## **Precision Pruning of Gala Apples**

T.L. Robinson, P. Francescatto and J. Lordan Horticulture Section, School of Integrative Plant Science, Cornell AgriTech, Cornell University, Geneva, NY, USA

Keywords: Apple, pruning, flower bud load, maximum crop value

This work was supported in part by the New York Apple Research and Development Program

Pruning is done not only to limit the size of the tree and improve light distribution within the canopy but it is also a way to reduce flower bud numbers. The number of flower buds left after pruning can greatly influence later fruit chemical thinning, fruit size and quality, tree vigor and return bloom. A four-year study with Gala showed a strong curvilinear relationship crop value and flower bud load with an optimum between 1.5-2.0 flower buds (left after pruning) relative to final fruit number. Growers can use flower bud counts before and after pruning to precisely leave an optimum number of flower buds each year.

Precision pruning is a strategy to reduce the flower bud number per tree to a pre-defined flower bud number through pruning (Robinson, et al., 2013). It is part of a complete precision crop load management strategy that includes pruning, chemical thinning and hand thinning (Robinson et al., 2014a). Knowing the target number of flower buds per tree allows growers to reduce initial flower bud numbers by pruning off excess fruit buds and only keeping those needed to set the optimum crop.

Calculations of crop value at various crop load levels using fruit size and yield as the main variables has shown in a number of experiments to that the relationship of crop value to crop load is curvilinear (Fig. 1). At very high crop loads (un-thinned Gala trees) fruit size is often very small but yield is very high. Crop value in this situation is almost zero since the value of the fruit is often exceeded by the packing and storage costs. When crop load is reduced to more moderate levels through pruning and thinning, then crop value rises dramatically even though yield is lower due to larger fruit size, which has greater value. At some point crop value peaks and then with further reductions in crop load crop value declines due to lower and lower yield. Although fruit size continues to increase it does not compensate for the loss in yield. Identifying and then achieving this optimum crop value is often very difficult for apple growers. It is difficult for fruit growers to know the economic impact of not achieving the optimum crop load without having various levels of thinning each year to construct the curves shown in Fig. 1. The difference between the optimum crop load and higher or lower crop loads can sometimes be a difference of thousands of dollars per acre. Thus growers often fail to capture the maximum crop value possible and don't know how much "money they left on the table". Managing crop load more precisely through pruning can help growers achieve the optimum crop load through later chemical and hand thinning and maximize crop value.

Pruning is used primarily to limit tree size and improve light distribution in the canopy but it also is an excellent way to reduce flower bud numbers and accomplish a significant portion of the thinning required before the season begins. Also the number of flower buds left after pruning can greatly influence later fruit thinning, fruit size and quality, tree vigor and return bloom. In addition, in the pruning process there is the option to select individual buds through selective pruning retaining only those that are of the highest quality (Robinson et al., 2014b). By pruning to a specified bud number, growers can reduce the number of potential fruits before flowering and thus reduce competition among flowers and fruitlets resulting in increased resources for the remaining buds and the subsequent fruits and thereby improve fruit size and quality.

To prune to a specific flower bud number requires first to determine the proper bud number and then count buds on representative trees to determine how many buds to remove. 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 number per tree depends both on the desired yield, desired fruit size, climate and the bearing capacity of the trees (have the trees filled the space allotted to them). However the optimum number of buds also depends 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 flower bud, most growers prefer to keep extra "insurance" buds to account for natural factors that cause buds not to set a fruit such as frost or freeze, poor pollination, and poor flower viability. The exact number of extra buds to leave has been unclear. The objective of this project was to determine the proper bud load to optimize fruit size and maximize crop value of 'Gala' apple.

## **Materials and Methods**

The experiment was conducted at the New York State Agricultural Experiment Station in Geneva, NY, USA, using Brookfield Gala apple trees grafted on M.9T337 rootstock. Trees were planted in 2009 at 1,157 trees/acre (3 ft X 12 ft) and trained as tall spindle trees. The trees were pruned to six different bud loads at tight cluster stage in the spring of 2014, 2015, 2016 and 2017. 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 six bud loads. Bud loads were defined as the ratio of flower buds : final desired fruit number per tree. The initial desired fruit number for these trees was determined at 130 fruit per tree and was calculated from the desired yield (1500 bu/acre) and desired fruit size (100 count fruit size) and the tree planting density 91157 trees/acre). The six bud loads treatments were 1 bud : 1 final desired fruit number per tree or 1.5buds:1 final fruit, 2.0:1, 2.5:1, 3.0:1 or 3.5:1.

To achieve the desired bud loads, first, standard tall spindle pruning was done by removing 1-3 whole large branches (>3/4inch diameter), 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 and fourth, if more pruning was needed individual spurs were removed. With each tree, a running count of buds removed was maintained as the tree was pruned. Pruning was stopped when the desired bud load was reached. After pruning, half the trees of each treatment were hand thinned at full bloom to a single flower per cluster while the other half were chemically thinned with a series of three to four thinning sprays.

The thinning sprays were: at Bloom stage – 10ppm NAA; at petal fall stage – 7.5ppm NAA plus 1pt Carbaryl 4L/100gal; at 12mm fruit size stage – 100ppm Maxcel plus 1pt Carbaryl 4L/100gal; and when needed at 18 mm fruit size stage – 10ppm Maxcel plus 1pt Carbaryl 4L/100gal plus 1pt oil/100gal. Treatments were applied with an airblast 12.5ft tall x 13 ft wide tunnel sprayer (Lipco, Germany) which limited drift to adjacent rows, applying 100 gal/acre of water.

At commercial harvest, the number of fruits and total yield per tree (kg·tree<sup>-1</sup>), crop load (fruit·cm<sup>2</sup> TCA) and fruit size (g) were calculated. A 10 kg sample per tree was graded using a commercial sorting equipment to determine color (% red color). Then, ten representative fruits from each tree were assessed for fruit quality– length/diameter (L/D) ratio, firmness (kg), soluble solids (%) and number of seeds.

To determine the optimum economic bud load, the yields and fruit size at each bud load were converted to a simulated packout and typical prices were used to calculate total crop value (\$/ha).

Return bloom the following year was determined by counting the total number of blossom and vegetative clusters on terminal buds either on spurs or one-year old shoots on selected branches at the pink stage of flower development and expressed as percentage of flower clusters (%).

#### Results

Pruning severity had a large impact on final fruit number and yield per tree of Gala (Figure 2). When trees were pruned very lightly (bud load ratio of 3.5 buds : 1 final fruit number) the final fruit number per tree was significantly higher than the target fruit number of 130 fruits per tree despite the hand or chemical thinning used. Yield was also increased significantly higher with less aggressive pruning. However, fruit size was reduced linearly with less aggressive pruning. With the most aggressive pruning (1 bud: 1 final fruit number) the final fruit number was only slightly higher than the target number and fruit size was large (88 count), while with the least aggressive pruning, final fruit number was twice the target number and fruit size was small (113 count). Pruning severity also had large impact on fruit set. The higher the initial flower number per tree (less aggressive pruning) the lower the fruit set. When pruning was more severe final fruit set after chemical thinning was essentially 1 fruit per flower cluster. When pruning was less severe final fruit set after chemical thinning was 1 fruit per 1.5 flower clusters.

Pruning severity also had a significant impact on total crop value. When data from all four years were combined irrespective of thinning treatment, a curvilinear relationship was observed between crop value and bud load. The combined data shows that crop value was maximized when the optimum level of pruning severity for Gala was about 2.5 buds : final fruit number. This resulted in an optimum of 338 buds per tree (Figure 3) which is double the target bud number we had assumed before the experiment. The optimum number of apples at that bud load would be 258, much higher than the target number of 130. Additionally, these results indicate that maximum crop value was achieved when average fruit size was about 150 g.

The statistical analysis showed that the response to pruning varied by year. When years were studied separately (Figure 4), 2014, 2015 and 2017 showed a similar shaped response curve with the optimum crop value between 2-3 buds per final fruit number. However 2016 gave very different results than the other 3 years with a negative linear relationship between initial flower bud number and crop value (p=0.01) with the lowest bud load (1:1) having the highest crop value. This was likely due to the severe drought conditions experienced in that year resulting in very small fruit size (average of 111g).

Pruning severity did not have a significant effect on return bloom with the annual cropping variety Gala (>60%). In our study, return bloom was primarily affected by crop load. The heavy crop harvested in 2015 and 2016 reduced flower formation slightly but each year there was adequate return bloom.

In our study trees that were pruned more severely, with lower bud load ratios and consequently carried less fruit, had firmer fruit at harvest with better fruit color and higher soluble solids.

## Discussion

An important result of this study is the reduction in fruit set with greater flower bud numbers after pruning. Similar results were found by Schupp et al. (2017), where fruit set of 'Buckeye Gala' as a percentage of initial blossom clusters tended to increase in a quadratic pattern with increasing pruning severity. With greater number of initial flower buds (light pruning), the spring uptake of nutrients from the root system and the flux of plant hormones from the root system are distributed into many more buds provided a smaller amount of nitrogen and growth promoting hormones to each flower. Thus resulting in lower fruit set from weak flowers and smaller fruit size from those that due set a fruit. This result suggests growers should reduce flower bud numbers through pruning to improve fruit set and ultimately fruit size.

A second important result of this study is that crop value was optimized at 338 buds per tree which is double the target bud number we had assumed before the experiment. The optimum number of apples at that bud load would be 258. This resulted in a relatively higher bud load optimum of 2.5 than that found by Robinson et al., in 2014. Schupp et al. (2017), also found with mature 'Buckeye Gala'/'M.9' the best economic outcome, was achieved when moderate to light pruning was performed. Our results can also be interpreted by considering the initial calculation of optimum fruit number. It appears that our target fruit number of 130 fruits/tree was too low for these excellent tall spindle trees. Perhaps our target should have been 50% higher.

A third important result of this study is that crop value was optimized with a medium average apple size and a very high yield of 2000 bu/acre. This size is smaller than we predicted before this experiment. This result is in contrast to the goals of many growers who target larger fruit size. However, our results indicate that targeting larger fruit size in the New York State climate does not result in the maximum crop value due to the large penalty in yield to achieve larger fruit size. The crop values reported here were calculated with market prices from 2017 and higher or lower prices would change the optimum fruit number and the optimum bud load.

The fruit quality effects we observed in this study of increased fruit firmness, fruit red color and fruit soluble solids associated with more severe pruning and lower bud loads is consistent with other studies with 'Honeycrisp' that reported better color, sugar content and firmness with lower crop loads (Robinson and Watkins, 2003). It is likely that by removing potential competitive sinks through early flower bud pruning, the availability of carbon and water to the remaining buds was increased. The fruit quality effects we observed on fruit quality were also related to the weather conditions. The weather during the 2016 and 2017 seasons was quite different. Whereas, 2016 was marked with an early spring freeze event, followed by a prolonged and severe drought period from July to mid-September; 2017 brought a cold and wet spring followed by an above-average rainfall summer. In fact, regardless of crop load or treatment, apple fruits harvested in 2017 were much firmer and with lower sugar content than other years.

Lastly, the low fruit size of 2016 which was due to the drought that year shows it is difficult to prune to proper bud load if subsequently a very dry year occurs. If weather could be predicted, in dry years pruning should be more aggressive, as the lowest bud load

numbers gave us the highest crop value in 2016. However, more intensive irrigation than we applied in this study may mitigate the negative effects of dry years on fruit size.

# Conclusions

Our results indicate that maximum crop value for a 'Gala' Tall Spindle orchard in New York State was achieved when fruit size was about 150 g and fruit number per tree was 338 fruits/tree which is double the target fruit number we had assumed before the experiment. It appears that when growers attempt to get large size they are sacrificing some dollars as large Galas are accompanied with significantly lower yield. However, fruit marketers in NY State indicate that if all the Gala's in the state were medium sized then the prices we used for medium sized Gala's would be lower. Given that market reality, perhaps the best strategy for NY Gala growers is to prune slightly more aggressively than this study indicated. Perhaps 1.5-18.8 flower buds per final fruit number (Figs 5 and 6). This would allow better chemical thinning and would improve fruit size while optimizing crop value for all growers in the State. We suggest that apple growers count flower bud numbers on Gala trees before pruning and then define a target bud number based on 1.5 buds for final fruit number and prune to that number using precision pruning.

## Literature Cited

- Schupp, J.R., Winzeler, H.E., Kon, T.M., Marini, R.P., Baugher, T.A., Kime, L.F., and Schupp, M.A. 2017. A method for quantifying whole-tree pruning severity in mature tall spindle apple plantings. DOI: 10.21273/HORTSCI12158-17.
- Robinson, T.L, and C.B. Watkins. 2003. Crop load of Honeycrisp affects not only fruit size but many quality attributes. New York Fruit Quarterly 11(3): 7-10.
- Robinson, T., Lakso, A., Greene, D. and Hoying, S. 2013. Precision crop load management. NY Fruit Quarterly 21(2):3-9.
- Robinson, T., Hoying, S., Miranda Sazo, M. and Rufato, A. 2014a. Precision crop load management: Part 2. NY Fruit Quarterly 22(1):9-13.
- Robinson, T. L., Dominguez, L.I. Acosta, F. 2014b. Pruning strategy affects fruit size, yield and biennial bearing of Gala and Honeycrisp apples. New York Fruit Quarterly. 22(3), 27-32.

**Terence Robinson** is a research and extension professor at Cornell's AgriTech campus in Geneva who leads Cornell's program in high-density orchard systems, irrigation and plant growth regulators. **Poliana Francescatto** and **Jaume Lordan** were Postdoctoral Associates at Cornell's Geneva Experiment Station in Dr. Robinson's program. Poliana currently works for Valent Corporation and Jaume works for IRTA research station in Spain.



Fig. 1. Counter balancing responses of Gala fruit size (solid black line) and yield (dashed red line) and the curvilinear response of crop value (solid green line) as affected by crop load showing an optimum crop value at a crop load of ~8-9 fruits/cm<sup>2</sup> TCA. (from Robinson et al. 2013)



Figure 2. Final fruit number per tree and fruit set of Brookfield Gala after trees had been pruned to 6 different bud load and hand or chemically thinned over 4 years at Geneva, NY, USA. Means followed by different letters (uppercase letters for fruit number and lowercase letters for fruit set) are significantly different using Duncan's at P≤0.05. ns: non-significant.



Figure 3. Fruit size and crop value responses of Gala apples to initial flower bud over 4 years showing a curvilinear response of crop value to initial flower bud showing an optimum crop value at a crop load of ~338 buds per tree (~2.5 buds per fruit ratio) (p=0.0055 and p<0.0001 for crop value and fruit size, respectively).



Figure 4. Crop value response after trees had been pruned to 6 different bud loads in each of the four years studied. Geneva, NY, USA. Vertical bars represent standard error. Means followed by different letters are significantly different using Duncan's at P≤0.05. ns: non-significant.



Fig. 5. Photo of Gala trees pruned to 1.5 floral buds : 1 final fruit number at Geneva, NY in 2014



Fig. 6. Photo of Gala trees pruned to 1.5 floral buds : 1 final fruit number at harvest with 1500 bu/acre yield and a crop value of \$24,000/acre in 2014.