

Mechanical Blossom Thinning Using a Darwin String Thinner

2010 CTFA Annual Research Report

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Abstract

Multiple tests with the Darwin String Thinner were conducted in peach and nectarine orchards during bloom in 2010 to quantify the effects of various parameters. The following conclusions were made: Thick strings thinned more aggressively than thin strings. More aggressive thinning was achieved with no gaps between strings compared to four inch gaps and the location of the gaps made no difference. Absolute levels of thinning varied considerably from one variety and timing to another, but the slope of the curve (with respect to spindle rotation) stayed fairly constant. Flowers were easier to remove up to the period of full bloom, but then became more firmly attached and thus more difficult to remove after bloom. Increasing the number of rows of strings increased the aggressiveness of the thinning but not by a lot. Tractor speed had a much more dramatic effect on flower removal than rows of strings. Increasing the tractor speed from two to four mph cut down considerably on the percent flower removal. Reversing direction of the spindle rotation thinned about the same, but caused more injury by pulling branches in front of the spindle. Finally, flower removal was effected by shoot orientation. Those shoots parallel to the row and pointing in the direction of travel of the Darwin (down the row) had about twice as many flowers removed as parallel shoots pointing up the row. We concluded that 50% flower removal is a good goal to aim for as it substantially reduces initial fruit load but does not over thin too many individual shoots. This level of thinning is achievable with various settings of the machine.

Introduction

Fruitlet thinning is a major expense for stone fruit growers. The process is still carried out by hand since successful methods of chemical and mechanical thinning have yet to be developed. Past approaches to mechanical thinning have not worked very well mainly because of non uniform removal of fruit throughout the tree. Recently, a new approach has been tested which shows much more promise. It involves a Darwin String Thinner, produced by a company in Germany. This piece of equipment attaches to a tractor and has dozens of individual strings (similar to a weed eater) along a 10' spindle. The strings are 24" long and easily remove blossoms when the spindle is rotated. Successful bloom thinning on apples and peaches has been reported in several areas around the world.

In 2009, the Darwin Thinner was tested in many different orchards and was shown to effectively remove flowers throughout the canopy. It was clear the degree of flower removal could be substantially altered by changing rotation speed and/or string density on the spindle. When adequate thinning was achieved it cut down considerably on the follow-up hand thinning operation. It was also clear that the Darwin achieved the best results when trees were trained to create a continuous fruiting wall down the row. Furthermore, it showed the greatest benefit under conditions of heavy fruit set. Several growers were interested in trying the Darwin in "V" and quad "V" orchards of heavy setting varieties.

In 2010, our main objective was to quantify the effects of various parameters such as spindle rotation speed, spindle rotation direction, ground speed, string type and string

configuration along the spindle. This information would be useful for helping a grower zero in on the settings for achieving a given level of thinning.

Materials and Methods

To run the tests we needed orchards trained to “V” or quad “V” systems with bloom times spread over as long a period as possible. We eventually located 5 varieties as follows: Zee Fire nectarine, Polar Light nectarine, Spring Bright nectarine, Rich Lady peach and O’Henry peach. Time of bloom varied by about a month. Within each of these orchards we tagged sections of flowering shoots. A section consisted of 50 shoots spread over 3 to 12 adjoining trees. Between 40 and 50 sections were tagged within each orchard, leading to a total of over 10,000 shoots tagged. Before imposing treatments in an orchard, flower counts were made on each shoot. Immediately after treatment, flower counts were again taken so percent flower removal could be calculated. Generally, a given treatment was imposed on three sections per variety for a total of 150 shoots. Besides calculating average percent flower removal from the 150 shoots, histograms of the distribution of flower removal levels were also generated.

Within each orchard, one treatment that achieved about 50% flower removal was identified for more detailed analysis. Shoot orientation, height in the canopy and shoot lengths were recorded for each tagged shoot.

Results and Discussion

Figure 1 illustrates all the treatments imposed on the first variety to bloom, Zee Fire nectarine. Treatments included different spindle rotation speeds, two dates, two types of strings and three string configurations.

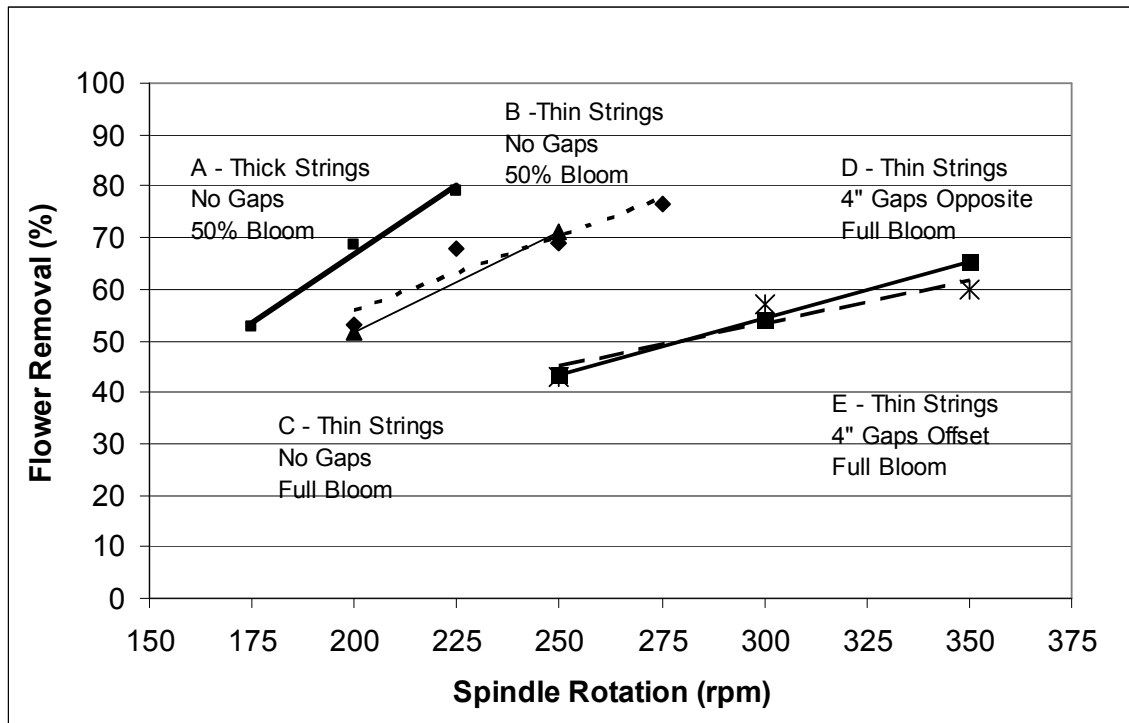


Figure 1. Flower thinning treatments using the Darwin String Thinner on Zee Fire nectarine. See text for details of each treatment.

The following conclusions were derived from this first set of experiments:

1. Thick strings thinned more aggressively than thin strings (A vs B). The Darwin Company recently changed from thin strings threaded through a metal plate to thicker molded strings. This experiment confirmed that the newer and thicker strings could achieve the same level of thinning at spindle rotations 25 to 50 rpm slower than the older strings. Similar treatments on other varieties (data not shown) gave similar results. We further concluded that the thicker strings are generally more desirable to use because there is less shoot damage at slower spindle rotations (although shoot damage was never a serious problem, even at 300 to 350 rpm).
2. More aggressive thinning was achieved with no gaps between strings compared to four inch gaps (C vs D & E). As produced by the Darwin Company, the strings are spaced one inch apart along the ten foot spindle. For treatments D and E, we removed four strings in a row and then left four strings, repeating this pattern all along the spindle. Clearly, where gaps were left, less thinning was achieved. Once again, this was confirmed by similar experiments on other varieties (data not shown). Notice also that the more aggressive the thinning (thicker strings, no gaps), the steeper the slope of the line (Figure 1). Therefore, one would need to be careful to avoid over thinning by increasing the spindle rotation too much.
3. The location of the gaps made no difference (D vs E). All of the treatments in Zee Fire (and most other varieties as well) were carried out with two opposing rows of strings along the spindle (there is room for six rows). For treatment D, the four inch gaps were located at the same place in both rows. For treatment E, the gaps were offset, so the gap in one row corresponded to four strings in the other row. As illustrated in Figure 1, these two configurations achieved the same level of thinning. This principle was confirmed by similar treatments in other varieties (data not shown).
4. Time of bloom didn't matter (B vs C). As opposed to conclusions 1-3 above, this conclusion did not hold true for other varieties (to be discussed later). However, for Zee Fire nectarine, thinning at 50% bloom on February 12 achieved about the same level of thinning as five days later when the trees were in full bloom (Figure 1).
5. Finally, notice that 50% thinning was achieved with many different treatments.

Before proceeding to conclusion derived from treatments on the other varieties, a brief discussion about the distribution of thinning on individual shoots will be interposed here. Since before and after flower counts were taken on each individual shoot, histograms of percent flower removal per shoot can be generated. Figure 2 shows an example of such a histogram for one of the Zee Fire nectarine treatments that achieved an average of about 50% thinning. Notice the distribution is a fairly typical "bell shaped" curve often found in nature – most shoots were thinned to about the average of 50%, but there were still a substantial number of shoots over thinned (90-100%) and others under thinned (0-20%). We found none of the treatments differed significantly from this typical shaped curve. Therefore, a grower may need to adjust pruning or subsequent hand thinning procedures to account for over thinned shoots

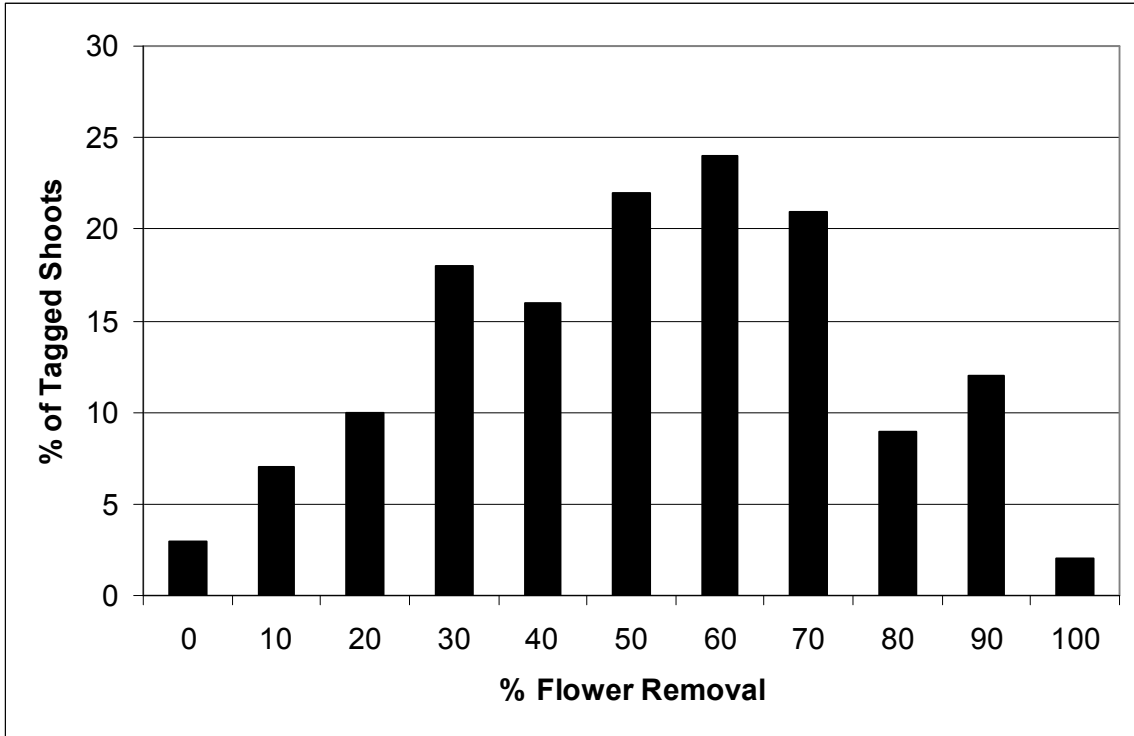


Figure 2. Histogram of the level of flower removal on the 150 shoots of one of the Zee Fire nectarine treatments that achieved about 50% flower removal on average.

Another way of looking at these same data is illustrated in Figure 3. This is a histogram of the actual numbers of flowers per shoot before and after thinning. This figure clearly shows that the number of flowers per shoot was substantially reduced from 20 to 30 per shoot down to an average of 8 to 16. Thus, substantial savings in hand thinning should be possible.

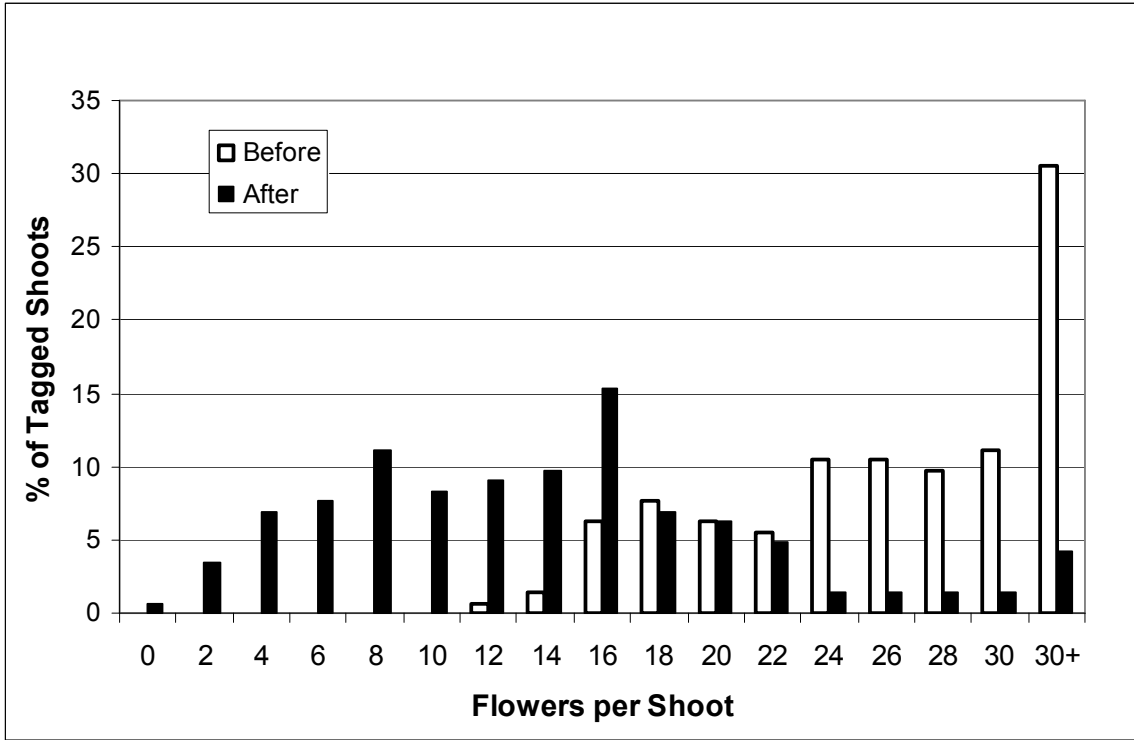


Figure 3. Histogram of flowers per shoot before and after thinning with the Darwin String Thinner that achieved about 50% flower removal on Zee Fire nectarine.

The figure also illustrates that less than five percent of the shoots were left with two or less flowers. If we consider this number of flowers (0 to 2) to be over thinned, there is a pretty tight relationship between average thinning and over thinned shoots (Figure 4). It can be concluded, any treatment that thins about 50% of the flowers off will have very few over thinned shoots.

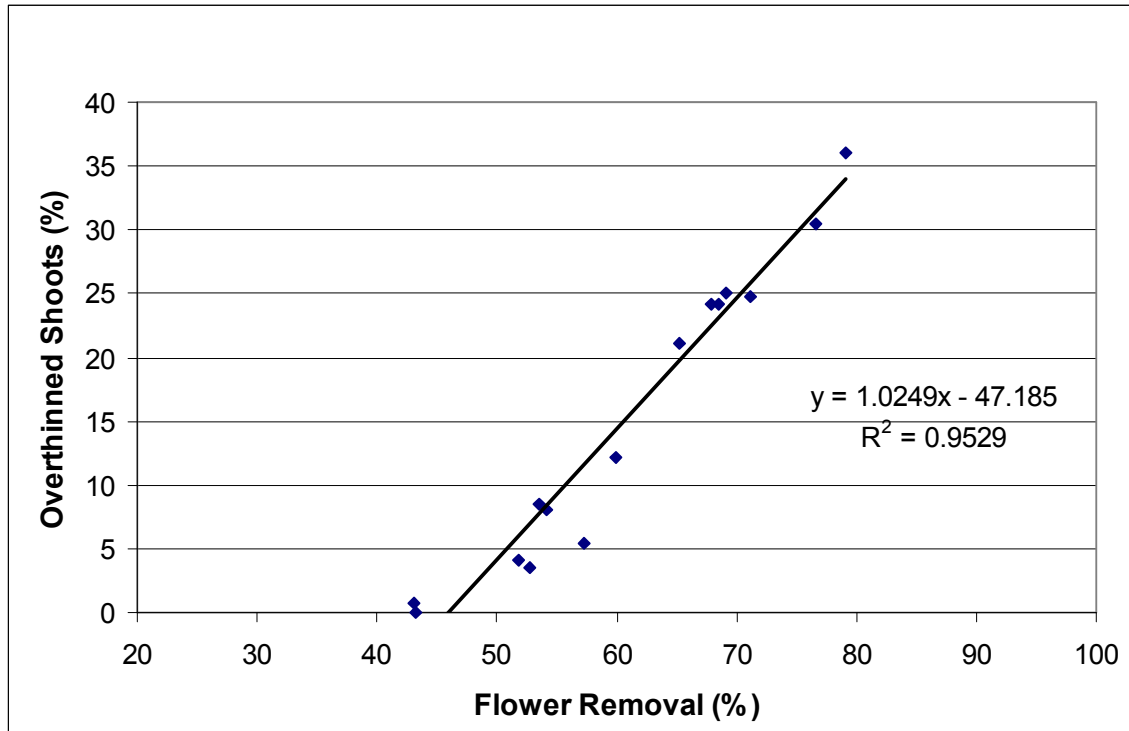


Figure 4. The relationship between percent flower removal and over thinned shoots (0, 1 or 2 flowers per shoot) for all the mechanical thinning treatments imposed on Zee Fire nectarine.

As other treatments were imposed on the other four varieties, different parameters were tested, some on more than one variety. Additional conclusions were drawn as follows:

6. Absolute levels of thinning varied considerably from one variety and timing to another, but the slope of the curve (with respect to spindle rotation) stayed fairly constant. Figure 5 shows our “standard” treatment imposed on all five varieties, and at two different times for two of the varieties. Our standard treatment was two rows of the newer molded strings with no gaps and the tractor driving at about two mph. In each case two to three different spindle rotation speeds were used so that about 50% flower removal was achieved at one of the speeds. This varied from less than 150 rpm (the lowest setting on the machine) to about 225 rpm. Certainly, one of the first conclusions to be drawn is that it is impossible to predict what setting will be needed to achieve 50% flower removal in a given orchard on a particular date (even a given setting in the same orchard could achieve different results from year to year). However, a given increase in spindle rotation should achieve a fairly constant increase in flower removal. Thus, an increased rotation of about 15 rpm should remove an additional 10% of the flowers (Fig. 5).
7. In contrast to the Zee Fire results (conclusion 4 above), three other varieties showed the earlier date of thinning removed more flowers than the later date (Fig. 6). For all three of these varieties, the second date was four or five days after bloom. However, for Zee Fire (Fig. 1), the first date was at 50% bloom and the second date right at full bloom. Therefore, our conclusion is that flowers are easier to remove up to the period of full bloom, but then become more firmly attached and thus more difficult to remove after bloom. It is still possible to achieve good flower thinning after bloom but takes a faster spindle rotation to accomplish that, in some cases an additional 50 rpm.

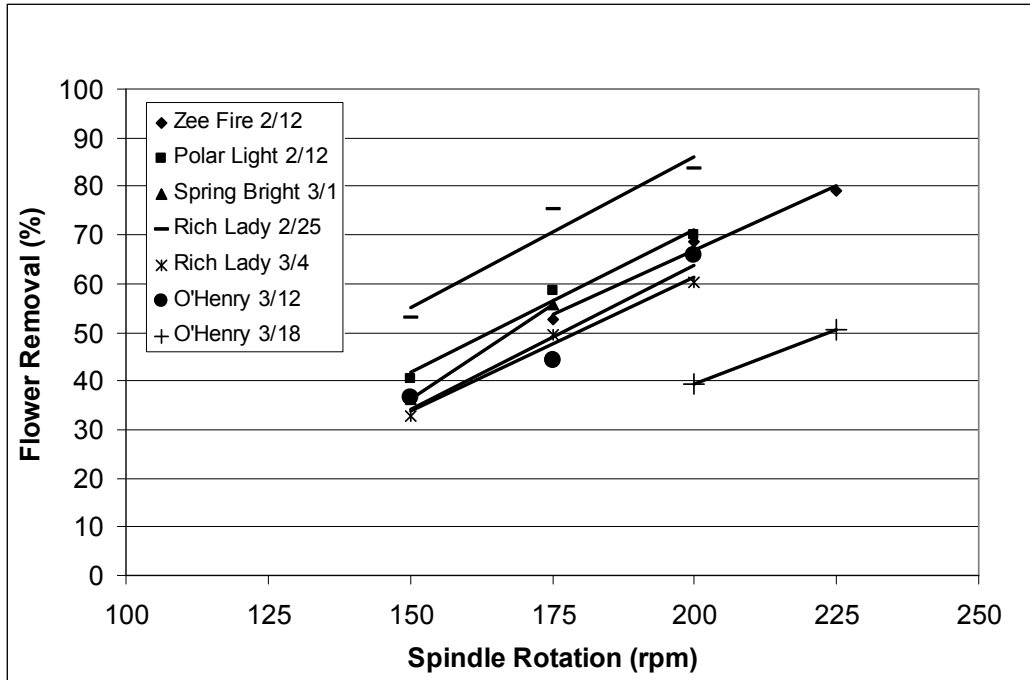


Figure 5. Flower thinning achieved using the Darwin String Thinner on five varieties of peaches and nectarines during bloom. For each variety the “standard” treatment was imposed at different spindle rotations. This “standard” treatment consisted of two rows of the newer molded strings with no gaps and a tractor speed of about two mph.

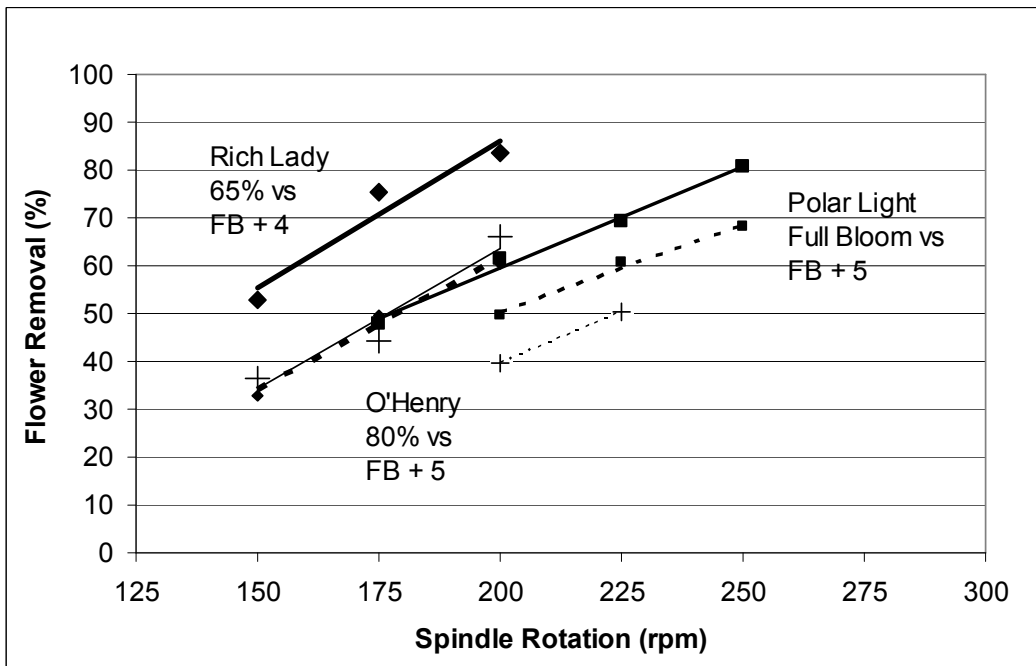


Figure 6. Flower thinning achieved using the Darwin String Thinner on different dates for Rich Lady peach (◆), Polar Light nectarine (■) and O’Henry peach (+). The first date (solid line, larger symbol) was at full bloom or shortly before. The second date (broken line, smaller symbol) was four or five days after bloom.

8. Increasing the number of rows of strings increased the aggressiveness of the thinning but not by a lot (Fig. 7). Thus, tripling the rows of strings (2 vs 6 rows) only increased percent flower removal by about 10 to 20%. No differences could be measured between 2 and 3 rows.

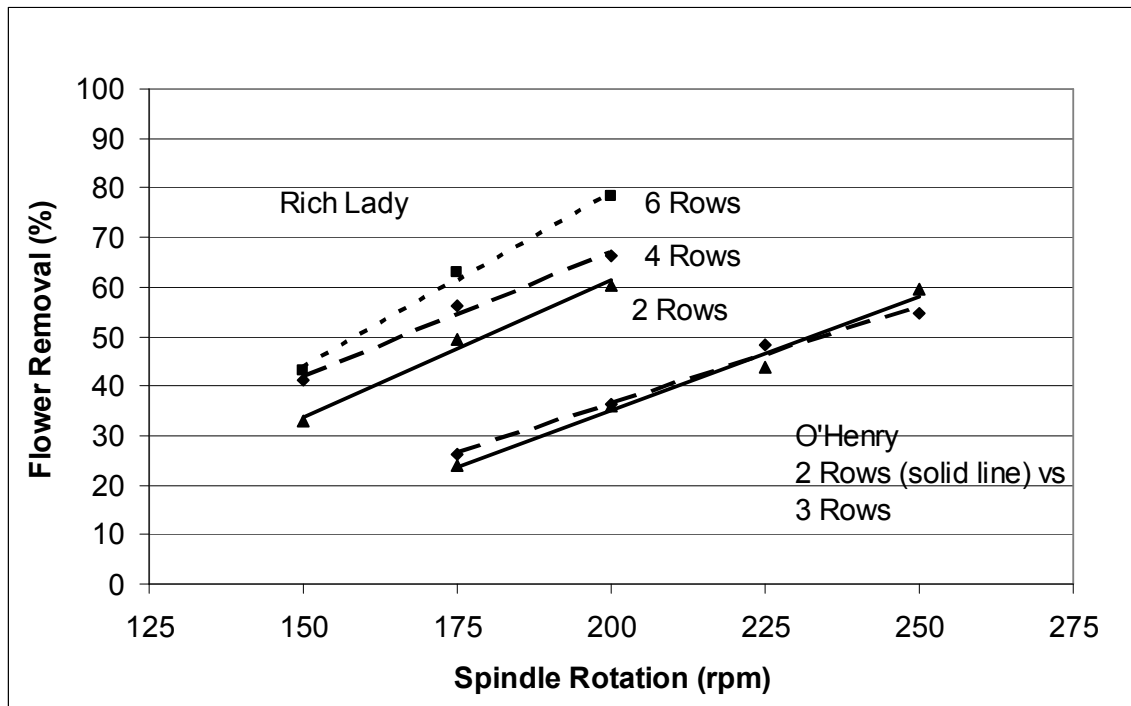


Figure 7. Flower removal achieved with the Darwin String Thinner using 2, 3, 4 or 6 rows of strings along the spindle on Rich Lady and O'Henry peach.

9. Tractor speed had a much more dramatic effect on flower removal than rows of strings. Increasing the tractor speed from two to four mph cut down considerably on the percent flower removal (Fig. 8). Many growers who attended demonstrations of the Darwin String Thinner commented that two mph was too slow and they felt four mph would be a more realistic travel speed to use in order to cover more acreage. Thus, to achieve the same level of thinning, spindle rotation would need to be increased by about 50 rpm in order to compensate for the increased tractor speed. For all the treatments and various demonstrations we used a standard tractor speed of two mph so the tractor driver could maneuver in and out of uneven canopies and thus reach as many flowering shoots as possible. Clearly, the more uniform the flowering "wall" in an orchard, the faster the tractor driver could travel. In the O'Henry orchard, the flowering wall was quite uniform and the orchard floor was also smooth and free from gopher holes. Therefore, we also tried some treatments at six mph (Fig. 8). Although reasonable results were obtained, it is unlikely that commercial orchards would be uniform, smooth or safe enough to travel at such a speed.

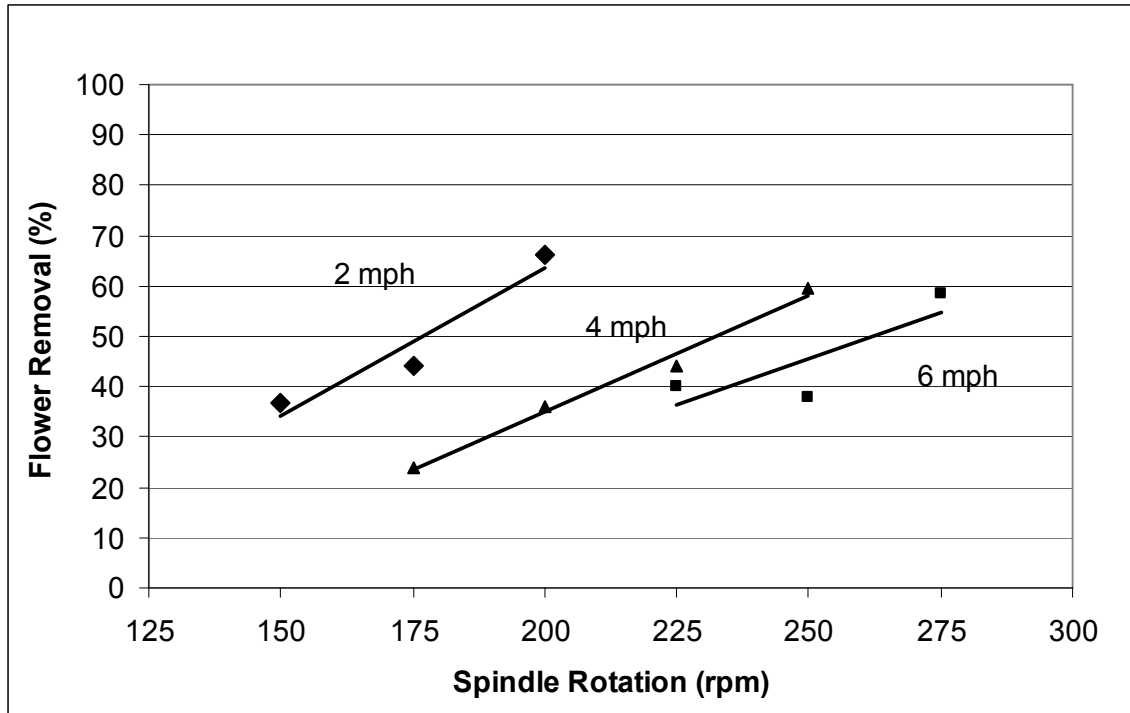


Figure 8. Flower removal achieved with the Darwin String Thinner at different tractor speeds in an O’Henry peach orchard.

10. We also gathered some information about spindle rotation direction. As designed by the company, the strings turn in a clockwise rotation. We found it easy to reverse the direction and tried a few treatments in a counter-clockwise rotation. Although similar levels of flower removal were achieved (data not shown), the strings had a tendency to grab branches and pull them in front of the spindle, thus causing bark injury. This was not observed in the clockwise direction.
11. Finally, useful information was obtained from the detailed measurements taken in one treatment of each variety. Thinning effectiveness was not influenced by shoot location or height in the canopy but was greatly affected by the orientation of shoots with respect to the row. Those shoots parallel to the row and pointing in the direction of travel of the Darwin (down the row) had about twice as many flowers removed as parallel shoots pointing up the row (Table 1). Flower thinning on perpendicular shoots was in between these two extremes. This type of information could help guide pruning practices in orchards where the Darwin String Thinner will be used.

Table 1. The effect of shoot orientation on percent flower removal by the Darwin String Thinner. For each variety, one treatment that achieved about 50% average flower removal was selected and shoot angle with respect to the row was determined for each of the 150 shoots.

Variety	Shoot angle with respect to the row					Significance
	0° (up the row)	45°	90° (perpendicular)	135°	180° (down the row)	
Zee Fire	35.2 b*	40.8 b	56.9 a	58.3 a	60.1 a	.0001
Polar Light	39.6 c	33.3 c	52.3 b	60.4 a	67.0 a	.0001
Spring Bright	32.1 b	43.6 b	53.4 ab	49.5 ab	71.0 a	.02
Rich Lady	42.6 a	44.3 a	49.1 a	48.5 a	63.8 a	NS
O'Henry	26.2 d	41.5 cd	50.5 bc	59.9 ab	72.2 a	.0001
Average	35.1 c	40.7 c	52.4 b	55.3 b	66.8 a	.0001

* Values in a row followed by different letters are significantly different by LSD test.

Conclusions

These series of experiments have demonstrated the usefulness of the Darwin String Thinner as an aid to hand thinning. We have concluded that 50% average flower removal is a good goal to aim for and is achievable with various settings of the machine. Since thinning effectiveness is influenced by many different factors, a grower will probably need to experiment in each orchard to achieve 50% flower removal. However, these experiments provide guidelines that should minimize the trial and error needed. We have concluded that for most situations, two rows of the new molded strings with no gaps (1" apart) and a tractor speed between two and four mph should work fine. The grower would only need to adjust the spindle rotation speed, generally between 150 and 225 rpm, to achieve the desired 50% flower removal. As a basic guideline, 10% greater flower removal would require an increased rotation speed of about 15 rpm.

It goes without saying that the Darwin String Thinner will have no effect on shoots it cannot reach. Thus, it will have a minimal effect on an open vase canopy where most of the shoots are out of reach. Clearly, the ideal situation is a "V", quad "V" or vertical canopy which has been pruned to leave most of the fruiting shoots in a 24" swath outside of the scaffolds. Such an orchard of a heavy setting variety could benefit greatly from the Darwin String Thinner.