PennState
College of Agricultural Sciences

PROPOSAL TRANSMITTAL

Date: 12/7/2018 **PSU Ref. No: 205977**

Title: Development of a High Density, Highly Mechanized, Pedestrian Peach Production System

Submitted to: Patti Keller

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Proposed Project **7/1/2019 - 6/30/2020** **Total Project Request: $10,691**

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Please reference PSU Ref. Number in all correspondence.

Research Grant Proposal for 2019
State Horticultural Association of Pennsylvania

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

Personnel: Dr. Jim Schupp, Penn State Fruit Research and Extension Center, Biglerville, PA.
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Duration: Multi-year, (year 2 of 7).

Justification: This project addresses the SHAP Research priorities: Stone and Other Pome Fruit Research; Integration of New Technology for Improved Farm Efficiency; and Novel Pruning Strategies. The proposed orchard would also be used for integrating future engineering research under: Mechanization/ Automation Technologies for Improved Farm Efficiency.

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 for multiple (often 3) 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 the natural growth habit of trees. 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.

V systems are simpler to manage, and more compatible with mechanization. The high-to-moderate planting density increases the amount of productive bearing surface of these systems, producing higher yields than open vase. 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 lessens the additional expense.

Both vase and V systems have challenges inherent to the natural tree form of the peach tree. Peach bears fruit on 1-year-old wood, so a substantial amount of annual vegetative re-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 weakly, 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.

Migration of the bearing surface can be slowed, but not eliminated, by pruning with bench cuts in the open vase system. The heavy bench cuts required to keep the trees short result in strong local invigoration of the canopy and increase shading. Early season shading reduces vigor and flowering in the lower canopy in the following year, and late season shading reduces red fruit coloration. The strong regrowth that results from heavy pruning must be counteracted with summer pruning once or twice a season to prevent severe shading effects.

In the taller V systems, the acrotonic growth pattern and shade intolerance of peach limits renewal of fruiting laterals within reach of workers on the ground. Peach does not readily renew fruiting branches from short stubs as does apple. As a result, short sections of 2-year-old wood (secondary

branches are stubbed back to the most proximal fruiting lateral. This increases the complexity of the canopy and of pruning decisions, which is counterproductive to the original intent of the simplified pruning rules of the V systems.

Neither the low headed open vase nor tall Vs 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 study techniques for further reducing labor inputs through mechanization.

In the 1980s, a "meadow orchard" system was described and tested. Peach trees were planted at very close density and mechanically harvested, by cutting off the entire tree at harvest, much like combining corn. Even in regions with an extended growing season, [Georgia (US), and Israel], it wasn't possible to grow annual crops of quality peaches. In Israel it could be accomplished only with early maturing cultivars, and even then, fruit maturity was delayed, and fruit quality suffered when the growing of annual crops was attempted on trees that were regenerated in a single season.

Israeli scientists therefore proposed modifying the meadow system to trees with two perpendicular scaffolds which were spaced at 2- 2.5 ft. x 6 ft. and named this the "intensive system". During orchard establishment, it appeared similar to the familiar perpendicular V, then annually, one of the scaffolds was pruned to a short stump shortly after harvest, leaving the second scaffold to bear fruit the second season. The pruned stump regenerated during this year and became the productive canopy in year three. By alternating removal/ renewal of the 2 scaffolds, the trees maintained enough vigor to produce adequate flowering, fruit set and yield. Yield per acre was very high, but since no effort was made to thin the crop, fruit size was small. At 5260 trees per acre, the planting density exceeded the threshold to produce marketable fruit. Additionally, they lacked equipment small enough to access the trees at such tight between-row spacing.

Research with intensive spindle peach systems in Italy was reported in 1984. With between-row spacing held at 4m (13 ft.), in-row spacing ranged from 1.25m to 2 m (4 ft. to 6.5 ft.), a range of 516 to 838 trees per acre. The scientists noted increasing yields at in-row spacing below 2 m (6.5 ft.), but also reported a reduction in fruit size with increasing tree density. They concluded that competition for sunlight, water and mineral nutrients became hyper-critical. This system did not utilize scaffold renewal, which may have helped with light distribution.

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

These 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 of an intensive system will be renewed when it is 3-4 years old, so the orchard would remain pedestrian.
- The challenge of renewing fruiting laterals in the lower canopy associated with the tall V-systems would be 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 renewed continuously.
- "Dormant" pruning would consist of cutting off one scaffold to a short stump about 30inches from the ground; an action which could be mechanized.
- Summer pruning would be 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.
- Thinning would be done with the Darwin string thinner.
- The narrow tree wall canopy, with no secondary limbs would be 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 will be required to position scaffolds for efficient mechanized thinning and pruning.
- Potential for rapid development of water and/or mineral nutrient deficiencies, and small fruit size.
    - Diligent monitoring of water and mineral nutrient requirements will be required.

Objectives: To establish a trial planting of a high density, highly mechanized, pedestrian peach system at 12 ft. between rows and 2, 4, or 6 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 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 (Fig. 3). 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 row/replicates. Two additional guard rows were planted at 2 ft. between trees for additional future mechanization studies. Trickle irrigation was installed.

Trees will initially be trained to a perpendicular V system with a two-wire T-trellis system and bamboo stakes to align scaffolds to facilitate mechanized pruning and thinning. The trees will be cropped in year two. One scaffold will be removed entirely shortly after harvest, and the remaining second scaffold will be cropped in year 3, while the first side renews. Then the second scaffold will be removed shortly after harvest and the first side will be cropped in year 4. Scaffold renewal will follow the alternating pattern of alternating side renewal. Trees will be thinned with the Darwin blossom thinner, and summer pruned with a hedger. Harvest will be by hand, pending development of a mechanical harvester.

Yield, fruit size distribution, and fruit color will be evaluated annually and cumulatively. Establishment costs and management cost will be recorded and returns over specified costs will be calculated.

Budget:

Wages:	$8920.00
Fringe (7.81%):	$696.00
Supplies:	$1075.00
Total:	**$10,691.00**

Budget Justification:
Wages are to provide labor for second year tree training, harvest and growth measurement, and fruit quality assessment. Supplies are requested for seven ft. bamboo stakes and tie materials for training the trees and flagging and tagging materials for identifying the plots.

Fringe benefits are computed using the fixed rates of 38.97% applicable to Category I Salaries, 14.74% applicable to Category II Graduate Assistants, 7.81% applicable to Category III Salaries and Wages, 0.18% applicable to Category IV Student Wages, and 25.34% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2019 (July 1, 2018, through June 30, 2019). 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, 2019, 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.

Figure 1. Starfire peach trees at end of 2018 growing season. Bamboo stakes are 7 ft. long.