Improving Cherry Fruit Size of Self-Fertile Cultivars in NY Orchards

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Figure 1. Excessive flowering of Sweetheart on Gisela 5 rootstock.

The introduction of new high-quality sweet cherry varieties and dwarfing cherry rootstocks, such as Gi.5 and Gi.6, has created diversification options for many fruit growers in the Northeastern U.S. In addition, dwarfing and precocious rootstocks have allowed for the possibility of developing productive high-density orchards. However, dwarfing rootstocks are often excessively productive with self-fertile varieties like Lapins or Sweetheart that result in very high crop loads and small fruit size (Figure 1).

> **"Dwarfing cherry rootstocks are often excessively productive with self-fertile varieties like Lapins or Sweetheart that result in very high crop loads and small fruit size. Our studies have shown that fruit size in 'Sweetheart' cherry is largely a function of Leaf: Fruit ratio. In order to obtain good fruit size in most years in NY State, crop load of self-fertile cherries must be regulated with pruning or thinning treatments. We have tried both pruning and thinning techniques to control crop load, and improve fruit size. Each treatment improved fruit size in relation to the effect on crop load and L:F ratio. Thus, growers could use a combination of the treatments we have used such as stubbing back pruning of weak shoots, spur extinction and flower thinning by chemical treatment to increase fruit size."**

In order to improve fruit size in New York State, some kind of crop regulation must be performed to reduce crop load and increase leaf area: fruit ratio (LA: F). Previous research has shown a linear relationship between LA: F and fruit size, and a rule of thumb has been developed that each fruit requires at least 200 cm^2 of leaf area to obtain large size fruit. Crop regulation can be performed through dormant pruning or flower thinning. Flower and spur thinning trials to improve fruit size have been conducted in several places in the world, and now it is well accepted that flower thinning or spur thinning generally improves fruit size. Promising results have also been obtained with chemical thinning during bloom time or even when applied 14 days after full bloom. In addition, training system can also affect fruit size especially when the training system affects leaf: fruit ratio.

Even though fruit size has been improved through crop regulation, there is an inverse relationship between fruit size and yield, with lower yield from crop regulated trees. Generally crop value has been found to be highly dependant on yield, and in many cases less crop value is obtained with crop regulated trees, which means that growers often have greater return with medium size fruit but high yields. Thus, crop regulation strategies must consider the break even point where crop value is optimized taking into account yield, fruit size and the price of the fruit in the market place. The objective of this two-year study at the New York State Agricultural Experiment Station was to evaluate the effect of crop regulation strategies and training system on 'Sweetheart' cherry fruit size when grown on precocious Gisela rootstocks under New York State conditions.

Material And Methods

In 2006 and 2007, two experiments were conducted using 'Sweetheart'/Gisela5 and 'Sweetheart'/Gisela 6 at the New York State Agricultural Experiment Station at Geneva, NY. The trees were eight years old in 2006.

2006 Experiment

A split plot, randomized complete block design was used, where each of five blocks of the same pruning system and rootstock (Gi.5) was assigned to the treatments. Two training systems were used: Vertical Axis with trees spaced 6' by 15' or Central Leader with trees spaced 8' by 15'. Four crop regulation strategies were tried in each block: hard pruning (HP), where trees were lightly pruned and all branches with less than 30cm terminal shoot growth were cut back to two or three spurs; Spur extinction (SP), where trees were lightly pruned and then spurs underneath the branches and in the juncture between different year wood were removed at swollen bud stage (April 11); Flower bud extinction (FE), where trees were lightly pruned and flower

Table 1. Average fertility values for 'Sweetheart' cherry trees grown on 'Gisela 5' rootstock in New York State.

Fertility variable	Average number
Flower bud per 1 year old spur	5.76
Flower buds per spur older than 1 year	4.64
Flower buds per long shoot (> 30cm)	5.16
Flower buds per short shoot (< 30cm)	8.30
Flowers per bud	3.00

Table 2. Flower density, fruit set and crop load for different crop regulation treatments in 'Sweetheart' cherry trees, in 2006 and 2007.

Treatment	Flower density (flower/cm² BCA)	Fruit set (%)	Crop load (fruit/cm² BCA)	Yield efficiency (g/cm² BCA)	Fruit weight (g)
Season 2006					
Control	136.3 1 aZ	73 a	79.2 a	464.2 a	7.2 a
Spur thinning	105.71 a	70 a	60.7 a	428.9 a	8.9 a
Hard pruning	112.99 a	66 a	63.9 a	351.7 a	8.3 a
Flower thinning	37.17 b	71 a	27.5 b	171.8 b	9.9 a
Season 2007			(fruit/cm² TCA)	(g/cm² TCA)	
Minimal pruning			17.9 a	135.3 a	8.6 b
Stubbing back pruning			10.0 b	99.1 b	9.3 ab
Spur extinction			5.9 c	66.2 c	10.0 a

ZMeans followed by different letters are significantly different.$P \leq 0.05$

buds were removed from each spur, leaving two flower buds per spur and three to four flower buds per one year old shoot at swollen bud stage; and Control (CR) where only light pruning was performed. Light pruning was done on April 10, and consisted of cutting out damaged branches and vertical shoots and heading back old hanging branches, but no other crop regulation was performed. Three branches per tree were selected to evaluate fruit set and fruit size, which was evaluated at harvest by counting and weighing the crop. Also, on each tagged limb, leaf area was determined.

2007 Experiment

'Sweetheart' cherry trees on Gisela 5 and Gisela 6, trained as vertical axis were used. Each experimental block (training system) consisted of two rootstock plots, with three different crop regulation treatments each, imposed at popcorn stage (4 May, 2007) to entire trees, consisting of minimal pruning, hard pruning (Stubbing), and Spur Extinction. Three branches per tree were tagged for crop load, leaf area, and fruit quality evaluation as done in 2006.

Results and Discussion

Flower and fruit density

'Sweetheart' cherry trees bloom profusely when they are grafted on Gi.5 or Gi.6 rootstocks, in New York State. We calculated flower density per branch based on the number of spurs per branch, average flower buds per spur, and average flowers per flower bud with units of flowers per cm² of branch cross-sectional area (BCSA); average values obtained from several shoots and spurs are given in Table 1. This table shows the great potential for fruit production that this combination of variety and rootstock has under NY conditions. Our calculations indicate that by performing minimal pruning, as it was performed in these experiments, crop load would be excessive if a high fruit set was obtained. We calculated that the minimal pruning treatment could have a potential crop load of 100 fruits/cm² of BCSA shows a fruiting potential that it well over the point where fruit size starts to be affected, as it will be seen later.

Additionally, we evaluated fruit set, as a percentage of flowers that became fruits, and we found for the spring of 2006, which had good pollination and fruit set conditions, that fruit set was very high (70%). Although fruit set was not evaluated in spring 2007, crop load levels obtained on lightly pruned trees were considerably lower than in 2006, thus a larger fruit size was achieved in 2007 than in 2006 (Table 2).

Crop regulation treatment

In 2006, flower bud thinning was by far the treatment with the lowest flower density (37.2 flowers/cm² BCA);

spur thinning and hard pruning were numerically lower than the control, but were not significantly different from the control (Table 2). For a high fruit set season, like 2006, crop loads ranged between 27.5 and 79.2 fruit/cm² BCSA depending on crop regulation treatment with flower thinning having the lowest crop load while there were no differences between the control and spur extinction or hard pruning, even though those treatments had only 75% of the control crop load (Table 2). In 2007, with a lower fruit set, crop loads ranged between 5.2 and 25.7 fruits/cm² TCSA. Minimally pruned trees on G.5 had the highest crop load.

Yield efficiency was significantly affected by crop regulation treatments (Table 2). In 2006, flower thinning reduced YE the most. In 2007, yield efficiency was lowest with the spur thinning (extinction) treatment and highest with the minimal pruning treatment. Yield efficiency (YE) was highly dependant on crop load. Thus, as crop load increased, greater yield efficiency was obtained, and a maximum YE was obtained when crop load was over the threshold of around 140 fruits per cm² of BCA (Figure 2). In 2007, when entire trees were evaluated and crop load was expressed as fruits/cm² TCA, the maximum of 250 g of fruit/cm² TCA appeared to be around a crop load of 40 fruits/cm² TCA (Figure 2).

Fruit size showed a great range among treatments, between 5.2 and 11.2 g per fruit, mainly due to training system and crop regulation treatment. In 2006 the largest fruit size was obtained with flower thinning followed by spur thinning, and hard pruning while the minimal pruning treatment had the smallest fruit size (Table 2). In 2007, the spur extinction treatment had the largest fruit size followed by the stubbing back pruning and the minimally pruned treatment.

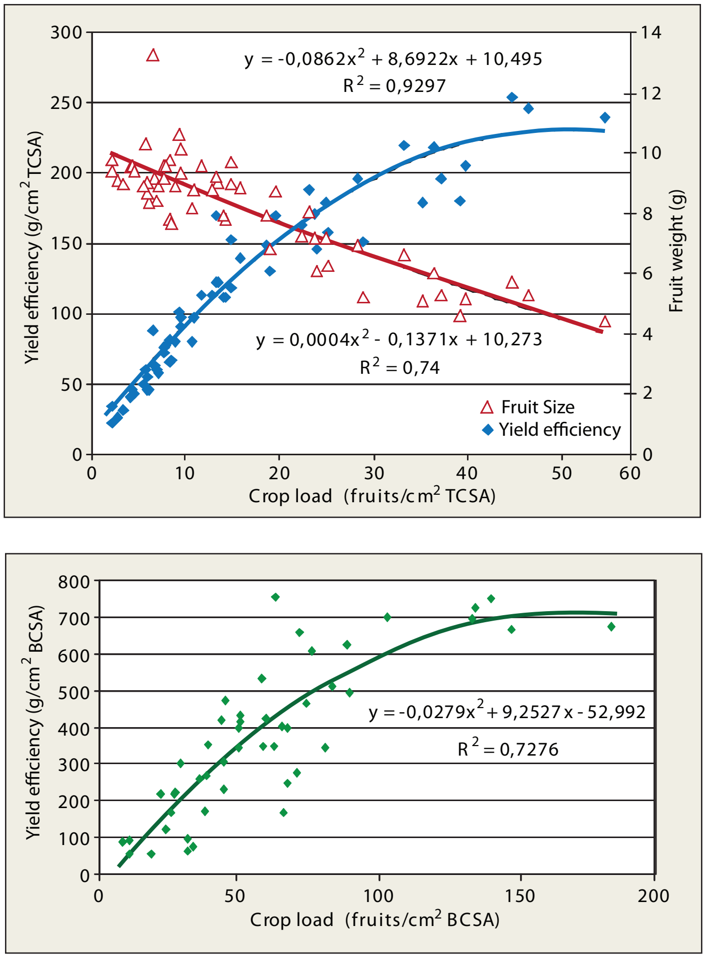

Figure 2. Yield efficiency and fruit size as a function of crop load. Top, 2007, fruit size, in g, and yield efficiency and crop load expressed in terms of cm² TCSA. Bottom, 2006, YE and crop load expressed in terms of cm² BCSA.

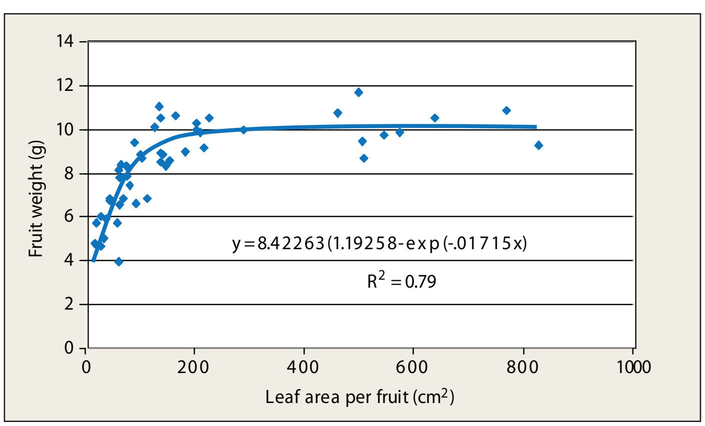

Figure 3. 'Sweetheart' cherry fruit weight as a function of leaf area per fruit. Season 2006.

Fruit size and leaf area

When the data from all pruning treatments, rootstocks and training systems from the 2006 experiment were plotted together we found a strong and tight relationship between leaf area per fruit and fruit size (Figure 3). The relationship shows a maximum fruit size is achieved at around 200 cm² of leaf area per fruit. This value is similar to other published reports. Additionally, our preliminary results indicate that it does not matter how this leaf area is distributed among different plant organs. The leaves can be on the new shoots, on recently formed spurs on one year old wood, or on two year

Table 3. Estimated yield efficiency and crop share for different cherry fruit size category, expressed as percentage of total crop. Based on results from 2007 trials.

	Share of different fruit size category					
Fruit size	< 18 mm	18 - 22 mm	22- 25 mm	25 - 28 mm	> 28 mm	Expected YE (g/cm2 TCSA)
-- g	------------------------- % of total crop	------------------------				
5.0	2.5	57.9	37.7	1.9	0.0	193.8
5.5	2.1	42.0	51.3	4.6	0.1	182.0
6.0	1.9	27.3	58.0	11.2	1.7	170.1
6.5	1.6	16.2	58.5	21.8	2.0	157.8
7.0	1.3	8.9	53.8	35.0	1.1	145.2
7.5	0.9	4.7	45.4	48.5	0.6	132.4
8.0	0.6	2.5	35.2	59.6	2.2	119.2
8.5	0.4	1.3	24.7	66.2	7.3	105.8
9.0	0.2	0.7	15.6	67.0	16.5	92.1
9.5	0.1	0.2	8.7	62.1	28.9	78.1
10.0	0.0	0.0	4.4	52.7	42.9	63.9

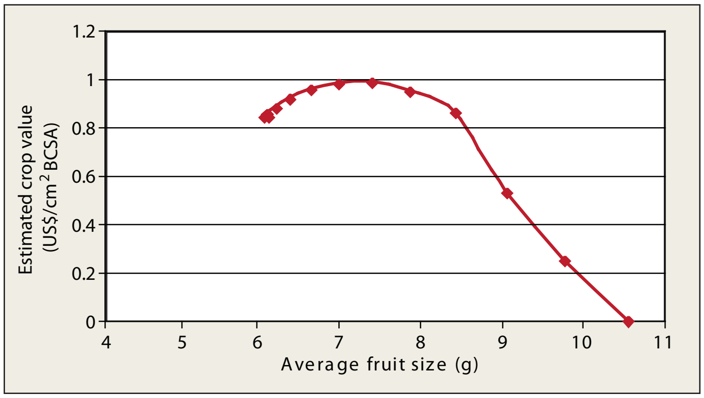

Figure 4. Estimated crop value, expressed as US dollars per cm² of BCSA, as a function of average fruit size for 'Sweetheart' cherry.

old or older spurs, which are the carrying fruits. On average we calculated, for NY grown 'Sweetheart' cherry trees, that each fruit should have 4.1 leaves from new shoots, 0.9 old spurs or 1.6 newly formed spurs. Another important finding is that no matter which crop regulation treatment was applied the effect on fruit size was a function of the amount of leaf area, which resulted from the treatment.

Fruit size and yield

From the 2006 experiment, we found a tight curvilinear relationship between yield and crop load with a maximum yield around 700 g/cm² BCSA at a crop load of around 100 fruits/cm² BCSA. The same was observed in 2007, but with a yield maximum of around 250 g/cm² TCSA, at a crop load of around 40 fruits/cm² TCSA when entire trees were evaluated. In both years increases in yield were accompanied by reductions in fruit size. This is in contrast with some published reports, which showed no reduction in fruit size with increasing yield. This can be explained considering the data from Figure 3 described earlier which shows a curvilinear relationship between L:F and fruit size. These data predict that at high crop loads (below 200cm² leaf area per fruit), crop load reductions don't result in yield reductions, since there is a proportional increase in fruit size. However, at low crop loads (above 200cm² leaf area per fruit) further reductions in crop load result in yield reductions since there is no further increase in fruit size due to surplus leaf area. Thus, for any given experiment, different results could be obtained depending on which part of the fruit size to leaf area response curve those particular treatments are. In our cases reducing crop load caused an increase in fruit size because we were on the high end of the crop load range (less than 200 cm² leaf area per fruit).

Crop Value

Since reductions in crop load result in reductions in yield, the optimum crop load is a function of economics. To determine the optimum for NY we calculated fruit size distribution for different yield efficiencies of 'Sweetheart' cherries on Gi.5 or Gi.6 (Table 3). The share of total crop of each commercial size category was fairly well described as a function of average fruit size. These data were used to establish a breakeven point, where yield, fruit size and price are optimized according to harvest cost and expected return for the fruit. Estimated crop value as a function of fruit size was calculated, based on the response of yield efficiency and fruit size to increasing crop load, and the estimated share and price of each fruit size category (Figure 4). There was a broad economic optimum from 7-8 g fruit size. If crop load was reduced sufficiently to produce larger fruit size than 8g, the reduction in yield was so great that the total crop value was reduced. To achieve this size in 2006 would have required a L:F ratio of about 100, while in 2007 this would have required a crop load of around 15 fruits/cm² TCSA.

Conclusions

Fruit size in 'Sweetheart' cherry is largely a function of L:F ratio. To obtain good fruit size in most years in NY State crop load of self-fertile cherries must be regulated. Pruning and other orchard management practices must be aimed at developing a well-balanced tree, which can guarantee the leaf area needed to develop the fruit. To obtain a better balance between fruit: leaf, the focus can be either to regulate crop load or to improve foliage growth. We have tried different management techniques to control crop load, to improve fruit size. From these experiments we conclude that one treatment is not better than another, but that each improves fruit size in relation to the effect on crop load and L:F ratio. Thus, growers could use a combination of the treatments we tried such as stubbing back pruning of weak shoots which naturally have a low L:F ratio, spur extinction on intermediate branches to improve L:F ratio and flower thinning by chemical treatment to increase fruit size. Using the data from Table 1 and measurements of leaf area we calculated that shoots which are shorter than 30 cm (1 ft) have a low leaf area: fruit ratio (<100) and will produce small fruit size (Figure 5). Unfortunately, Sweetheart trees in G.5 produce a large number of such short shoots. Thus shortening these shoots back to one bud is essential to improving fruit size of this combination. The need for these crop regulations and the severity of crop regulation depends on the fruit set in each year and on the economics of fruit size. From the biological perspective, NY climatic conditions almost always result in

Figure 5. Short shoots of Sweetheart on Gisela 5 rootstock with too many flower buds and too few leaf buds.

high crop loads for self-fertile varieties on Gi.5 or Gi.6, which will almost always need some crop regulation treatment. However, from the economic perspective, the NY marketing conditions don't offer a large premium for very large fruit size thus moderate crop regulation treatments that don't reduce yield too much and aim to produce medium sizes of 8g per fruit will optimize crop value.

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