Research Grant Proposal for 2021
State Horticultural Association of Pennsylvania

Title: Development of a high density, highly mechanized, pedestrian peach system

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Duration: Multi-year, (year 4 of 7).

Justification:

The availability of skilled labor continues to be a major concern for fruit growers. Peaches are a high-value crop in the Mid-Atlantic, but current peach production practices are labor-intensive. Multiple trips through the orchard are required to dormant prune, hand thin, hang OFM mating disruption, summer prune, and to conduct multiple harvests.

The traditional approach to training and pruning peach trees in the eastern U.S. has been the low headed open vase, at low tree densities of 113 to 173 trees per acre. In this system, trees are pruned severely, using bench cuts to spread the scaffolds at a wide angle and keep the canopy within 9 feet of the ground. This allows growers to maintain a pedestrian orchard.

The pedestrian objective of the open vase exerts a heavy toll on economic returns. Low tree density equates to low precocity and production of low yields. The severe pruning required by open vase further reduces early bearing and its vigorous regrowth requires that it must be summer pruned to produce fruits of marketable red color.

V-shaped canopies such as Tatura, Perpendicular-V, Quad V, and Hex V, have been shown to be more productive and more compatible with labor-saving mechanization. Bench cut pruning is not required, so V trees come into bearing earlier. The modest increase in early yield per tree is multiplied 2.5 to 3 times because of the higher number of trees per acre. But V systems are inherently tall and require the use of a ladder or platform to access the upper canopy. This adds to the cost of labor, although use of mechanical string thinning and labor platforms were shown to lessen the additional expense.

Growing trees in both vase and V systems is challenging due to the natural tree form of the peach tree. Peach bears fruit on 1-year-old wood, so annual shoot growth is needed to generate a new bearing surface each year. The pattern of growth in peach is acrotonic, meaning most of the new growth occurs in the outer portion of the canopy. This growth pattern is an inherent trait, and it is amplified by the species' intolerance of shade. Shaded portions of a peach canopy grow weak, fail to flower, and quickly die off. As a peach tree matures, the natural tendency is for its bearing canopy to migrate up and out of reach from the ground.

Upward migration of the bearing surface is slowed by pruning with bench cuts in the open vase system, but heavy pruning to keep the trees short invigorates the canopy and increases shading. Early season shading reduces vigor and flowering in the lower canopy in the following year, and late season shading reduces red fruit coloration. In the taller V systems, the acrotonic growth pattern and shade intolerance of peach lessens renewal of fruiting laterals within reach of workers on the ground.

Since neither the low headed open vase nor tall V are ideal peach production systems, research is needed to develop a system that is more compatible with peach tree growth and bearing habits. We must also continue to develop growing systems that are compatible with mechanization to reduce labor inputs.

Yields can be increased with ever increasing tree density, but fruit size and quality can become limiting factors with very high-density orchard systems. The biological limitations and mineral nutrient needs of such systems are undoubtedly affected by the climate, soils of a region, and by management practices.

Recent research at FREC showed that peach trees at 5 ft. in-row spacing were 45% smaller than the same trees at 10 spacing, with 50% more yield per acre and a 6% reduction in fruit size. This level of growth reduction may be useful when designing a high-density peach system and should be evaluated. Leaf nitrogen became limiting at the five-foot spacing in year six due to the increased competition for nutrients. Intensive peach systems warrant our attention again, as we intensify the search for more labor efficient methods of growing fruit, and for systems that can readily adapt to mechanization and automation.

Potential benefits of an intensive system include:

- The canopy is renewed when it is 3-4 years old, so the orchard will remain pedestrian.
- The challenge of renewing fruiting laterals in the lower canopy associated with the tall V-systems is eliminated by the renewal of scaffolds.
- The upper region of the canopy, where vigorous young fruiting laterals originate and produce the strongest flowers / biggest fruit would be continuously renewed close to the ground.
- Dormant pruning consists primarily of cutting off one scaffold to a short stump 30 inches from the ground; an action which could be mechanized.
- Summer pruning is mechanized with a hedger. Potential problems resulting from regrowth from hedging are not an issue, as the (hedged) bearing scaffold is removed entirely after harvest.
- Initial fruit thinning is done with the Darwin string thinner, so only touch-up hand thinning is required.
- The narrow tree wall canopy, with no secondary limbs is highly compatible with future advances in mechanized harvest and automation.

Economic analysis will be a critical component of this project. Concerns with the intensive system include:

- Higher establishment cost.
    - Six to 12 times more trees per acre.
    - A simple trellis is required to position scaffolds for efficient mechanized thinning and pruning.
- Potential for quicker development of water and/or mineral nutrient deficiencies, and for reduced fruit size.
    - This study will inform us about potential changes in nutrient demand.

Objectives: To evaluate a trial planting of a high density, highly mechanized, pedestrian peach system at 12 ft. between rows and 2, 3, 4, or 5 ft. between trees.

- To determine the feasibility of such a system for increasing yields and minimizing labor costs of peach production.
- To identify the biological limitations and mineral nutrient requirements of intensive peach systems in the Mid-Atlantic.

Procedures: In 2018, Starfire / Lovell peach trees were planted at the Penn State Fruit Research and Extension Center and trellis was installed. Between-row spacing was 12 ft. Treatments consist of ten-tree

plots of intensive system trees planted at 2, 3, 4, or 5 ft. between trees, with an additional plot of trees at 5 ft. spacing which will be trained as a perpendicular V with permanent scaffolds. The study has 6 rows. Two additional guard rows were planted at 2 ft. between trees for additional future mechanization studies. Trickle irrigation was installed.

Trees were trained to a perpendicular V system with a two-wire T-trellis system to align scaffolds into a regimented row in 2018 and 2019. In 2020, mechanical hedging was done dormant, followed by manual touch-up, then hedging was repeated in mid-June and mid-July.

Blossom density was very heavy in 2020, so string thinning was conducted with the Darwin blossom thinner at pink. The trees set a moderate crop despite a frost on April 7, and hand thinning consisted of breaking clusters and removing deformed fruit. Despite drought during the final swell stage, fruit size was adequate and fruit color was outstanding (Figure 1). All labor operations were performed on the ground. Shortly after harvest we removed all the scaffolds 30 inches from the ground on one side, (Figure 2), except for one plot per replicate, where both scaffolds remained intact for comparison. Preliminary results will be reported in the March issue of Pennsylvania Fruit News.

The remaining second scaffold will be cropped in 2021, while the first side renews. Then the second scaffold will be removed shortly after harvest and the first side will be cropped in 2022. Scaffold renewal will follow the alternating pattern of alternating side renewal. Trees will be mechanically thinned with the Darwin blossom thinner. Mechanical hedging will be supplemented by hand dormant pruning, and summer pruning will be performed with the hedger.

Tree growth, canopy light distribution and leaf mineral nutrient concentrations will be evaluated. Fruit will be harvested several times as needed at commercial maturity. Yield, fruit size distribution, and fruit color will be evaluated. Establishment costs and management cost will be recorded and returns over specified costs will be calculated.

Budget Request Summary: $7998.00

Wages:	$6160.00
Fringe (7.94%):	$488.00
Leaf analysis:	$1200.00
Supplies:	$150.00
Total:	**$7998.00**

Budget Justification:

Project Dates: 7/1/2021-6/30/2022

Wages: $6,160

To provide labor for measuring, collecting, and analyzing data, including labor inputs, yield, fruit quality, and growth measurement, leaf mineral nutrient analysis and canopy light distribution.

Fringe Benefits: $488

FY21 – FIXED RATES

Fringe benefits are computed using the fixed rates of 34.88% applicable to Category I Salaries, 12.35% applicable to Category II Graduate Assistants, 7.94% applicable to Category III Salaries and Wages, 0.31% applicable to Category IV Student Wages, and 23.88% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2021 (July 1, 2020, through June 30, 2021). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2021, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

Materials and Supplies: $150

Supplies are requested for maintaining the trellis and for markers, bags, flagging and tagging materials used for identifying samples and plots.

Purchased Service: $1,200

Analytical services are for leaf mineral nutrient analysis.

Direct Costs - $7,998

Indirect Costs - $0

F&A – Off Campus Research

F&A rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency. Penn State's current provisional off-campus rate for research is 26.00% of MTDC from July 1, 2020, through June 30, 2021. New awards and new competitive segments with an effective date of July 1, 2021, or later shall be subject to adjustment when superseding Government approved rates are established. Per 2 CFR 200 (Appendix III, Section C.7), the actual F&A rates used will be fixed at the time of the initial award for the duration of the competitive segment. ***Indirect costs are not allowable per Sponsor. State funding.***

Total Requested - $7,998

Figure 1. Starfire peaches harvested from the high-density pedestrian peach study in the 3rd season.

Figure 2. Starfire peach trees at end of 2020 growing season. Wooden crossbar height is 6 ft.