Summer Pruning: The Good, the Bad and the Ugly

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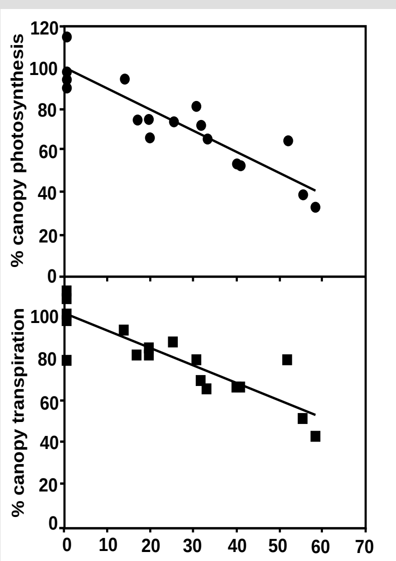
Color and size are the two most important criteria in the market value of apples. To obtain good red fruit color, fruit must be exposed to a significant amount of direct sunlight. As canopies become denser during the season, summer pruning has become a routine practice in modern apple orchard management to improve light penetration to the fruit and to control tree size. This is especially important for red varieties such as McIntosh grown in New York where the light intensity in the summer is not always ideal for color development. Removing shoots from the outer canopy of dense trees in August increases light penetration into the canopy and increases fruit color. However, summer pruning reportedly reduces final fruit size. Why would this occur?

The removal of exterior shoots reduces the canopy size and that might reduce the amount of sunlight the tree captures to provide the energy to produce carbohydrates by photosynthesis. We have also found that the interior spur leaves that are re-exposed after summer pruning are not as efficient at photosynthesizing as the healthy and well-exposed leaves of exterior shoots removed by pruning. These leaves do not recover their photosynthetic ability with time. Problems with reduced fruit size are likely due to the combination of reduced sunlight capture and reduced photosynthetic efficiency leading to reduced carbohydrate supply to support fruit growth, especially if there is too heavy a demand for carbohydrates for fruit growth. We propose that an imbalanced carbohydrate supply and demand lead to reduced fruit size.

FIGURE 1

Effects of summer pruning on canopy photosynthesis and transpiration rate.



. . . Summer pruning can cause significant losses in canopy photosynthetic activity, resulting in a potential shortage of carbohydrate supply for final fruit sizing.

This imbalance has already been shown to be the reason for reduced fruit size caused by European Red Mite damage in apple trees (Lakso et al., 1995). Furthermore, a shortage of carbohydrates might not only affect fruit growth, but also the growth of other parts of the tree, such as the root system, and possibly flower bud development. Research with summer pruning on small trees indicated that root growth was markedly affected. Problems with root development and return bloom may then carry over into following years as well.

These effects are dependent, of course, on how severely the trees are pruned. Defining summer pruning is not easy, as it can vary in style and severity. Several preliminary observations and measurements on commercial levels of summer pruning have indicated that 25 to 30% of the tree's leaf area is commonly removed. Growers may remove twice the amount of leaves on varieties with a higher demand for color such as McIntosh.

There may be other advantages of summer pruning beyond fruit color and tree size control. Removing leaves by summer pruning can be expected to reduce total canopy water loss (transpiration) and consequently improve tree water status. In Washington State, heavy summer pruning has been used to help pear and peach orchards survive in severe drought seasons. Therefore, in dry years in New York, summer pruning might help relieve drought-induced reductions in fruit growth.

The effects of summer pruning might be more complex than we previously thought. To document the interactions of summer pruning, fruit quality and tree productivity, we conducted research over several years on the intensity of summer pruning on canopy leaf area, canopy photosynthesis and transpiration, fruit growth and quality, return bloom and new root production.

METHODS

We summer pruned 20-year-old slender spindle Empire apple trees on M.9 in early August with various intensities. Vigorous exterior extension shoots from the upper and outer parts of the canopy were removed to allow improved light penetration. Relatively few cuts were made into older wood. Pruning intensity varied by changing the percentage of extension shoots removed. To quantify the severity of summer pruning, we measured the total leaf area removed by summer pruning to obtain the percentage of leaf area removal.

Whole canopy photosynthesis and transpiration were measured on sunny days before and after summer pruning by enclosing each tree in a clear Mylar canopy balloon chamber with air passing through. We recorded the changes in carbon dioxide and humidity in the air in the balloon. Selected fruits within each tree were monitored for growth rates before and after summer pruning. At harvest, total fruit number and weight per tree were recorded and fruit quality assessed. The number and percentage of flowering spurs were counted the following spring to estimate return bloom.

Root growth before and after summer pruning was monitored with a minirhizotron-video recording system. This device, a miniature camera slid through clear plastic tubes installed in the root zone under the trees, periodically examined and recorded root growth. Root production was expressed as the number of new fine roots appearing over time. Since individual roots could be followed over the season, the functional lifespan of each active fine root could be estimated.

RESULTS AND DISCUSSION

Canopy Photosynthesis, Fruit Growth and Return Bloom

There were clear reductions in canopy photosynthesis rates approximately proportional to the severity of summer pruning as expressed as percentage leaf area removal (Fig. 1). There was a similar reduction in canopy transpiration (i.e., water loss). We estimate that the intensity of summer pruning in commercial orchards is equivalent to the moderate to severe pruning in this study. This means that commercial growers remove up to about 50% of the leaf area during summer pruning, resulting in a 50% reduction in canopy photosynthesis and 40% reduction in canopy transpiration. Interestingly, the 50% reduction is about the same effect caused by severe bronzing of leaves in August on trees exposed to over 2000 cumulative European Red Mite days, which is four times the IPM threshold and clearly unacceptable.

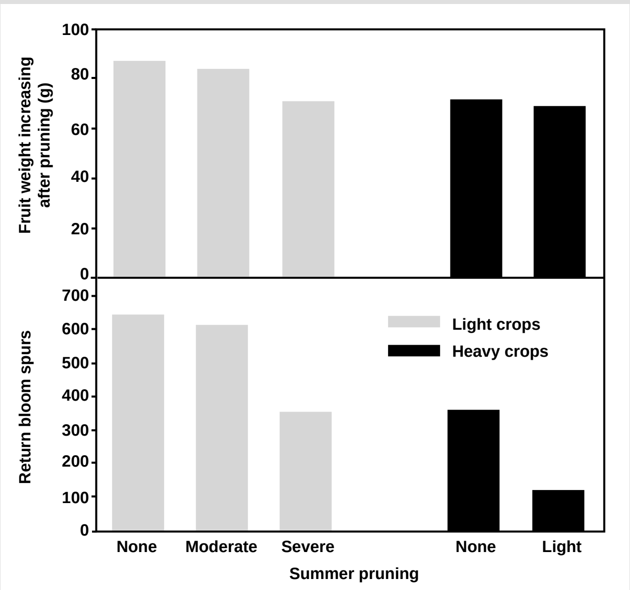
Decreased canopy photosynthesis after summer pruning may cause a shortage of carbohydrate supply for fruit growth, especially in trees with high crop loads. Both fruit growth and return bloom were affected by summer pruning (Fig. 2). The more severe the summer pruning, the more fruit size was affected in light cropped trees. Even light summer pruning affected fruit size in trees with heavy crops (Fig. 2, top). The effect on return bloom the year following summer pruning was similar to fruit growth patterns but was affected more strongly (Fig. 2, bottom). In heavily cropped trees, a light summer pruning reduced fruit size somewhat and very strongly reduced return bloom. This suggests that it is the carbohydrate supply vs demand balance that is important in fruit sizing and return bloom, not just the intensity of summer pruning or the crop load alone.

Canopy Water Loss and Water Status

The reduced canopy transpiration rate indicates that less water was lost through the leaves after summer pruning. In a follow-up study, we found the tree water status for fruit expansion, expressed in midday stem water potential, improved after summer pruning. Therefore, for overall fruit growth, improved tree water status might compensate for the storage of carbohydrate supply in drought years.

FIGURE 2

Interaction of summer pruning intensity and cropping level on fruit weight and return bloom on Empire apples.



Fruit Quality Effects

Internal fruit quality as expressed as total sugar content, starch levels, firmness and internal breakdown after cold storage was not markedly affected by summer pruning or the initial fruit set, nor was the percentage of acceptable red skin surface of the fruit. Although one of the major objectives of summer pruning is to improve fruit color development, it has been reported that this may be true only on fruit in a dense canopy. We harvested a high percentage of well-colored fruit in both years regardless of the pruning intensities the trees received. This might be due to the well-trained and relatively open canopy of the trees used in this study that allowed sufficient light to reach a large proportion of the fruit inside the canopy.

Root Growth

Our root growth observations in 1999 and 2000 showed similar patterns of new apple root production (Fig. 3). In both years, the peak of new root production was completed by early August before summer pruning. Our treatments apparently did not affect root production in the current year. Even though a small growth peak was recorded after harvest in 1999, the amount of root production was not related to the intensity of summer pruning. New roots remained active for only about 2 to 4 weeks. There were indications of possible interactions between root lifespan and pruning and crop load, but that needs more research.

SUMMARY

This study suggests that summer pruning can cause significant losses in canopy photosynthetic activity, resulting in a potential shortage of carbohydrate supply for final fruit sizing. When the crop load was high or trees were severely summer pruned, an imbalance between carbohydrate supply and demand occurred. Consequently, fruit growth and flower bud development were retarded. Flower bud development the following year was more severely affected than fruit growth. Production of new roots was not affected since most root growth occurred earlier in the season prior to summer pruning. The reduction in canopy transpiration after summer pruning, however, might alleviate the impact of carbohydrate imbalance by improving tree water status. A possible carryover effect of summer pruning and crop loads might potentially affect tree productivity in the long term.

ACKNOWLEDGMENT

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LITERATURE CITED

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FIGURE 3

New root production in relation to the time of summer pruning and harvest in Empire apple trees. The number of new roots was recorded from 27 minirhizotron tubes installed around nine trees.