Precision Pruning to Help Maximize Crop Value

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Precision Crop Load Management is a strategy to adjust crop load to a predetermined number of fruits per tree using pruning, chemical thinning and hand thinning. The pruning component, which we call Precision Pruning, consists of reducing flower bud numbers to a pre-determined target bud number through removing whole limbs, simplifying the remaining limbs and shortening small pendant limbs. Our research in 2014 indicates that a target bud number of 1.5-2 times the final desired fruit number results in better success with chemical thinning and optimum crop value.

Crop load in apple can be adjusted by three management practices: pruning, chemical thinning and hand thinning. In recent years US growers have relied primarily on chemical thinning to adjust crop load with a lesser reliance on pruning and hand thinning to reduce crop load. In other countries hand thinning is still the primary means of adjusting crop load. A few progressive growers have also begun to utilize pruning as a means to adjust crop load. We have been developing a systematic way to adjust bud load by pruning we call precision pruning.

Precision Pruning

Precision pruning is a strategy to reduce the flower bud number per tree to a pre-defined flower bud number through pruning. It begins with counting the number of flower buds on a few representative trees per orchard. In the past, the lack of uniformity of semi-dwarf trees and the massive number of buds on a tree made accurately counting buds impractical if not impossible. However, with adoption of the Tall Spindle growing system, which utilizes ~1000 trees per acre, it becomes practical to count the number of flower buds on representative trees in each orchard.

Knowing the number of flower buds per tree allows us to reduce initial flower bud numbers by pruning off excess fruit buds and only keep those needed to set an adequate crop. In addition, we have the ability to select individual buds through selective pruning retaining only those that are of the highest quality. By pruning to a specified bud number, we can start the process of fruit thinning early to reduce competition among flowers and fruitlets resulting in increased resources for the remaining fruit and improved fruit size and quality. Making accurate fruiting bud counts requires an investment in time, but this is a practice, which can provide an immediate return on the investment of time.

Determining the "proper" bud numbers per tree depends both on the desired yield and fruit size but also on the level of risk the grower is willing to accept. Although some growers prune aggressively leaving only the exact number of buds needed assuming 1 fruit per bud, most growers prefer to keep extra buds to account for natural factors that cause buds not to set such as frost or freeze, poor pollination, and poor flower viability. The exact number of extra buds to leave has been unclear. This project was aimed at determining the number of buds to leave on the tree to maximize crop value.

Materials and Methods

Six-year old Gala and Honeycrisp trees on M.9T337 rootstock planted at 3.3 ft X 12 ft (1100 trees/acre) were pruned to seven different bud loads at tight cluster stage in the spring of 2014. This was accomplished by first counting the number of flower buds on each of the trees and then reducing the number of buds on the tree through pruning to one of seven bud loads. Bud loads were defined as the ratio of flower buds : final desired fruit number per tree. The desired fruit number per tree was calculated by using a desired yield/acre and desire fruit size. In this study the desired final fruit numbers were 130 fruits/tree for Gala and 100 fruits/tree for Honeycrisp. The seven bud loads were 1 bud : 1 final desired fruit number/tree or 1.5:1, 2.0:1, 2.5:1, 3.0:1, 3.5:1 or 4.0:1. To achieve the desired bud loads, first 1-3 whole large branches were removed according to the traditional tall spindle pruning protocol, second each of the remaining branches was simplified by removing secondary lateral branches, third pendant branches which had small diameter distal ends were shortened back to the point where the branch was about pencil size. With each tree a running count of buds removed was maintained as the tree was pruned and pruning was stopped when the desired bud load was reached.

After pruning, half the trees were hand thinned at full bloom to a single flower per cluster while the other half were chemically thinned with a series of 4 thinning sprays for Gala and 3 sprays for Honeycrisp. The thinning sprays were:

Timing	Date	Gala	Honeycrisp
Bloom	May 20	100ppm Maxcel	100ppm Maxcel
Petal Fall	May 26	7.5ppm NAA+600ppm Carbaryl	10ppm NAA+600ppm Carbaryl
10-12mm	June 3	100ppm Maxcel+600ppm Carbaryl	7.5ppm NAA+600ppm Carbaryl
18-20mm	June 10	75ppm Maxcel+600ppm Carbaryl	no spray

At harvest the tree was harvested in two halves (top and bottom) and the final fruit number and yield on each half were recorded. To determine the optimum bud load the yields and fruit size at each bud load were converted to a simulated packout and typical prices for 2014 were used to calculate total crop value. Data were analyzed by ANOVA and means were compared using Least Significant Difference (P=0.05).

Results

Pruning severity had a large impact on both initial flower number per tree and final fruit number per tree of both Gala and Honeycrisp (Fig. 1). When trees were pruned very lightly (bud load ratio of 4 buds : 1 final fruit number) the initial flower number per tree was very high (~2300) but also the final fruit number per tree (after multiple chemical thinning sprays) was significantly higher than the target fruit number (Fig. 2). As pruning severity increased the initial number of flowers per tree decreased in a linear manner and also the final fruit number per tree also decreased linearly. With the most severe pruning (bud load ratio=1:1), the final fruit number was below the target number indicating these trees were over thinned. The multiple chemical thinning sprays reduced the number of fruitlets on the tree by similar percentages at both the light pruning (87% Gala and 90% Honeycrisp) and the severe pruning (89% and 93% Honeycrisp).

When trees were hand thinned to 1 flower at bloom and received no chemical thinning sprays there were similar results as with chemical thinning (Fig. 3). At high bud loads the hand thinning reduced the fruit number by 89% and 91% for Gala and Honeycrisp respectively while at low bud loads (severe pruning) fruit number was reduced 84% for Gala and only 81% for

Honeycrisp. Only with severe pruning did fruit numbers approach the target fruit number while with more moderate pruning final fruit numbers were substantially higher than the target.

Fruit size and yield showed opposite responses to increasing pruning severity (Fig. 4). At high bud loads yield was very high (2600 bu/acre for Gala and 1700 bu/acre for Honeycrisp) while fruit size was small (146g for Gala and 166g for Honeycrisp). At the lowest bud load (most severe pruning) yield was lower (1260 bu/acre for Gala and 1070 bu/acre for Honeycrisp) but fruit size was large (203g for Gala and 224g for Honeycrisp).

Total crop value was calculated from the simulated packout at each bud load and typical fruit sales prices exclusive of storage, packing and sales charges. At low and high bud loads, crop value was less than at intermediate bud loads (Fig. 5). The optimum bud load when trees were chemically thinned appeared to be about 2.5 buds : final fruit number for Gala and 2.0 buds for Honeycrisp. When trees were hand thinned there was a similar optimum bud load for Gala but for Honeycrisp there was an odd result showing the highest crop value at the lowest bud load. This was because with hand thinning of Honeycrisp, high bud loads carried excessively high numbers of fruits with small size. Only the most aggressive pruning reduced fruit numbers close to the target.

The percentage of fruit in the bottom of the trees versus the top of the trees was quite different when the trees were chemically thinned vs. hand thinned. With chemical thinning the percentage of fruit in the top of Gala trees was 72% and only 28% in the bottom half of the tree while with hand thinning there was 60% of the fruit in the top half and 40% in the bottom half (Fig. 6). With Honeycrisp, the percentage in the top half was 56% when chemically thinned and 50% when hand thinned.

The effect of each of each of the chemical thinning sprays was evaluated by using the fruit growth rate model (Robinson et al., 2014a) to determine the number of fruits on the tree which were still growing after each spray and how many had stopped growing and would abscise using only Gala trees at the bud load density of 2.0. After the bloom and petal fall sprays the number of fruitlets on the tree had been reduced from the initial number of 1300 to 549 (Fig. 7). After the 10-12mm spray the number had been reduced to 385 and after the 4th spray at the 18-20mm the number of fruits was 276. Through natural drop in early June the final fruit number was 190.

Discussion

Using pruning to reduce bud load was a successful first step to managing final crop load of Gala and Honeycrisp. When pruning reduced bud load sufficiently it resulted in more successful chemical thinning. In contrast, leaving a high number of flower buds relative to the final desired fruit number resulted in too many apples on the tree despite an aggressive chemical thinning program for both Gala and Honeycrisp. The optimum level of pruning severity in our study was about 2 buds : final fruit number. This resulted in the maximum crop value (Fig. 7). However, it remains to be seen in May of 2015 if this level of cropping will result in adequate return bloom for both Gala and Honeycrisp. Pruning to lower bud loads resulted in over-thinning with chemicals and too few fruits on the tree.

Another consideration of optimum bud load (pruning severity) also is how much rain each season will have. 2014 was a very good year for rainfall and fruit size of even over cropped trees was acceptable. This resulted in a relatively high bud load optimum of 2.0-2.5. However, in a drier year fruit size would be reduced and lower bud load numbers would likely give the highest crop value. Based on the possibility of a dry year and on the need for good return bloom

we are currently suggesting that growers prune using a bud load of 1.5 flower buds for each final fruit number for Gala and 1.8 for Honeycrisp. The higher value for Honeycrisp is to help ensure adequate return bloom by leaving more buds as insurance buds. If the higher initial fruit number with Honeycrisp can be managed with good chemical thinning down to the target fruit number this will ensure a number of resting spurs.

To accomplish precision pruning we have outlined the steps of doing this:

1. Select 5 uniform trees per variety per block and count entire number of fruit buds per tree. It is important to count each variety within the block separately since different cropping levels and growth habit will result in different number of buds per tree and the resulting pruning severity.
2. Calculate the target number of apples per tree to produce the yield of a specific size fruit desired by the grower.
3. Multiply the target number of fruits by 1.5 for Gala or 1.8 for Honeycrisp to determine the number of fruit buds that should be left on each tree to achieve the desired yield with some insurance buds.
4. Prune to remove excess buds above that target bud number using the 3 rules of Tall Spindle pruning. 1) Cut the leader at the optimum height (90-100% of between row spacing) to a lateral branch; 2) remove 1-3 large limbs with a bevel cut and stub for renewal; and 3) columnarize the remaining branches by cutting off large secondary lateral branches. This initial pruning should be followed with a more detail pruning of removing inferior buds to reduce bud level to the target level. Removing buds should be done selectively by removing first those buds that are of poor quality or positioned so that they will produce lower quality fruit, such as those that are on pendant wood or small diameter wood.
5. After pruning, recount bud numbers of 5 representative trees to assess success of pruning and readjust pruning methods to better reflect target levels. Regularly reassess pruning to ensure that target bud levels are being achieved.

An example of how to calculate the target fruit number and target flower bud number in steps 2 and 3 is presented for a Gala orchard on M.9 rootstock planted 3'X12' (1210 trees/acre). In this example, we set a target yield of 1500 bushels/acre of 100-count fruit size or 100 apples per bushel.

1. Multiply the target yield of 1500 bushels/acre by 100 fruit per bushel to calculate the need for 150,000 apples per acre. By dividing the total number of fruit/acre by the number of trees per acre we calculate that we need 125 apples per tree.
2. Multiplying the desired fruit number by a bud load factor of 1.5 indicates we need to leave 188 flower buds per tree to achieve our desired yield and to have some insurance buds against frost and poor pollinations.

In this example lets assume our initial flower bud counts of 5 representative trees in step 1 above indicated we had 500 flower buds per tree before pruning. This means that through pruning we need to remove 312 buds.

The beauty of using precision pruning is that we can implement this practice today to achieve higher profit levels. And with higher density orchards and uniform trees it should be a simple procedure to tag, and count bud numbers for each variety in each orchard and then calculating the pruning that should be done with very little risk or cost.

An interesting additional result of this study is the observation that with chemical thinning we often remove too many apples in the bottom of the tree and too few apples in the top of the tree. In our study Gala had more of this problem than Honeycrisp. With Gala we ended up

with 70% of the fruit in the top half of the tree. To correct this problem requires adjustment in the spray pattern used. We suggest for the bloom spray the entire canopy be sprayed uniformly, but for the petal fall spray, 2/3 of the spray should be directed to the top half of the tree by re-nozzleing the sprayer. For the 10-12mm and the 18-20mm spray we suggest only spraying the top half of the tree. This is based on 3 unpublished studies we did with Andrew Landers showing that even with all of the lower nozzles turned off we still had adequate thinning in the bottom of the tree. This is likely due to some drift from the top into the bottom. It is important that if growers begin turning off nozzles that they adjust the amount of chemical in the tank to still get the same amount of chemical applied per acre.

The results of fruit diameter measurements made after petal fall thinning sprays on May 26th showed that the bloom and petal fall sprays provided significant thinning on Gala but that additional thinning was still needed. In general fruit set was reduced from 100% down to about 42% by those two sprays (The target was 10%). This was much less than we saw in 2013 when the early sprays reduced fruit set down to 30%. In 2014 the early sprays gave only moderate thinning. The 12mm spray gave a little more thinning and reduced fruit set down to 29%. This modest response was partially due to a high carbohydrate balance. The 18mm spray gave a little more thinning and reduced fruit set only to 21%. This modest response was also due to a high carbohydrate balance. In contrast in 2013 the 18mm spray gave a much greater response. After thinning sprays were complete additional fruit drop was observed likely caused by a natural deficit of carbohydrates resulting from a period of cloudy warm days in mid June. In general the thinning efficacy was correlated with the estimated carbohydrate balance at the time of the thinning applications. Even with 4 sprays the fruit number per tree with Gala remained above the target fruit number, which required significant hand thinning.

Conclusions

The new precision pruning program for managing apple flower bud load allows growers to first determine a target fruit number and define a target bu load to guide pruning severity. This can be done for each variety. By pruning to a specific target bud load, precision chemical thinning can more successfully achieve the target fruit number. This will then reduce hand-thinning costs and will maximize crop value. The costs of implementing precision pruning are small and the potential benefits are large. Lastly, precision pruning can be more easily applied to the simple trees in high-density orchards such as the Tall Spindle or Super Spindle where counting of whole trees is easier than large trees.

Acknowledgements:

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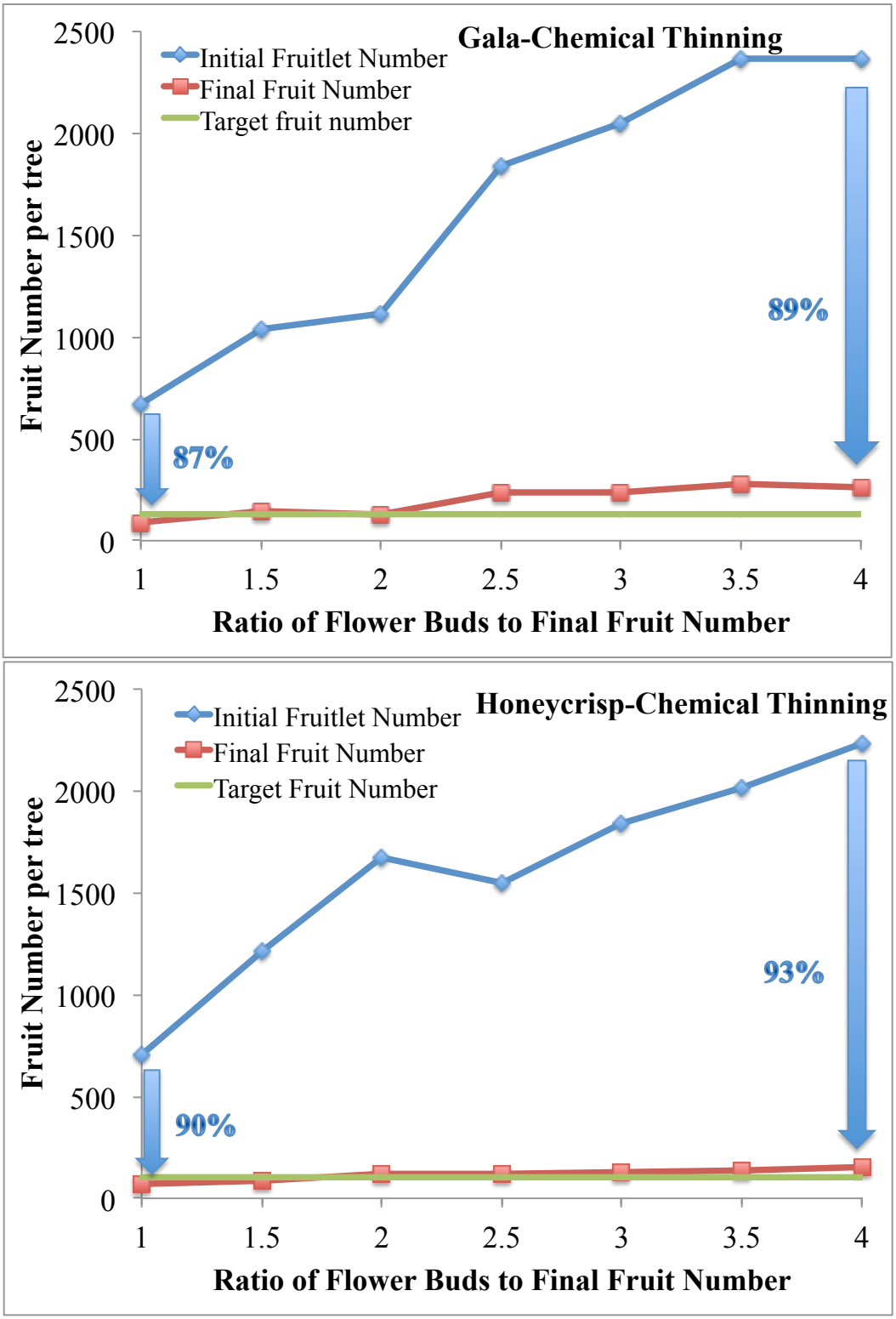


Fig. 1. Original and final fruit numbers per tree of Gala/M.9 and Honeycrisp/M.9 when pruned to 7 different bud load and then thinned with 4 sequential chemical thinning sprays at full bloom, petal fall, 11mm and 18mm fruit sizes at Geneva, NY in 2014.

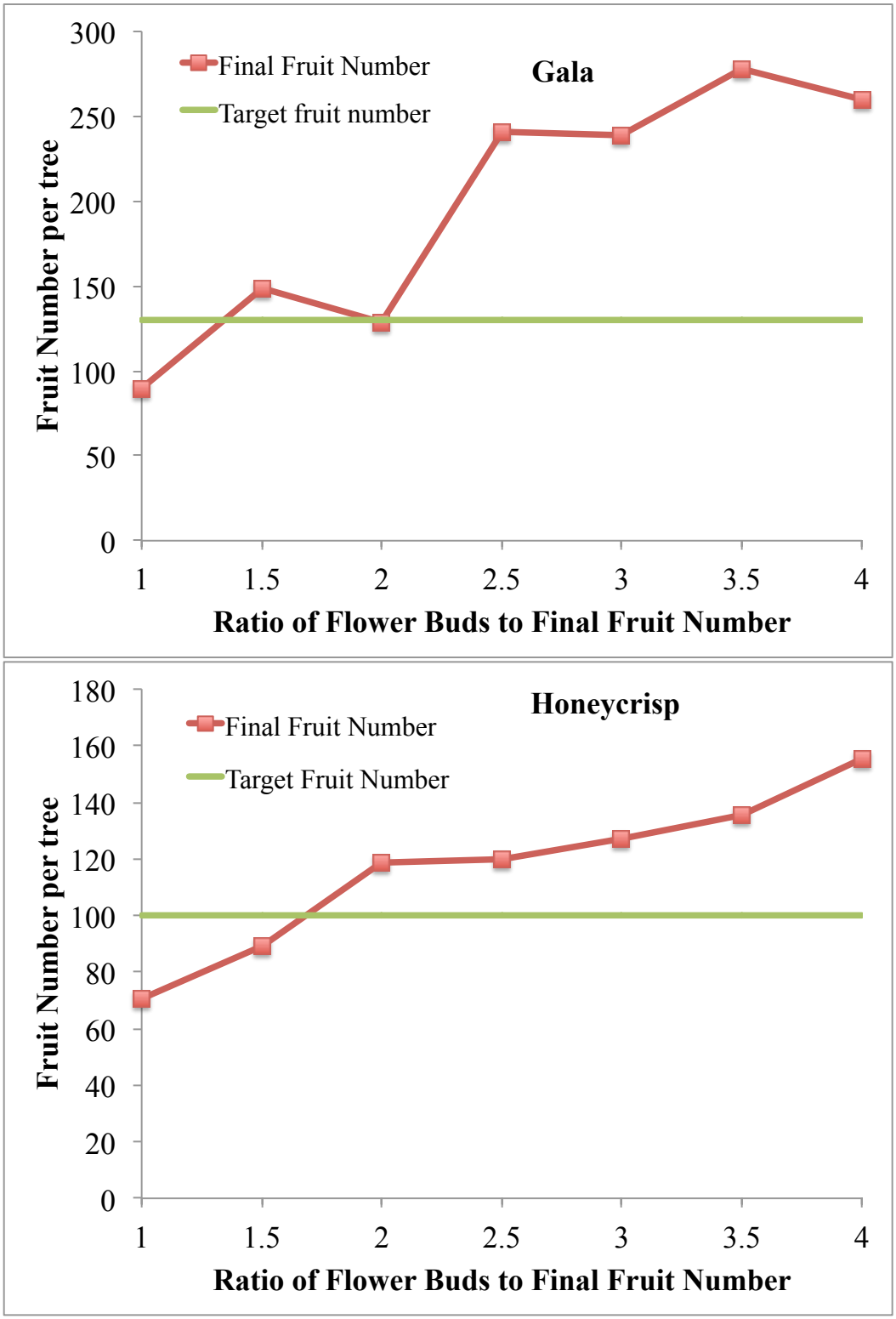


Fig. 2 Final fruit numbers per tree of Gala/M.9 and Honeycrisp/M.9 compared to the target fruit number per tree after trees had been pruned to 7 different bud load and then thinned with 4 chemical thinning sprays at full bloom, petal fall, 11mm and 18mm fruit sizes at Geneva, NY in 2014.

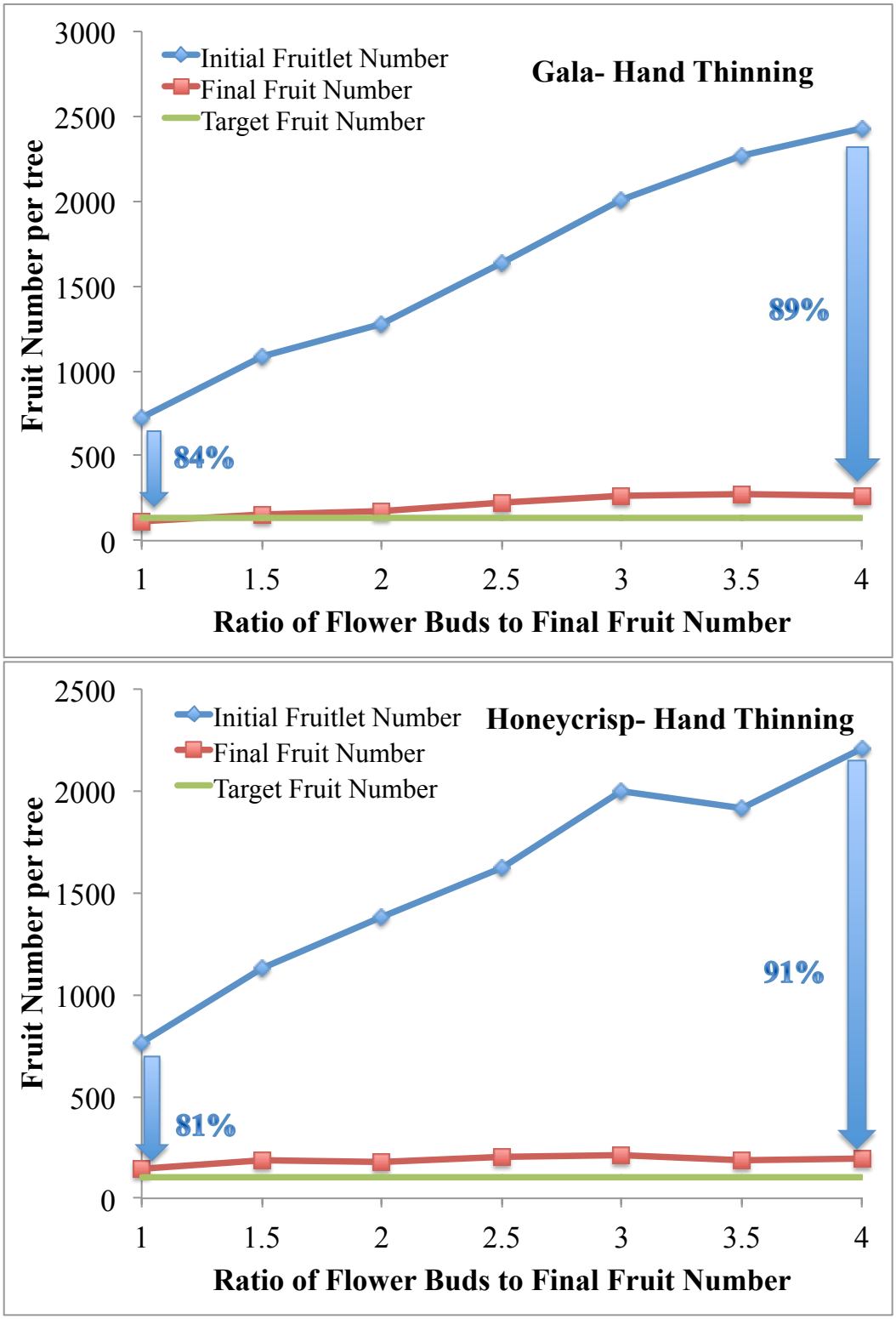


Fig. 3. Original and final fruit numbers per tree of Gala/M.9 and Honeycrisp/M.9 when pruned to 7 different bud load and then hand thinned at full bloom to a single flower per cluster at Geneva, NY in 2014.

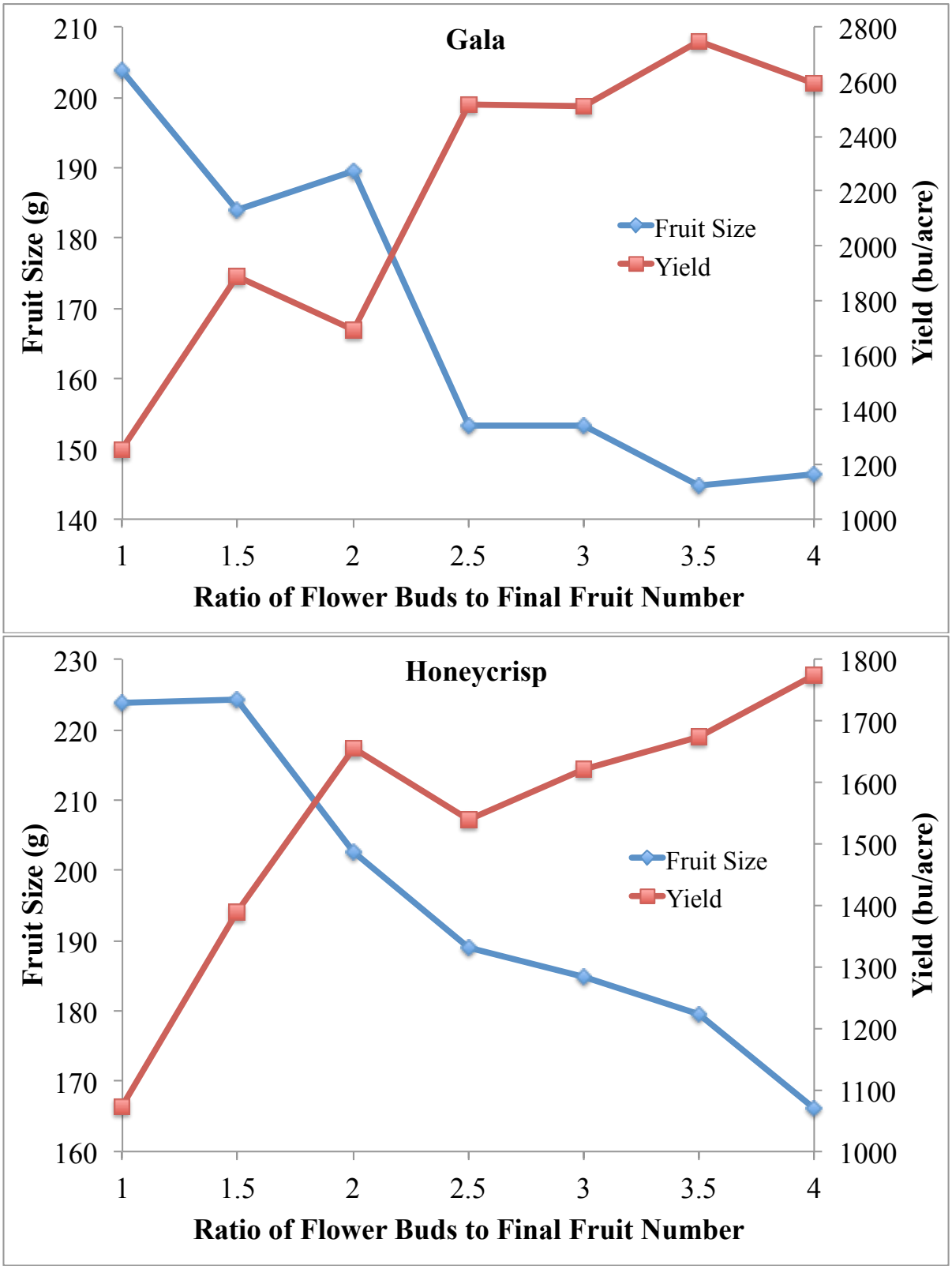
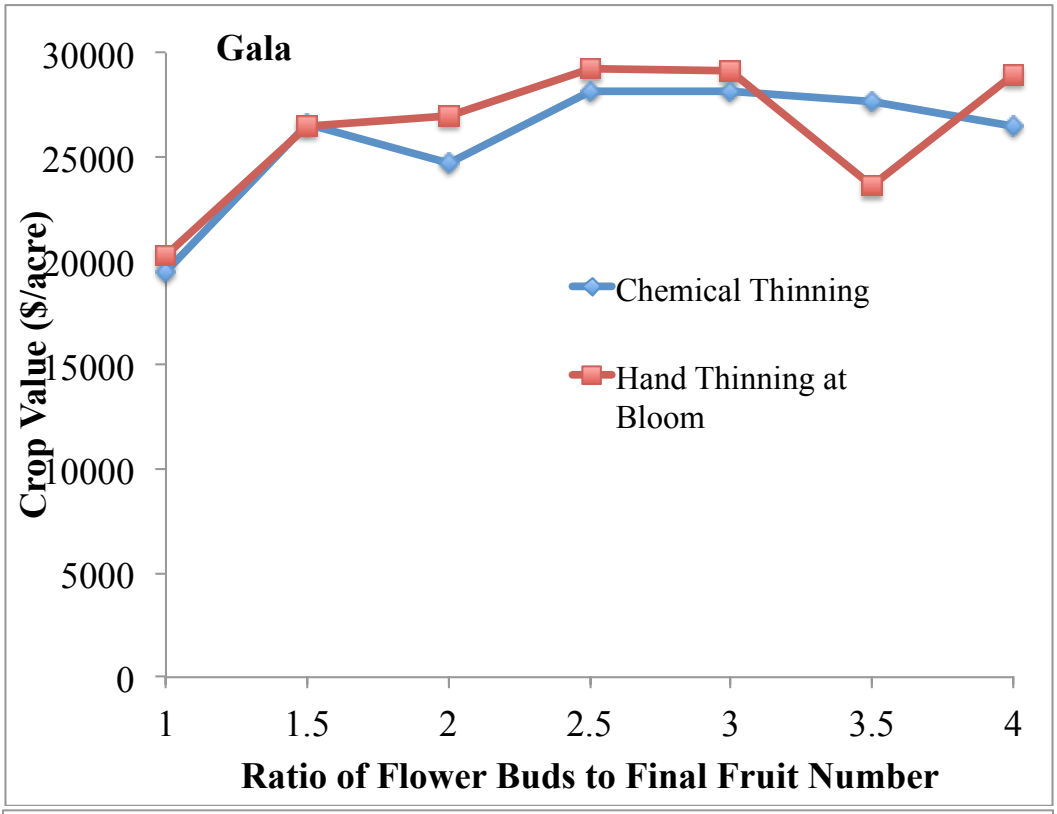


Fig. 4. Fruit size and yield of Gala/M.9 and Honeycrisp/M.9 after trees had been pruned to 7 different bud load and then thinned with 4 sequential chemical thinning sprays at full bloom, petal fall, 11mm and 18mm fruit sizes at Geneva, NY in 2014.



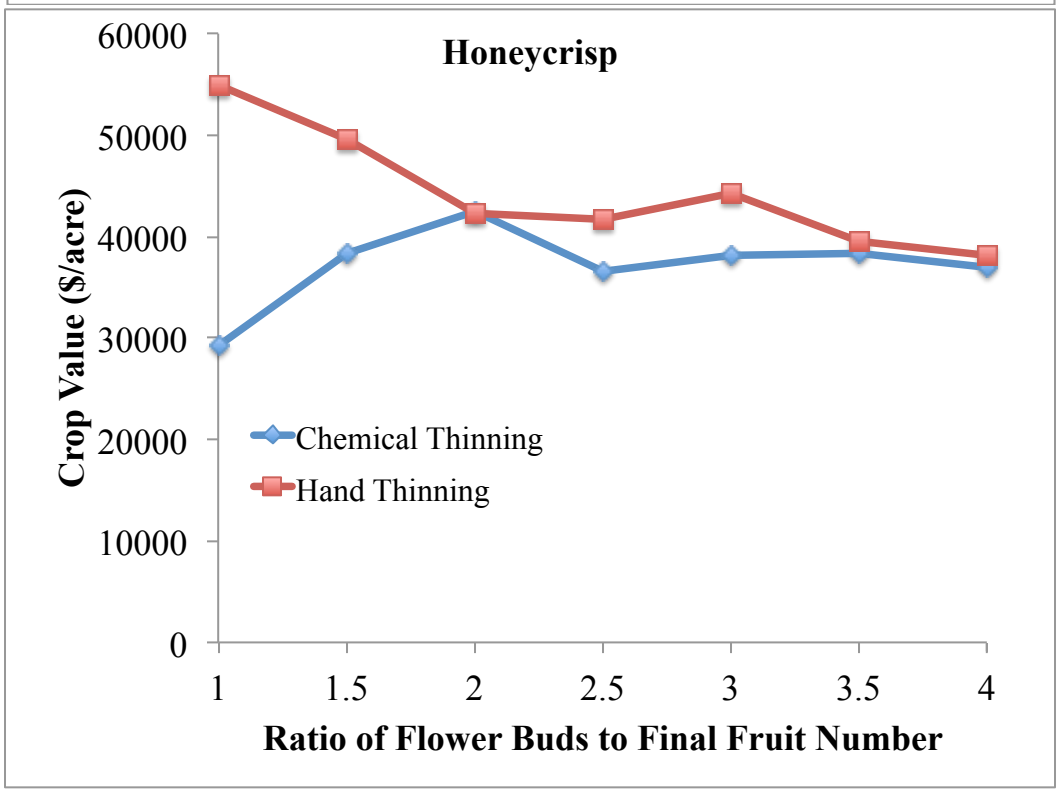


Fig. 5. Fruit size and yield of Gala/M.9 and Honeycrisp/M.9 after trees had been pruned to 7 different bud load and then thinned with 4 sequential chemical thinning sprays at full bloom, petal fall, 11mm and 18mm fruit sizes at Geneva, NY in 2014.

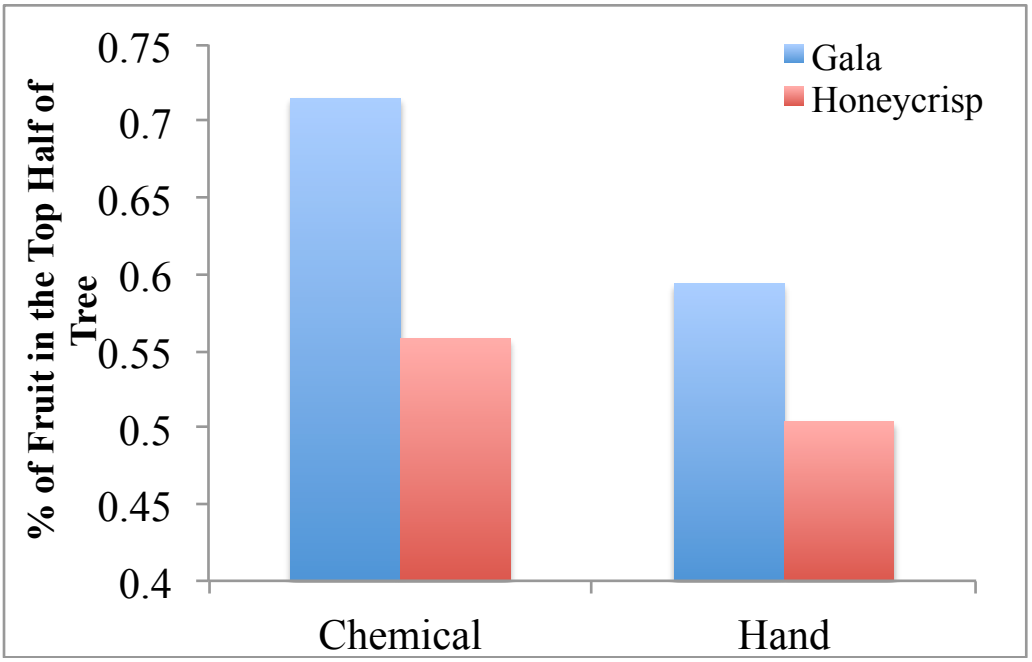


Fig. 6. Percentage of fruits in the top of the tree after either 4 sequential chemical thinning sprays or hand thinning to a single fruit at full bloom with Gala and Honeycrisp apple trees at Geneva, NY in 2014.

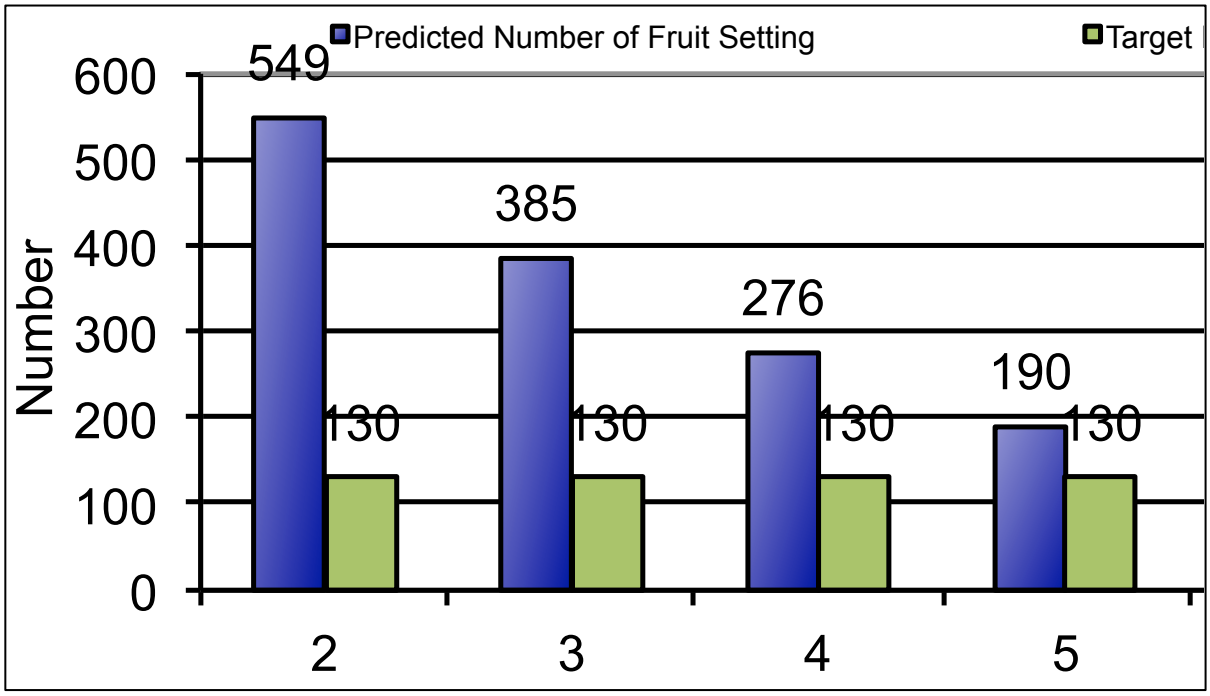


Fig. 7. Fruit number per tree of Gala/M.9 when thinned sequentially with 4 chemical thinning sprays at full bloom, petal fall, 11mm and 18mm fruit sizes at Geneva, NY in 2014. Green bars are the target fruit number=130.

Fig. 8. Gala/M.9 apple trees pruned to 2.0 buds : 1 final fruit number and then chemically thinned with 4 thinning sprays in 2014. Yield=1800 bu/acre and fruit size=185g (100 count) and crop value=$24,000/acre