MECHANICAL THINNING IN CLING PEACH: FINAL REPORT, 2008 – NORTH STATE TRIALS

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SUMMARY:

Mechanical thinning trials were performed at two sites in Sutter and Yuba (District 10) Counties to compare with hand thinning. The District 10 site proved to be unsuitable for mechanical harvest as fruit would not 'shake' from trees. The grower reported that hand-thinners also find this orchard very difficult to thin historically, as fruit remain very firmly attached. The Sutter County site, where we performed mechanical thinning trials in 2007 as well, allowed us to advance mechanical thinning technology to the point of readiness for commercial adoption. Mechanical thinning, with and without follow-up hand thinning, was compared to hand thinning alone, with each thinning treatment applied to a single row of 51 similarly moderately-cropped 'Loadel' trees; mechanical thinning occurred on April 19 (full bloom date was March 10) and hand thinning on April 30 (grower timing). Number of fruit per pound at machine thinning averaged 91 and at hand thinning (without machine thinning) averaged 48 fruit per pound.

Cropload estimation:

- More trees used in estimating cropload improves accuracy.
- It is much faster to use the 'shake' method of estimation, although growers may not be comfortable with removing all fruit off a few trees and losing that small portion of the crop.
- The larger the cropload, the greater the likelihood of errors in counting fruit on the tree.
- If bin-sorting is used to eliminate all but the #1 fruit, and the largest #1 fruit, it is not possible to have an accurate estimate of cropload from grading station yields. Only obtaining accurate values for fruit numbers in grade categories with an accurate measure of initial cropload and amount of crop thinned, using direct methods of measurement, will provide the best information for a grower to maximize thinning efficiency and net financial gain.

Thinning method effects on man-time and cost per acre:

- Hand thinning was timed on 18 of 51 trees in the hand thinning only treatment; four thinners required 3.75 hours, or 50 'man-minutes' per tree. In the machine + hand thinning treatment, 6 trees were thinned by 2 men in 96 minutes, which can be calculated as 16 'man-minutes' per tree. Two men broke clusters using poles in the upper canopy and then broke clusters by hand, thinned to spacing in the lower canopy.
- Cost to thin per acre was estimated at $95 for mechanical, $280 for mechanical + hand and $800 for hand only

Fruit drop was reduced 55% by mechanical thinning, compared to hand-thinned trees, which suggests that mechanically-thinned trees should be thinned to a final cropload, without leaving any overage intentionally. In this trial, mechanically-thinned trees that did not receive a hand thinning 'touch-up' had an excess of undersized and #2 fruit, based on researchers' samples and the grading station data, and should have been thinned to a final, expected cropload.

Fruit growth over time:

- No significant differences in diameter existed based on canopy location, except on June 19 and July 3 (P = 0.1% highly significant, P = 5%, significant, respectively).
- Differences in weight by canopy location were significant only from June 12 on (P = 5% on June 12 significant, P = 0.1% on June 19 highly significant, P = 5% on July 3, significant)

- Weight of fruit in the upper canopy averaged 4.9 oz on July 3 and in the lower canopy, fruit averaged 4.3 oz on July 3, without separating fruit by grade. This data was 11 days prior to harvest.

Yield and fruit quality at harvest:

- Mechanical thinning alone, when thinned to anticipate 20% of cropload dropping post-thinning, resulted in smaller fruit overall. These trees should have been thinned to final cropload, as evidenced by percentages of the fruit by grade.
- Fruit from the mechanical + hand-thinned trees had more #1 fruit than did the hand-thinned only trees (92% vs 87%), but this difference was not significant. Fruit size, overall, was greater in the mechanical + hand-thinned treatment, reflecting early cropload adjustment. Adjustment of cropload by hand, following mechanical thinning, increased the size of #1 fruit in the upper canopy
- No immature #1 fruit were found (grade by Konica Minolta CR-10 as per grading station procedure).
- Firmness was least in hand-thinned fruit, and significantly greater in mechanical + hand-thinned fruit, greatest in mechanically-thinned fruit. No fruit was excessively firm or soft.
- Once the net yield was divided by the number of trees per treatment (adjusting for 'weak' trees), yield per tree for mechanical thinning alone was 259.14 lb of fruit/tree, for mechanical + hand thinning yield per tree was 249.47 lb, and for hand thinning alone, yield per tree was 319.02 lb.
- When these weights are multiplied by the average weight per fruit prior to grading for each treatment, an estimated yield per tree for each treatment, respectively, was 805 fruit, 670 fruit, and 905 fruit, not taking into account fruit removed by bin-sorting.
- The researcher-sampled #2 + undersized fruit for the mechanically thinned was 24.7%, vs the grading station sample of 11.1%, 7.7% vs 6.8% for mechanical + hand-thinned, and 13% vs 4.2% for hand-thinned. Thus, the estimate of final number of fruit per tree based on grading station data (805, 670, 905 for each respective treatment), is grossly under-estimated for all thinning treatments. Bin-sorting may have been excessive, based on the differences in grade (explained above) and the size distribution of #1 fruit (explained below).
- Most #1 fruit from all thinning treatments were well above the minimum size to 'make grade', possibly reflecting over-thinning by hand and excessive bin-sorting.
- Grading station percentages for #2 and undersized fruit (0.48 and 3.77%, respectively), for the hand-thinned treatment were well below the tolerances, possibly reflecting over-thinning by hand and excessive bin-sorting.

Machine thinning to carrying capacity at fruit diameter range of 20-28 mm will result in uneven fruit distribution, nonselective sizing, but overall reduction in management costs, even with some extra undersized fruit. Follow-up hand thinning after mechanical thinning also reduces management costs, and provides an additional level of grower choice.

PROBLEM AND ITS SIGNIFICANCE:

Cling peach trees typically set far more fruit than the trees are able to 'size' for commercial purposes; reducing the cropload by hand labor is intensive, expensive and dependent on an uncertain labor force that is increasingly inexperienced. Alternatives to hand labor must be found for all aspects of cling peach orchard management; mechanical harvest is already an established practice for some growers. Thinning mechanically and chemically are alternative technologies that have shown substantial promise experimentally, but require improvement technically.

Grower success in cropload management will depend upon the ability to anticipate annual fruit-sizing potential (largely determined by initial fruit set and first 30 DAFB temperatures, or GDH_{30}) for individual cultivars and knowing the historic bearing capacity of their orchard and management practices. Hand

thinning is far less random than chemical thinning, mechanical thinning, or even natural thinning, such as by late frost, poor pollination, or too warm/too cool temperatures during bloom. Early fruit drop, which is cultivar- and weather-dependent, will also affect final cropload, yet is rarely considered by the grower who hand-thins as early drop occurs prior to reference date.

We still need to develop better precision in cropload reduction with either chemical or mechanical thinning, and at the same time, redefine what the optimum goals for cropload and fruit quality are, using these non-selective technologies. Crop value is based on both yield (tons per acre) and the quality of the yield (fruit size). Growers will vary in their choices, some considering that optimum fruit quality is worth higher cost.

OBJECTIVES:

- To 'fine-tune' mechanical thinning to a 'single shake' adjustment of desired cropload (+ some margin of excess to account for 'small fruit drop' that normally occurs prior to 'reference date', proposing 20% additional), using orchard historic 'optimum' cropload.
- To develop a better method of determining cropload prior to thinning, and during the process
  - Method 1: Count all fruit in 1 tree quadrant, then multiply by 4.
  - Method 2: as in prunes, shake all fruit from ~3 trees, weigh total fruit, subsample for count/lb and estimate number of fruit
  - Compare final cropload using these methods for accuracy
- To measure fruit growth throughout the season to confirm 'decision-making' timing for thinning
- To measure fruit drop throughout the season for cropload estimation purposes (see Objective 1) and to compare drop on mechanically thinned vs hand thinned treatments

PLANS AND PROCEDURES:

Trial Site: Micheli/Yuba City

We continued cooperating with Justin Micheli in the 'Loadel' vase-shaped trained orchard we've worked in for 2 years. Trees crop well at ~1050 fruit/tree (upper limit is ~1400), and can produce 20 or more tons to the acre with very low offgrade (J. Micheli, personal communication).

Initial fruit set: We estimated fruit set on 1 'high potential' tree and 1 'low potential' tree (strong tree with numerous scaffolds and blooms vs weak tree) by counting all flowers on March 7 and then fruit on April 15, on 6 major secondary limbs per canopy location (upper, lower); half of limbs counted were in the northeast quadrant and half in the southwest quadrant. Percent fruit set range was from 36 to 100% (strong tree, northeast), 68 to 90% (strong tree, southwest), 72 to 85% (weak tree, northeast) and 52 to 100% (weak tree, southwest). Flowers per cm shoot length at bloom ranged from 0.14 to 0.77, an indicator of highly variable productivity from shoot to shoot.

Initial cropload estimation:

- Cropload prior to thinning was estimated by two methods (see Objectives for details): (1) counting all fruit in the southeast quadrant of two or more trees and multiplying this value by 4, and (2) at machine thinning by removing all fruit from two or more trees by shaking, weighing the fruit removed under half the canopy, as well as a subsample of 1 pound, then counting fruit per pound.
- Method 1: We counted fruit as previously described (in Objectives) on three trees, estimating cropload of 4493, with 74% of fruit in the upper canopy (Tree 1), 3355 fruit with 70% of fruit in the upper canopy (Tree 2), 2780 with 88% of fruit in the upper canopy (Tree 3).

- When we used Method 2 on the same set of three trees, weighed all fruit shaken under half the canopy, weighed a subsample and counted fruit, we estimated 5279, 2047, and 2070 for Trees 1, 2 and 3, respectively.

Estimated #fruit/tree	Method 1	Method 2	Count per lb
Tree 1	4493	5279	105
Tree 2	3355	2047	85
Tree 3	2780	2070	95

We found a wide range of cropload based on both estimation methods and on our fruit set counts.

Thinning treatments:

To reduce variation in cropload data that may not be thinning treatment-related, the number of 'weak' trees per 51-tree treatment row was recorded and 'weak' trees were counted as half a tree in final crop estimates. The mechanically-thinned treatment row of 51 trees included 7 'weak' trees, the hand-thinned row did not have any 'weak' trees, and the mechanical + hand-thinned row had 9 'weak' trees, all of which were counted as 'half' a tree for yield purposes.

Mechanical thinning (by Erick Nielsen Enterprises), with and without follow-up hand thinning, was compared to hand thinning alone, with each thinning treatment applied to a single row of 51 similarly moderately-cropped 'Loadel' trees; mechanical thinning occurred on April 19 (full bloom date was March 10) and hand thinning on April 30 (grower timing). Number of fruit per pound at machine thinning averaged 91 and at hand thinning (without machine thinning) averaged 48 fruit per pound. Treatments were as follows:

1. Grower's normal hand thinning practice (April 30)
2. 'Single' shake mechanical thinning at 20-27 mm fruit diameter (April 19); target level of cropload reduction to achieve ~1000-1100 fruit per tree cropload after thinning + 20% (1200-1220 fruit), adjusting for a 'guesstimate' of 20% small fruit drop between mechanical thinning and normal 'reference date'. The estimated cropload left on trees when mechanically thinned was by 'eye', judged by the grower and his foreman to approximate desired final cropload + 20%.
3. 'Single' shake mechanical thinning as above, followed by hand thinning from the ground only, breaking clusters in upper canopy by pole and spacing fruit in lower canopy by hand. Small fruit were not removed as these were anticipated to drop by reference date.
4. Hand thinning was timed on 18 of 51 trees in the hand thinning only treatment; four thinners required 3.75 hours, or 50 'man-minutes' per tree. In the machine + hand thinning treatment, 6 trees were thinned by 2 men in 96 minutes, which can be calculated as 16 'man-minutes' per tree. Two men broke clusters using poles in the upper canopy and then broke clusters by hand, thinned to spacing in the lower canopy.

Number of fruit thinned at each thinning date was estimated for the whole tree by weighing all fruit collected on tarps under the north half of each of six sample trees for each thinning treatment, then weighing a pound subsample of that fruit and counting all fruit in the pound subsample (Table 1). The estimate was then calculated for the half tree and doubled for whole trees. Twenty-five fruit from the pound subsample were selected randomly and their diameters (measured at the widest point from the suture to the opposing side) and weight obtained for an average size of fruit thinned. The weights of fruit thinned from 'half trees' ranged from: 7.4 to 12.4 g and fruit per pound ranged from 85 to 105 (mean 94.5 fruit/b) on April 19. Diameters for fruit thinned ranged from 12 to 33 mm at the widest point (from suture to opposite suture), with the average diameter of fruit thinned 26.5 mm.

Fruit drop over growth period: Fruit drop was recorded on a weekly basis throughout the growing season for hand thinned treatment and machine thinned only treatment, on two trees per treatment. This data was taken to test the hypothesis that machine thinning at an early timing could result in a reasonable

carrying capacity for the orchard, anticipating a certain percentage of fruit drop by reference date, without excessive undersized fruit. Fruit drop data was also taken to compare percentage of drop with machine vs hand thinning. Approximately one-tenth of the ground surface under each tree was covered with landscape cloth and all fruit counted that dropped was counted on a weekly basis, then fruit was removed.

Rate of fruit growth: Rate of fruit growth on hand-thinned trees, collected at random from upper and lower canopy separately, was determined on a weekly basis throughout the growth season. Both individual fruit weight and diameter (from suture across widest point to opposite of suture) were recorded on 50 (March 27-May 9) or 25 (May 15-July 3) fruit collected at random from upper vs lower canopy (50 or 25 fruit per location, per date) from approximately 10 trees chosen from 2 hand-thinned rows next to the research plot.

Yield and fruit quality at harvest: Crop yield and quality was determined experimentally and at the grading station, by thinning treatment. Commercial harvest occurred on July 14, at which time we hand-harvested 25 fruit per canopy location (upper and lower) on each replicate tree (six per thinning treatment) for quality measures:

- weight per 25
- diameter for grading: #1 fruit won't pass through 2 3/8" ring, #2 fruit are 2 3/8" in diameter or less, but won't pass through the 2 ¼" ring; undersized are 2 ¼" or smaller in diameter
- diameter and weight of ten #1 fruit per canopy location/replicate tree
- firmness, measured by the Imada DS2-11 Digital force gauge
- maturity, measured color by Konica Minolta CR-10 as per grading station procedure.

Prior to measuring with the Imada gauge, we removed a very thin slice of skin on one cheek of the fruit using an official CDFA slicer for cling peach, then used the Imada digital force gauge fitted with a chisel-end, conical tip and the ability to read up to 11 psi (5 kg) of force in 1 gram increments. The tip was inserted into the flesh up to a reference point on the tip (i.e. each insertion was to the same depth), and the force required for the insertion recorded.

Colorimetric determination of fruit maturity followed grading station guidelines (Slaughter et al., 2004). A Konica Minolta CR-10 colorimeter was used with minimum maturity CDFA No.2 color disk used as the 'target' color for 'passing' minimum maturity with the hue angle of the No. 2 disk providing the 'pass/fail' threshold.

All measurements were evaluated by standard statistical analysis using Statistical Analysis Systems software (SAS Institute, Cary, NC) to perform the means separation (Tukey's means separation; 5% level of significance) and analysis of variance (PROC GLM) or PROC TTEST for mean separation by canopy location, as appropriate.

Fruit was then commercially harvested by thinning treatment for each treatment of 51 trees was followed to the grading station where bins were weighed for total yield and percentage of the crop for each size category was determined, along with other defects, by official inspection methods of the California Department of Food and Agriculture testing a 50-55 lb sample.

RESULTS AND DISCUSSION:

Thinning treatments, cost to thin and cropload estimation:

April 19:

Treatments 1 and 2 (Mechanical thinning only, Mechanical + Hand thinning, respectively; Table 1) -- We estimated number of fruit removed on 6 replicate trees for Treatment 1 (mech thin only) and 6 trees for Treatment 2 (mech thin + hand thin). Count per pound for all 12 trees ranged from 82 to 104 (average

94.5). Estimated numbers of fruit removed for all 12 trees averaged 1804 per whole tree (1700 for 6 machine-thinned only trees and 1908 for 6 trees machine-thinned on April 19 thinning date and later hand-thinned), based on an average weight of fruit removed per half tree = 9.7 lb.

Average number of fruit remaining per tree after mechanical thinning was 1328. Total time to shake Treatments 1 and 2 (102 trees total) was 56 minutes, or 33 seconds per tree, for a total shake time of 1.1 hours per acre for 121 trees per acre.

April 30:

Treatment 2, Mechanical Thin + Follow-Up Hand Thin from ground only to break clusters and reduce crop on lower hangers – Hand thinning on April 30 removed an additional average 678 fruit/tree for an average total number of fruit removed 2586; Table 1). In the machine + hand thinning treatment, 6 trees were thinned by 2 men in 96 minutes, which can be calculated as 16 'man-minutes' per tree. . Two men broke clusters using poles in the upper canopy and then broke clusters by hand, thinned to spacing in the lower canopy. Thus, total man-hours for hand thinning following machine thinning was estimated at 32.3 hours per acre.

Treatment 3, hand thinning only -- Hand thinning was timed on 18 of 51 trees in the hand thinning only treatment; four thinners required 3.75 hours, or 50 man-minutes per tree (100.8 man-hours per acre). This represents an increase of 68.5 man-hours per acre over the hand thinning time on the mechanical + hand thinning treatment. Hand thinning alone removed an average of 3432 fruit per tree.

Cost of thinning by treatment:

At an estimated cost of $95 per acre (Erick Nielsen Enterprises), the cost to thin by machine only is $0.90 per tree. Cost to hand thin (hand thinning treatment with no mechanical thinning) was $800 per acre (J. Micheli, pers. comm.), requiring 151.25 man-hours per acre, or $6.61/tree (at $0.088 per man-minute). Machine-thinning with hand thinning touch-up cost is estimated at $0.90 + (16 man-minutes X $0.088 per man-minute = $1.41) = $2.31 per tree. Machine thinning alone saved 86% of the thinning cost of hand thinning alone, while machine- + hand thinning saved 65% of the cost of hand thinning alone.

Understanding how to estimate: Estimating the amount of crop before thinning or after thinning, regardless of thinning method, either relies on the eye, as Method 1 for initial cropload, or direct measurement using actual fruit weighed and counted, as in Method 2. Weighing and counting fruit at thinning (Method 2) was used for all thinning treatments and estimates show that 1400-1960 fruit were removed by shaking, and 2600-4700 fruit removed by hand thinning (alone).

When final harvest values were obtained from the grading station (Table 2), total yield for each row of thinned trees, representing a thinning treatment, could be used for a further estimation of cropload, however, this method is very inaccurate as it does not account for the number of fruit removed by bin-sorting. Once the net yield was divided by the number of trees per treatment (adjusting for 'weak' trees), yield per tree for mechanical thinning alone was 259.14 lb of fruit/tree, for mechanical + hand thinning yield per tree was 249.47 lb, and for hand thinning alone, yield per tree was 319.02 lb. When these weights are multiplied by the average weight per fruit prior to grading (Table 3), an estimated yield per tree for each treatment, respectively, was 805 fruit, 670 fruit, and 905 fruit, not taking into account fruit removed by bin-sorting.

Using grading station data to estimate cropload using harvest yields recorded at the grading station is highly inaccurate unless fruit grade is obtained prior to bin-sorting. Percentages for each grade were obtained by researchers in random samples on the trees prior to commercial harvest (Table 3). When considering the tree overall, by thinning method alone, mechanically-thinned trees had a significantly lower percentage of #1 fruit than either of the other thinning methods, due to the non-selective nature of machine thinning and leaving an 'overage' on the trees to offset subsequent fruit drop, and considerably more #2 and undersized fruit than trees thinned partially or completely by hand. The researcher-sampled #2+ undersized fruit for the mechanically thinned was 24.7%, vs the grading station sample of 11.1%, 7.7% vs 6.8% for mechanical + hand-thinned, and 13% vs 4.2% for hand-thinned. Thus, the estimate of

final number of fruit per tree based on grading station data, found in Table 3 (805, 670, 905 for each respective treatment), is grossly under-estimated for all thinning treatments. When using any method for thinning and cropload estimation, one must take into account that final cropload in this trial for the grower's choice of hand thinning suggests that these trees were at carrying capacity and that bin-sorting may have been excessive in that most #2 fruit were removed at bin-sorting. If an average of 250 fruit per tree dropped after hand thinning, and 115 fruit per tree are #2 + undersized (13% estimate, based on actual grade measured by researchers prior to bin-sorting), then the 905 fruit per tree cropload estimated from the grading station after bin-sorting becomes 1230 fruit per tree for the hand-thinned trees at hand thinning time and 980 fruit per tree prior to bin-sorting at harvest. The size distribution for #1 fruit (Figure 1) shows that most #1 fruit from all thinning treatments were well above the minimum size and the grading station percentages for #2 and undersized fruit (0.48 and 3.77%, respectively), were well below tolerances. Thus, fruit that could have increased the profit per acre were probably eliminated by bin-sorting.

In our 2007 trial, in this same orchard when fruit set was excessively heavy, we estimated that we thinned 3200-4800 fruit per tree and that trees that were hand-thinned twice had 1320 fruit per tree, at harvest. We had accurate records of percentages for all fruit grades since fruit were not bin-sorted. GDH_{30} indicated that 2007 was a 'short' growing season with less time to size fruit. This was not the case in 2008, and the carrying capacity of this orchard should have been closer to the 1230 fruit per tree estimate outlined above, and that bin-sorting to obtain only #1 fruit, and the largest #1 fruit may contribute to financial loss.

Fruit drop: Drop was significantly greater in hand thinned trees (thinned 30 April) than in mechanically thinned trees (thinned 19 April), reflecting increased competition among fruit on hand-thinned trees during critical fruit growth period (Figure 2). Thus, the largest difference in drop occurred between the time of machine thinning and hand thinning, with a difference that was three- to four-fold during the first week after machine thinning and 80-88% higher in the second week after machine thinning, in those trees that were subsequently hand-thinned on April 30. Final difference in fruit drop was, on average, 55% less at the end of the growing season in machine-thinned trees. This result was different than expected, based on thinning early and heavily in 'Simizu Hakuto' peach (Fukuda et al., 2006), in which the 'heavily thinned' treatment (thinned early May to final cropload) showed significantly more drop than those of either the 'standard thinned' trees (hand-thinned in early May to 2-3 fold final cropload anticipating more fruit drop), or 'lightly thinned' trees (thinned early June to 1.5 fold final cropload).

Thus, early thinning by machine in this study reduced 'physiological' drop by about 55%, based on growth data, despite uneven fruit distribution imposed by mechanical thinning. In a 'good' crop year, therefore, mechanically-thinned trees should be thinned to a final cropload, without leaving any overage, which could stimulate late fruit drop, as was observed in the mechanically thinned trees in late June (general observation in the treatment row). In this trial, mechanical thinning occurred more than 30 days after full bloom, by which time the GDH_{30} Model can give a reasonable prediction of harvest date, as well as sizing potential.

Fruit growth (Figure 3): No significant differences in diameter existed based on canopy location, except on June 19 and July 3 (P = 0.1% highly significant, P = 5%, significant, respectively). Differences in weight by canopy location were significant only from June 12 on (P = 5% on June 12 significant, P = 0.1% on June 19 highly significant, P = 5% on July 3, significant). Weight of fruit in the upper canopy averaged 4.9 oz on July 3 and in the lower canopy, fruit averaged 4.3 oz on July 3, without separating fruit by grade. This data was 11 days prior to harvest.

Yield and fruit quality at harvest:

When the 25-fruit sample from each replicate tree was weighed prior to grading, fruit from the mechanical thinning treatment weighed significantly less than those from either mechanical + hand (greatest weight) or hand only treatments (Table 3). When separated by canopy location within treatments, fruit from the upper canopy of the mechanically-thinned trees were significantly lighter than either mechanical + hand-

or hand thinning treatment; fruit from the lower canopy were not different from those of hand-thinned trees but were different from the mechanical + hand-thinned trees. Thus, mechanical thinning alone, when thinned to anticipate 20% of cropload dropping post-thinning, resulted in smaller fruit overall. These trees should have been thinned to final cropload, as evidenced by percentages of the fruit by grade. Fruit from the mechanical + hand-thinned trees had more #1 fruit than did the hand-thinned only trees (92% vs 87%), but this difference was not significant. Fruit size, overall, was greater in the mechanical + hand-thinned treatment, reflecting early cropload adjustment.

When graded into #1 fruit (Table 4), size of mechanical + hand-thinned #1 fruit were significantly larger than either of the other thinning treatments, by weight. Maturity, measured by hue angle, in all treatments indicated that no immature #1 fruit were found, and this was substantiated by grading station data (not shown). Firmness was least in hand-thinned fruit, and significantly greater in mechanical + hand-thinned fruit, greatest in mechanically-thinned fruit. Adjustment of cropload by hand following mechanical thinning, increased the size of #1 fruit in the upper canopy.

Yields for each thinning treatment computed on a per tree basis show that the highest yield was for the hand-thinned fruit (Table 2), reflecting an appropriate cropload after thinning, but, possibly excessive bin-sorting, as previously explained. Yield per tree for the mechanical and mechanical + hand-thinned treatments probably also were excessively reduced by bin-sorting, particularly when average fruit size is considered. Average fruit size for all fruit was in excess of 5 oz, although minimum weight for #1 fruit, based on actual sample size data and minimum diameter for #1 fruit (Figure 3), is about 4.4 oz. Estimating final croploads of 905 (hand-thinned), 805 (mechanically-thinned) and 670 (mechanical + hand-thinned) similarly indicates either overthinning or excessive bin-sorting. The tonnage per acre for the hand-thinned crop (19.3) approximates that of the grower's 'best' years. No doubt the crop on the mechanically- and mechanically + hand-thinned trees had excessive offgrade, based on researchers' samples (Table 3), due to leaving extra fruit on the trees anticipating higher drop rate and due to non-selective thinning method by mechanical methods. The net value in crop by the acre, once thinning costs are subtracted, shows a slight advantage of the mechanical thinning over that of hand thinning, even considering excessive bin-sorting and inadequate thinning (intentionally). In a heavy crop year with high thinning costs, such as 2007, the financial advantage in mechanical thinning would be far higher. The financial gain using mechanical + hand-thinned method is more than $900 per acre, compared to the hand-thinned trees. It is expected that in years when hand thinning costs are in excess of $800/acre (as in 2007 at $1500/acre), and when trees are mechanically-thinned to carrying capacity without excessive bin-sorting to obtain only the largest #1 fruit, that the financial gain in using mechanical thinning will be substantially greater, more than making up for uneven fruit size and distribution.

Demo trial site: Johl, District 10

Mechanical thinning was attempted on moderately-cropped, vertical V trained 'Loadel' on 19 April; we found that fruit would not shake but broke off from the stem. The grower reports his hand thinners always find this orchard very hard to thin for this reason.

Pertinent References

Galili, N., J. De Baerdemaeker and E. Verstreken. 1998. Performance evaluation of different firmness test methods in fruits. Acta Hort. 464:433-440.

Glozer, K, J. Hasey and D. Slaughter. 2005. Improving Fruit Firmness And Reducing Fruit Drop in Cling Peach: Final Report, 2005 California Cling Peach Advisory Board.

Kupferman, E., and N. Dasgupta. 2001. Comparison of pome fruit firmness testing instruments. Postharvest Information Network http://postharvest.tfrec.wsu.edu/EMK2001C.pdf Tree Fruit Research And Extension Center. Washington State University 1-12.

Slaughter, D., J. Hasey, R. Duncan, C. Crisosto, D. Garner, E. Staab, J. Horn, L. Hasey, and S. Griffin. 2004. Objective determination of color and firmness in cling peaches. Research report to The California Cling Peach Board. Dinuba, Calif.

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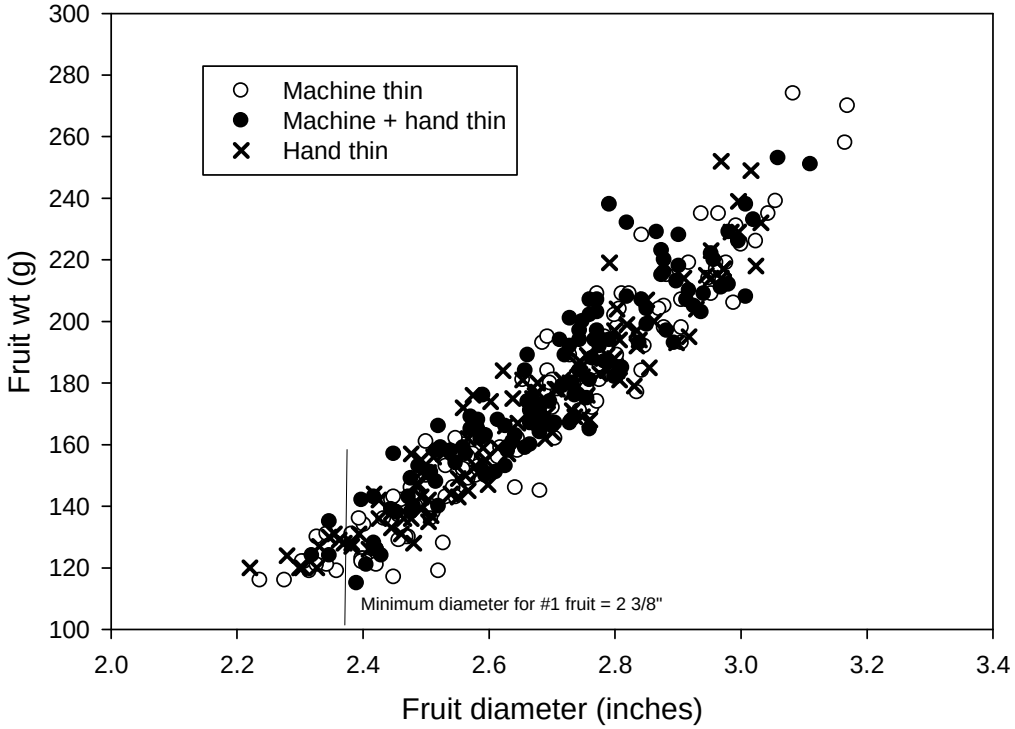

Figure 1. Size distribution of #1 fruit from Micheli harvest, indicating that almost all fruit were above minimum size, many of them well above. Fruit size grade as per California Department of Food and Agriculture (diameter of #1 fruit won't pass through 2 3/8" ring, #2 fruit are 2 3/8" in diameter or less, but won't pass through the 2 ¼" ring; undersized are 2 ¼" or smaller in diameter).

Figure 2. Fruit drop over growing season, 2008. Drop of 'Loadel' cling peach in Sutter County, California, on trees either machine-thinned on April 19 (full bloom March 10) or hand thinned on April 30 (grower practice). Typical cropload for good 'sizing' potential is 1050-1400 fruit per tree (grower, personal communication). Numbers represent approximately one-tenth of the canopy of the tree.

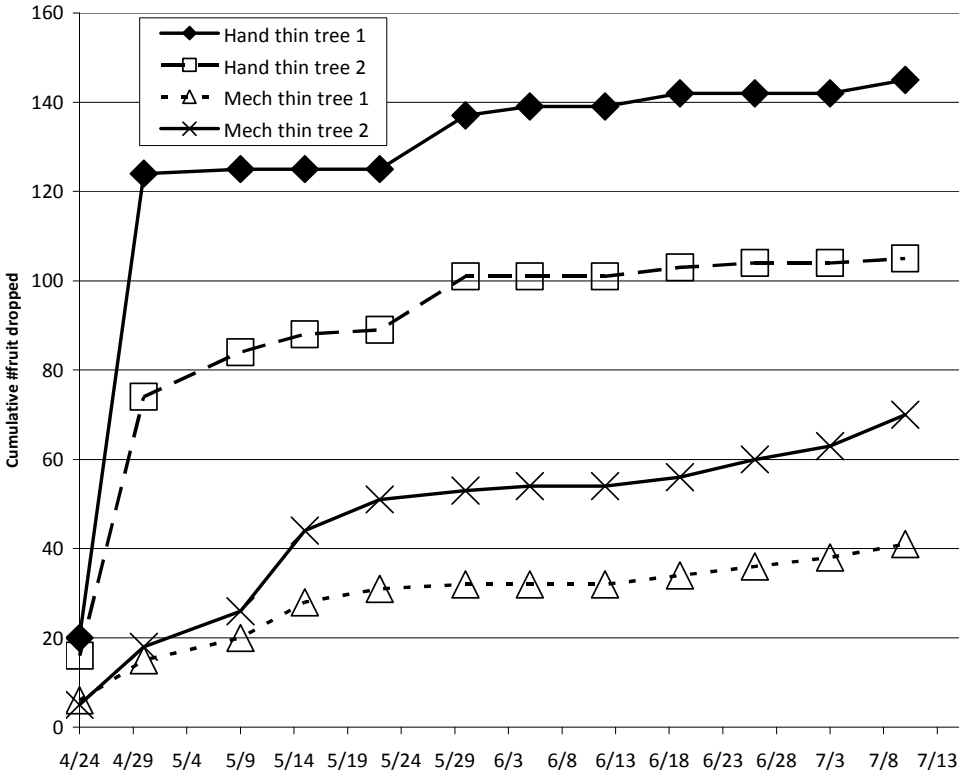

Figure 3. Cling peach growth over time, 2008, in Sutter County; full bloom estimated as 10 March. Fruit separated by canopy location as 'upper half' and 'lower half' of the canopy, which had approximately 7.5 feet vertical height of bearing canopy. Where standard error bars cannot be seen, errors are too small to show. Each data point represents an average of 50 fruit from either upper or lower canopy, for a given date.

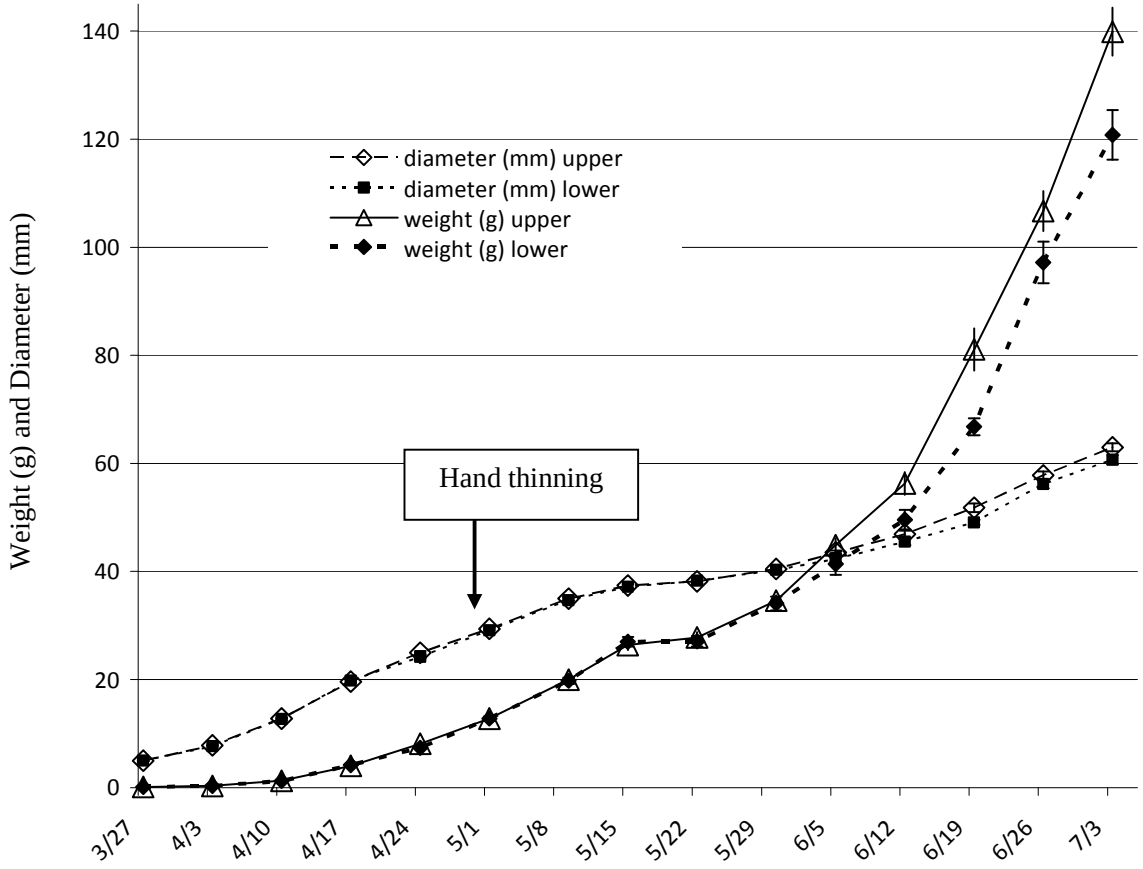

Table 1. Range of observed measures for fruit removal and size at thinning treatments for 'Loadel' cling peach (2008, Sutter County, California).

Thinning treatment	Average weight (lb) of fruit removed per half tree			Average # fruit per pound		Estimated average number of fruit removed per whole tree	Cost to thin per acre	Cost to thin per tree
	April 19	April 30	Total	April 19	April 30			
Machine	9.7		9.7	94.5		1700	$95	$0.90
Machine + hand		8.4	18.1		40.7	1908 (Apr 19) + 678 (Apr 30) = 2586	$280	$2.31
Hand		30.8	30.8		55.3	3432	$800	$6.61

Initial cropload estimates, using two methods of estimation, ranged from ~2050 to 5280 fruit per tree.

Table 2. Effect of thinning treatment on yield components and crop value from CDFA grading station for 'Loadel' cling peach (2008, Sutter County, California). Estimates of fruit harvested per tree were after in-field bin-sorting to remove offgrade, thus, the actual number of fruit per tree was probably slightly higher than shown, as supported by estimates made in researcher grading.

Thinning treatment	Weight (lb) of fruit harvested per tree	Average fruit weight (oz) and estimated #fruit/tree yield	Percentage, lb per tree				Value per acre (tons, $)[y]		
			#2	Undersize[z]	Bruised + overripe	Excessive offgrade	Initial	Less thinning costs	If thinned to 'hand' cropload of 905 fruit[x]
Machine	259.14	5.15 oz, 805	3.78	7.34	2.26	2.34% 6.06 lb	15.3, $5497	$5402	17.6, $6232
Machine + Hand	249.47	5.96 oz, 670	1.57	5.21	0.86	0.21% 0.52 lb	15.1, $5407	$5312	20.4, $7042
Hand	319.02	5.64 oz, 905	0.48	3.77	0.99	--	19.3, $6929	$6129	$6129

[x] Machine-thinned trees were over-thinned, based on the estimated cropload at harvest and considering a bearing capacity for the orchard of 1050 well-sized fruit per tree (grower estimate). Estimated value per acre for machine-thinned fruit if thinned to same cropload as hand-thinned trees assumes same average fruit weight and percentage of excessive offgrade as for actual machine-thinned values.

[y] Crop value in dollars, based on 2008 negotiated price by California Canning Peach Association (Peach Fuzz vol. 38 (7), July 30, 2008) for $321/ton with $38/ton premium for extra-early varieties. Acre value of crop calculated based on 121 trees per acre, actual number of trees used per thinning treatment, and actual yields and grades recorded at CDFA grading station. Tolerance for #2 fruit was 10% (paid), for undersized was 5% (paid) and excessive undersized (offgrade) was considered over 5% (unpaid).

[z] Fruit size grade as per California Department of Food and Agriculture diameter (diameter of #1 fruit won't pass through 2 3/8" ring, #2 fruit are 2 3/8" in diameter or less, but won't pass through the 2 ¼" ring; undersized are 2 ¼" or smaller in diameter).

Table 3. Effects of thinning method, on fruit weight and distribution of fruit grades for 'Loadel' cling peach, obtained by researcher sampling on trees prior to commercial harvest. Mean weight in any category is for a single fruit, as an average of 25 fruit.

Thinning treatment	By thinning method only					By canopy location							
						Wt (g) before grading)		Percentage in given grade [y]					
	Wt before grading		Percentage in given grade			Upper	Lower	#1		#2		Undersized	
	g	oz	#1	#2	Undersized			Upper	Lower	Upper	Lower	Upper	Lower
Mechanical	145c [x]	5.15	75.3b	12.0a	12.7a	148.2b	141.7b	77.3b	73.3b	11.3a	12.7a	11.3a	14.0a
Mechanical + hand	169a	5.96	92.3a	4.7b	3.0b	175.6a	162.5a	93.3a	91.3a	5.3ab	4.0b	1.3b	4.7b
Hand	160b	5.64	87.0a	9.3ab	3.7ab	170.2a	149.7ab	94.7a	79.3b	4.7b	14.0a	0.7b	6.7ab

[x] Mean separation by DMRT; P = 0.05.

[y] Fruit size grade as per California Department of Food and Agriculture diameter (diameter of #1 fruit won't pass through 2 3/8" ring, #2 fruit are 2 3/8" in diameter or less, but won't pass through the 2 ¼" ring; undersized are 2 ¼" or smaller in diameter).

Table 4. Effects of thinning method, on quality of #1 [y] 'Loadel' cling peach fruit in 2008, obtained by researcher sampling on trees prior to commercial harvest.

Thinning treatment	By thinning method only				By canopy location							
					Wt (g)		Diameter (inches)		Firmness (lb)		Maturity (hue)	
	Wt (g) of 25 fruit	Diam (in)	Firmness (lb)	Maturity (hue)	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Mechanical	168.6b	2.65a	9.3a	76.8a	167b	170.5a	2.65b	2.66a	9.7a	9.0a	76.8a	76.7a
Mechanical + hand	180.4a	2.70a	8.1b	76.6a	186a	174.4a	2.74a	2.67a	7.9b	8.3b	76.6a	76.6a
Hand	170.1b	2.65a	7.5c	75.7b	176ab	164.2a	2.70ab	2.60a	7.5b	7.4c	75.0b	76.4a

[x] Mean separation by DMRT; P = 0.05.

[y] Fruit size grade as per California Department of Food and Agriculture diameter (diameter of #1 fruit won't pass through 2 3/8" ring, #2 fruit are 2 3/8" in diameter or less, but won't pass through the 2 ¼" ring; undersized are 2 ¼" or smaller in diameter).