Ernie's Influence on a Pomological Career

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Presented as the Ernie Christ Memorial Lecture at the 2022 Tri-State Horticultural Meeting, Hershey, PA, February 2, 2022

I had the honor of presenting the first Ernie Christ Memorial Lecture and now that I will be retiring soon, I volunteered to make a second presentation to remind us of Ernie's contributions to the mid-Atlantic peach industry. I was the last pomologist on the Rutgers campus to work with Ernie and I shared an office with him for about 2 years before he retired in 1982. Although we were of different generations, we hit it off because we both loved pomology and I was lucky to have him as a mentor. During our time together, I travelled around the state with Ernie and he taught me about the history of the New Jersey fruit industry and about the changes he had seen during his career.

Photo 1. Ernie inspects apples with Bob Best, Sr. at Best Fruit Farm Hackettstown, NJ. https://www.facebook.com/profile.php?id=100057655419884 Photo: Credit Win Cowgill.

After visiting growers with Ernie, I was able to identify some of the problems facing the industry, most of which Ernie had been working on, and I continued to work on some of his favorite projects. Below is a discussion of some of the research projects that he helped me identify and how this has improved our understanding of peach tree physiology which has led to modifications in orchard practices.

Peach Variety Evaluations

Ernie was interested in evaluating new varieties and had a planting with more than 40 varieties from New Jersey, Maryland, Michigan, California, North Carolina, and Vineland and Harrow, Ontario. When I taught the tree fruit course at Rutgers in 1981, the 3 leading varieties were 'Redhaven', 'Loring' and 'Rio-Oso-Gem' and at

the Research Center at Cream Ridge we had research plantings of 'Redhaven', 'Cresthaven', 'Sunhigh', 'Blake', 'Sunqueen', and 'Jersey Queen'. However, due to cold winters, only 'Redhaven' and 'Cresthaven' cropped consistently. After a very cold winter in 1983, the only peach tree with a crop at Cream Ridge was the original 'Encore' tree and it quickly replaced 'Rio-Oso-Gem' as the leading late-season variety. The variety picture has changed quite a bit over the years and now the top 3 varieties being planted in the mid-Atlantic region include 'Redhaven', Glenglo' and 'John Boy'.

Photo 2. Ernie accepts an award from Bob Best and the NJ State Horticulture Society for his years of service to the NJ fruit industry.

In 1982 I wanted to establish a new planting for pruning experiments and Ernie recommended NJ244 that was recently named 'Jerseyglo'. The first year that the trees had fruit buds, they were killed by low winter temperatures and since the trees seemed to lack hardiness, I asked Ernie why he recommended it. He said that the trees had been observed in 10 locations around the state for 10 years, but they never experienced a cold winter. He said, "*It takes a long time to evaluate varieties*". In Virginia I evaluated more than 90 varieties and I think there is no minimum number of years required to evaluate a variety, but to identify its weaknesses of a variety must be exposed to different conditions, such as cold winters, spring frost, drought, hot summers, and wet summers.

Peach Rootstocks

Ernie was very interested in finding peach rootstocks that provided a range of vigor, were cold tolerant, and were disease resistant. He was also a skilled grafter and tried a number of grafting techniques to propagate peaches on peach (*Prunus persica*) and nonpeach rootstocks. He had several rootstock trials at Cream Ridge and Les Miller, Camden County agent, had trials in south Jersey. After several trials, Les preferred Halford and Ernie liked Lovell, but when I analyzed their data the two rootstocks performed similarly. Ernie like Lovell so much that he planted about an acre of Lovell to provide seed for the nursery at the Research Center. During my four years at Rutgers, I established 4 peach rootstock trials with every rootstock I could find in commercial nurseries, plus Citation from Floyd Zaiger, plus 3 harrow selections and some peach x almond hybrids that our peach breeder Shawn Mehlenbacher produced. The trees were still young when I left, but I learned that 'Redhaven', but not 'Cresthaven' or 'Loring' were incompatible with Citation.

Over the past 40 years many new peach varieties and rootstocks have been released. The 1980 Adams County nursery catalogue listed only 26 peach and 4 nectarine varieties, but today they offer 94 peach and nectarine varieties. All these varieties greatly extend the growing season, and most are higher quality and more attractive than varieties developed during the first half of the

20th century. However, we still need varieties with better cold hardiness and disease resistance, and bloom later in the north and have lower chilling requirements for the south. We have made less progress on peach rootstocks, and the leading rootstocks in the northeast are Bailey, Lovell and Guardian. West coast nurseries offer several others and some are interspecific hybrids. The Controller series from UC Dais shows promise for vigor control, however they need further testing in the east. It seems that the mechanism for dwarfing is reduced xylem hydraulic conductance. Now that we know the dwarfing mechanism, breeders may be able to select for vigor control, but we need a stone fruit breeding program in the U.S. similar to our apple rootstock program at USDA/Cornell.

Photo 3. The Rutgers University Fruit Team from the early 1980's that Rich Marini worked with.

Own rooted trees

In the early 1980s some nurseries mixed up varieties and rootstocks. As a result, growers were frustrated and were asking about growing their own trees. Ernie and I both discouraged on-farm nurseries because it is difficult to grow quality trees. One day in the office Ernie commented that it was too bad that we could not root peach cuttings and grow trees on the own roots. I told him about a recent publication where D.C. Coston and Armon Erez, at Clemson University, were able to root semi-hardwood cuttings. So, we tried rooting 6 varieties. The process involved cutting one-year-old shoots into 8"-long pieces, removing all but the 3 terminal leaves and cutting those leaves in half to reduce water usage. Strips of bark were removed from each side of the base of the cutting and the cutting was dipped into a solution of IBA. The cuttings were then stuck in flats and placed under intermittent mist for about 6 weeks. About 70% of the cuttings rooted. Later I learned that there was about a 2-week window from about August 8 to August 22 where we got the best rooting. Thick cuttings rooted better than thin cuttings and peach x almond hybrids did not root as well as peach. We compared own-rooted trees with trees on Lovell and Halford at several locations in New Jersey and own-rooted trees performed similar to trees on Lovell and Halford. The reason that own-rooted trees never became commercially important is because nurseries were not really set up to produce trees in this manner

Pruning and Tree Training

The first time I saw Ernie prune peaches was a demonstration for Neil Vincent's Pomology class from Delaware Valley College. He explained that he like the low open center tree and stressed the importance of balancing vegetative and reproductive growth. He said "*when you finish pruning you should be able to throw a cat through the tree without catching a branch*." He was also a promoter of mowing tree tops about a month before harvest. He said there were many benefits of mowing including, setting the tree height, increased light into the tree resulted in better fruit quality and flower bud formation, and some growers felt there was a reduction in cytospora canker. How-

ever there were no data to support these claims.

Summer Pruning Peach

During my doctoral research at Virginia Tech, I was not able to verify similar claims for summer pruning apples. So, I performed 3 summer pruning experiments and found that peach trees responded to summer pruning in a similar manner as apples. Summer pruning and summer mowing did not suppress tree vigor. Although summer mowing improved light penetration into the canopy, fruit color was improved slightly in the tops of the tree and fruit size and soluble solids were reduced. Summer mowing also delayed leaf drop and cold acclimation and cold hardiness in the early winter. A partial economic analysis showed that summer mowing reduced net profits by more than $350 per acre per year.

Importance of light

The fact that summer mowing improved light levels in the tree, but had little effect on fruit quality made me wonder how much light is needed to produce high quality fruit. When I went to Virginia, I covered 'Redhaven' trees with shade cloth at different times to determine the effect on fruit and fruit bud development. I found that at least 45% full sun is needed during the final two weeks before harvest to develop highly colored fruit. At least 25% full sun is needed for flower bud development and the most critical time is mid-June to early July. Late season light is not important for flower bud formation because covering trees with 90% shade cloth from July 31 to September 30 had no effect on flower bud development or fruit set the following year. These results made me rethink the potential benefits of summer pruning. I found that especially for young trees, I could maintain high quality fruiting shoots throughout the tree canopy with summer pruning. As trees age, the fruiting zone tends to move further from the ground because the lower canopy is shaded out. Removing upright shoots that shaded the tree center about 40 to 60 days after bloom had little effect on the fruit, but trees fruited throughout the entire tree. With annual early-season summer pruning, trees can be maintained at 7 to 8' and the fruiting zone remains low.

Tree form

Ernie and I both recognized the benefits of central leader training for apple trees and we discussed the possibility of growing peaches as central leaders. He showed me some trees that he trained as central leaders, but they were actually open centers with a vertical scaffold branch in the middle. It seemed to me that the open center was important to let light into the tree, but a high percentage of the canopy volume was devoid of fruit and it seemed that central leader trees used land area more efficiently. So, I established a planting to evaluate different canopy shapes and different methods of tree training and pruning. I quickly learned that it is challenging to reorient peach limbs. Every place I used a spreader, the wound was infected with canker. If I tied twine around a limb to pull it down, I had to remove it within a couple of weeks because peach branches grow in diameter so quickly the branches are girdled. As much as I disliked bench cuts, they were the best way to obtain a spreading branch. But when the lower branches were oriented fairly horizontal like apple limbs to allow light into the tree, water sprouts developed along the branches and shaded the tree interior. So, summer pruning was required to remove most of the upright shoots. I also learned that central leader trees should be planted closer together than open center trees because long scaffold branches produce too many suckers. I conducted an experiment *where central leader and open center trees were spaced 16 or 8 feet in the row established. A third* treatment had temporary or filler trees at 8' apart, but trees were pruned to reduce competition with adjacent tree and were removed after 3 fruiting years. After 8 years, the lower density plantings were least profitable, the higher density planting was most profitable and open center trees were more profitable than central leader trees.

Peach orchard systems in the future will likely evolve to facilitate mechanization. As with apple, the optimum canopy is probably a narrow hedgerow about 3 to 4' wide. This narrow canopy allows adequate light into the tree for high production of high-quality fruit and vision-sensing devices can detect fruit throughout the canopy. Narrow canopies also facilitate the use of string thinners and platforms, and someday robots may do much of the work. Such systems will likely require summer pruning and possibly trellises. About 20 years ago Dr. Ralph Scorza, at the USDA, release a pillar peach tree that has very upright growth habit. He also had trees that were less upright, but more upright than commercial peach varieties. These types of tree form may be easily adapted to a narrow hedgerow.

Peach thinning

Ernie was a proponent of early thinning to optimize fruit size. Growers sometimes asked if fruit should be preferentially retained at the basal or terminal end of a shoot, and he recommended spacing fruit uniformly along a shoot. Recent publications had me confused. Researchers in Georgia published a paper where fruit on the terminal end of a shoot were larger than fruits at the basal end, but Luca Corelli-Grappadelli, a grad student at Clemson, found the opposite was true. So, I performed a few experiments to learn why their results conflicted. I learned that position along a shoot did not influence fruit size. The number of fruits per shoot, not the spacing influenced fruit size. Also, fruits developing on shoots with leafy axillary shoots produced the largest fruit. So large fruits developed at nodes with axillary shoots. Luca later told me he came across an old Italian report from the 1920s that supported my results. So, while thinning, one should retain the largest fruits, especially if they develop at nodes with leafy shoots. Also, fruit size was positively related to shoot length. Shoots less than 6" long produced small fruit and shoots 18 to 24' long produced the largest fruit because they were more likely to have axillary shoots.

While pruning, Ernie did not like to head the fruiting shoots because it removed flowers and potential fruit. While demonstrating pruning to a group of Master Gardeners in eastern Virginia, I was told that less fruit thinning was needed when some of the shoots were head by half. A few weeks later during a peach pruning demonstration with some visiting Egyptian fruit growers, a grower told me that heading shoots increased fruit size. These comments made me reconsider Ernie's approach and I performed an experiment to compare heading vs. no heading. Heading all the one-year-old shoots by 50% while dormant pruning did increase fruit size. So, I performed another experiment to determine the optimum severity of heading and headed shoots to retain about 75, 50, 25, 12.5 or 6% of each shoot and then I thinned the trees to retain the same number of fruits per tree. I found that the optimum length of shoot to retain was 50% and heading more severely reduced fruit size. Heading all the shoots on a tree was time consuming, so I thought maybe I could achieve the same results by reducing the number of shoots per tree by 50% rather than heading the shoots. Over three years, I pruned trees to retain varying numbers of shoots and then thinned the trees to retain the same number of fruits per tree. The time to thin trees was positively related to the number of shoots per tree and fruit size was negatively related to the number of shoots per tree. These relationships were even apparent in a year when frost reduced the crop to less than a full crop. A partial economic analysis showed that retaining only 70 shoots per tree and then thinning to retain 7 or 8 fruits per shoot was more profitable than pruning to retain 170 shoots and thinning to retain 3 or 4 fruits per shoot. The number of fruits per tree or per acre is important, not the spacing of fruits on a shoot. The appropriate number of shoots and fruits to retain per tree will vary with variety and tree spacing.

Climate change

One aspect of my research in graduate school and at Rutgers was measuring photosynthesis, and while calibrating my equipment I measured ambi-

ent carbon dioxide levels. In 1981 the CO_2 concentration in Blacksburg, VA was about 300 ppm, but in New Brunswick, NJ it was about 330ppm due to the more urban environment. When I returned to Virginia in 1985, the ambient CO_2 concentrations had increased to about 315 ppm. In the early 1980s the influence of rising CO_2 levels still had little effect on temperatures, but by the early 2000s fruit trees were blooming earlier than in the 1980s. Reports from California showed that early-season temperatures were increasing, resulting in early harvest dates and reduced fruit size. Eight members of the NC-140 regional project had a planting of 'Chresthaven' and we decided to learn if the effect of temperature on fruit size was influenced by crop load. We thinned trees to various crop densities and recorded growing degree days during the first 30 days after bloom and found that high early season temperatures did result in smaller fruit regardless of crop load. For example, average fruit weight for trees with a crop density of 3 fruit/cm^2 trunk cross-sectional area was 180, 170 and 145g, respectively when cumulative growing degree days was 220, 300, and 400. As our climate continues to warm, growers will likely have to thin more aggressively to produce large fruit.

Photo 4. Adam Costello, President NJSHS presents Dr. Rich Marini a Certificate and Honarium for presenting the Ernie Christ Memorial Lecture at Hershey PA in 2022.

Final comments about Ernie

Early in my career, I was fortunate to work closely with several experienced pomologists, such as Ross Byers, Jack Rollins, George Mattus, and John Barden at Virginia Tech, but Professor Ernie Christ had the greatest influence on my understanding of peach culture and his ideas greatly influenced my peach research program. I know that Ernie also had an impact on many students, fruit growers, and extension workers. I think my friend Dr. Mark Robinson, who shared the office with Ernie before I started at Rutgers, described Ernie Christ perfectly. As Mark was preparing to give the Gorenstein Lecture in October he said "I wanted to specifically mention people that have had a profound impact on me and were my best teachers, my list, like your list, included Ernie. He was such a kind, humble and decent person, and as I got older, I realized how very kind and humble and decent he actually was, I really wish he was here today.

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