Mechanization - Increasing Efficiency on Your Farm

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Labor for orchard operations is a major focus of discussion among fruit growers. Many cultural practices and pest control methods utilized in the past require abundant labor resources to be profitable, and these no longer exist in today's agricultural community. Additionally, fresh fruit packers and processors are focused on meeting consumers' expectations for popular new varieties. Consequently, we have focused on increasing orchard labor efficiency and grower profitability through the research and extension outreach on efficient orchard production systems, coupled with innovations in technology and practices.

Intensive Apple Growing Systems and Efficiencies

Intensive orchard plantings on size-controlling rootstocks are a central tenant of orchard efficiency, including labor efficiency. While it is well known and generally agreed that smaller trees require less labor because they require less pruning and minimize ladder use, few high density training systems were developed with labor efficiency in mind and fewer still specifically to facilitate the use of labor-saving mechanization. To address the requirements for growers seeking to adopt modern high density practices, we identified the following as the underlying key components of a successful intensive apple system:

- Size controlling rootstocks for tree density between 518 (6' X 14") and 1320 (3" X 11") trees per acre
- Quality nursery stock
- Supported canopies to maintain consistent canopy shape and position
- Single rows of tall narrow canopies ("tree wall")
- Canopy shape that compliments natural tree form
- Minimal pruning and branching structure
- Simplified pruning and training tasks

A number of named systems can be used to adhere to these underlying keys. These components have been incorporated into the trellis design and training protocols developed for the NRCS-CIG Program for Re-Tooling Mid-Atlantic Orchards; 12 one-acre plantings at fruit growers' farms, that are used for on-farm research and demonstration of labor efficiency.

On-going research on labor platforms has been useful to confirm that these orchard system parameters facilitate mechanically-assisted labor, and video sensing of fruit: narrow continuous tree walls, three feet wide and 10-14 feet tall, in rows spaced no more than 14 feet apart.

With narrow fruiting wall systems, we achieve both horticultural and technological compatibility. The biological efficiency of the tall narrow tree wall surpasses the performance of most existing systems. With three foot wide canopies, both light distribution and platform labor reach are addressed simultaneously. Ladder use can be eliminated with platform adoption. Close spacing in the row creates a tree wall that is readily identified by self-steering mechanisms, and sensor technology mounted on robotic platforms.

In-row spacing of three to four feet increases early yields, benefits labor efficiency by assuring a continuous flow of work, and permits simplified pruning decisions based on limb size.

Intensive Peach Growing Systems and Efficiencies

Peach production systems have remained largely unchanged for generations, due to the lack of tree size control and to large labor requirements. The lack of dwarfing rootstocks currently limits the extent of peach orchard intensification. The need to hand thin and to make multiple harvests makes working on tall peach plantings from ladders costly. Since 2007, we have evaluated new production systems that may improve both productivity and labor efficiency.

A recent development in California is the trend toward shorter trees. Growers there are addressing high labor costs and limited labor availability by reducing canopy height. UC Davis Extension Specialist Kevin Day has developed a system with trees are planted at 202-242 trees per acre and trained to 6 scaffolds, which are manipulated to grow at a 50-60 degree angle when the trees are young. Another component of the "Hex V" system is minimal pruning during canopy development, as this is thought to also promote the wider limb angles required by this system. Fostering wide scaffold angles through delayed pruning, and minimal pruning to manage canopy height and foster early crops in high density peach plantings are potentially valuable components in the development of intensive production systems.

Since we don’t yet have size-controlling rootstocks for peach, tree numbers between 181 (12’ x 20’) and 544 (5’ x 16’) trees per acre should be considered intensive systems. Our previous research shows that the 18- to 20-foot row spacing common to perpendicular V peach plantings is also applicable to mechanical labor platform use.

<u>Recent Results in Pennsylvania:</u>

The peach systems trial showed strong differences in yield and fruit size between systems in 2012. Yield per acre followed a similar trend as in the previous three cropping years: Quad V ≥ Hex V > Perpendicular V > Open Center. The moderate density systems have been the most productive for the first 7 years of the planting, because these systems produce more bearing surface per acre than the perpendicular V, and because they fill their space much faster than the Open Center

Trials were conducted for a second year in 2012 at the Penn State FREC and at several grower-cooperator plots with a compact electric platform designed by Carnegie Mellon, with support from the USDA-NIFA Specialty Crop Research Initiative grant: “Comprehensive Automation for Specialty Crops”. This self-guided platform featured a user-friendly control panel designed by CMU students and an in-row steering controller designed around a single laser sensor and a simple user interface. Labor efficiency increased with the platform between 55% - 100%, depending on the nature of the task.

We performed efficiency and bruise analysis trials on the newest prototype DBR vacuum harvest system to assess efficiency gains over the use of traditional ladders and picking buckets. We also conducted a demonstration of the harvester for fruit growers at FREC. This assessment included examination of bruise volume from hand harvested and vacuum harvested apples. Testing the new prototype with plantings of Golden Delicious, York, and Cameo, four harvest workers could simultaneously pick a 23 bushel bin of apples every 11-12 minutes. Compared to harvesting with ladders, this represented a 15% - 33% increase in harvest labor efficiency. Bruising was slightly elevated, and varied between 2.5% and 7.9%, depending on variety. Several refinements were proposed for reducing bruise incidence.

While our research resulted in the Darwin string thinner being successfully deployed to reduce hand thinning labor in peach, results from apple have been a mixed bag. Apple flowers from a mixed bud, and the spur leaves under the flowers are crucial to fruit growth during the cell division phase of growth. Although thinning has been achieved in our apple studies, fruit size has been increased in only one of several apple trials conducted in PA. It is thought that the spur leaf damage that accompanies the thinning explains the lack of fruit growth promotion.

A set of prioritized pruning rules was developed and refined for evaluation and eventual adoption by Ag engineers on a newly- awarded SCRI grant to develop automated dormant pruning. We are confident that these studies will help to refine current manual pruning practices in the near term as well.

We are blessed with ever-improving varieties and fruit products to sell to health-conscious consumers who regard us as local farms. The future for our tree fruit industry seems bright, if we can develop strategies to counter the growing cost and scarcity of farm labor. The aim of our research is to develop growing systems and technology that will allow greater mechanization and labor efficiency in the short term and fully automated systems in the future. It is our hope that the results will continue to provide growers with regionally-adapted recommendations on growing systems for high yields of quality fruit, grown with the efficient use of labor and other inputs.