance levels from a larger population and fruit size was similar to preferences of European consumers. From Hampson and Quamme. 2000. HortScience 35(5):921-924.