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The orchard of the future: Higher tree densities, more automation

If asked what commercial fruit orchards might look like in the future – even up to a century from now – those who've studied orchards closely will give you a wide range of answers. The speculation begins below.

Greg Peck, assistant professor of horticulture at Virginia Tech, tackled this question with graduate students Ashley Thompson and Candace DeLong. According to them, the trend toward increasingly larger orchards being owned by increasingly fewer people or corporations will likely continue. These large farms will be highly efficient, with the goal of decreasing variability in biennial bearing, fruit size and fruit quality. They also will be less diverse in the cultivars they grow.

On the flip side, consumer interest in local foods, farmers' markets and agritainment will continue to grow. Orchards planted for these markets may look very similar to the high-density orchards being planted today. Operators will need to focus on apple varieties with unique flavors and niche markets. The majority of apple producers might be these smaller-scale growers, even though large-scale producers will grow the vast majority of apples, according to Peck and his team.

Ted DeJong, a professor and pomologist at the University of California, Davis, said the diversification of orchard systems would continue in the future. In California, there are some very technologically advanced orchards using trellis systems with very precise management. These high-end growing systems will continue to expand, and their benefits will trickle down to lower-cost management systems.

Mario Miranda Sazo, a fruit Extension specialist with Cornell Cooperative Extension, said any future orchard system will include these five basic principles of modern orchard design: high light interception, good light

distribution throughout the canopy, high early yields, simple canopies for partial mechanization, and high planting density.

Robert Crassweller, professor of horticulture at Penn State University, expects fruit production for the wholesale market to be on one production system with one rootstock, offering a limited number of distinctive cultivars with nutraceutical properties. The local retail market, however, will bring higher prices and better profits, as well as a wide range of exotic flavors.

Future orchard architecture

Tall spindle likely will continue to be the best growing system, with small modifications to create a narrower canopy, which should reduce labor costs, improve fruit quality and boost pruning and harvest efficiency, Miranda Sazo said.

He said orchard systems of the future would likely be 10-11 feet high, due to the need to intercept 70-75 percent of available light. Shorter tree heights are possible with very narrow rows, but that will require a change in the tractor, spraying and bin-handling system. It is possible to imagine a future orchard planted with only 5-6 feet between rows (just a walking path) and with 6-foot-tall trees trained in a very narrow fruiting wall with the spraying done by a fixed, over-the-row system.

Orchards will likely have narrow, simple canopies no wider than 4-6 feet due to the need for good light distribution. The narrow canopies will be more adaptable to pruning with shearing machines, and will be easier to harvest with simple harvest aids, he said.

The optimum planting density will likely remain close to 1,000 trees per acre. As growers become more adept at managing this density, they will likely plant slightly closer, with densities close to 1,300 trees per acre. If they adopt summer shearing to reduce cost and maintain a narrow canopy wall, they will slowly move from 12 feet between rows to 11, 10 or even 9 feet between rows. Future systems likely will continue to utilize highly branched trees for high early yields. The only exception to this rule will be those growers who choose to plant very high tree densities (more than 1,500 trees per acre), where the cost of feathered trees is too high and the value of feathers is too low due to the small in-row spaces, Miranda Sazo said.

According to Peck's team, large-scale orchards will become more mechanized and automated. Over-the-row equipment for spraying, pruning and harvesting will allow tree rows to be planted 3-5 feet apart. Tree height would be limited to 4-6 feet, which would minimize the need for tree support and trellising. Without the need to develop much vegetative tissue, apple orchards could reach their full yield potential within three to four years. Many apple growers already plant 1,000-1,500 trees per acre. Densities of 3,000-4,000 trees per acre

are quite plausible within the next 50 years. Yields will edge toward the hypothetical maximum of 2,381 bushels per acre.

To make these ultra-high-density systems achievable, apple trees would likely be grown in place. These trees could be propagated by tissue culture, similar to how strawberry plants are produced, according to Peck.

As consumer preferences change, new varieties will replace today's apples. And as the functions of more and more genes are discovered over the next few decades, apples of the future will most likely be genetically engineered. Hopefully, advances in molecular biology and plant breeding will lead to highly nutrient and water-efficient rootstocks that are productive and disease-resistant, according to Peck's team.

Crassweller said trees would be no more than 6 feet tall, with 2-foot in-row spacing and 5 feet between rows. With automation, orchards will have one giant bed system without the need for drive rows.

New rootstock will be freestanding, dwarfing, precocious and resistant to all diseases and nematodes. There will be dwarfing rootstocks for peaches, plums and other stone fruits. Multiple-pick varieties will be a thing of the past. Maturity will be uniform for all the fruit on a tree, allowing a single picking. Fruit will mature at a specific number of days after full bloom, so growers will know the exact date they should harvest, Crassweller said.

As size-controlling rootstocks become increasingly available and growers gain confidence in them, stone fruit orchards will begin looking more and more like high-density apple orchards do today. Processing peach and Bartlett pear orchards might not look much different in 50 years, but for the more modern systems, tree height will be limited to no more than 7 or 8 feet. The trees will likely be planted in configurations such as hedgerows or V-shaped systems – with and without supporting trellis structures – with fruiting walls facing alleyways to accommodate increasingly efficient pruning, thinning, harvesting and pest control practices, DeJong said.

It is likely there will be more covered canopies to increase environmental control. Covered canopies can reduce fruit sunburn and increase the percentage of diffuse radiation, which distributes light more evenly through tree canopies and moderates climate under a net, he said.

Most orchards will be under some sort of localized irrigation such as buried drip, drip or micro-sprinklers; with buried drip taking on increased importance. Irrigation scheduling will be increasingly automated, as will fertigation, DeJong said.

Machines

Use of technology for orchard tasks like pruning, fruit thinning and harvesting likely will increase, but it won't replace people completely – because nothing beats the human eye and mind when making some of the required decisions, DeJong said.

There's also the fact that large investments in labor-saving equipment are often cost-prohibitive and risky, especially when the return on investment is unpredictable (which is the nature of the fruit industry). Thus, wholesale adoption of such equipment would be quite slow, DeJong said.

He predicted that machines would likely be most useful doing "approximate performance" jobs. Some of this "approximate performance" equipment will be used in orchards aimed at the mid- and low-end markets, where machine performance might be good enough to meet the standards. In these cases, hand work would be dramatically reduced. In orchards where the products are aimed at high-end markets, however, the machinery would likely be followed up with more detailed hand work.

Miranda Sazo said it is unlikely that complete mechanization will occur in either pruning or harvest. It is likely, however, that mechanization of summer pruning, using a shearing machine, will become common, though remedial hand pruning will be required every second or third year. The value of harvest-assist machines will depend on the gains in labor efficiency and cost.

According to Crassweller, mechanical equipment will be solar powered and operated remotely via GPS. GPS-operated robotic machines will apply weed-control materials, but only when they sense green leaves. Solar-powered LED light systems will be placed over the orchard. Harvest will be done with over-the-row machines. Fruit will be sorted, packed, cooled and loaded onto transportation in the field to be taken directly to market.

Through conventional breeding techniques, cultivars will need few if any pesticides. What is needed will be delivered via automated systems. Irrigation will be automated through soil moisture sensors that automatically turn the system on. Planting will still be done by hand, but instead of single-row planters we will see three- to four-row transplanters, Crassweller said.

According to Peck and his team, remote sensing with satellites and drones will become commonplace. Irrigation and fertilizer regimes will become highly integrated with the data from remote sensing and be based on immediate plant needs. Not only can these systems increase orchard efficiency, they also have the potential to reduce water and nutrient use. Drones will be used for scouting and maybe even pest control, using low-power lasers to literally zap bugs in mid-flight. These lasers could possibly be used for zapping apple flowers and/or fruitlets for precise crop load management. Peck referred to it as "laser guided thinning."

These sophisticated orchards of the future will be expensive to install and operate. There will be significant labor savings with mechanical pruning and harvesting, as well as greater efficiency and yields, but many of these technologies will be used by only a few very large operations. And these operations will need to hire highly skilled workers to operate the control systems and machinery, according to Peck's team.

What else?

In Crassweller's vision of the future, there will probably be no Extension personnel, but there will be automated trouble-shooting programs each operation can consult for a fee.

Peck's team predicted that organic and conventional apple production would look more and more alike in the future, because of increased restrictions on pesticide formulations and greater reliance on things like biocontrols, naturally derived products and pest- and disease-resistant germplasm.

No matter their size, all apple growers will need to contend with a changed climate in the future. Predicted effects include warmer winters with less chill hours, earlier bloom dates with more chances for frost damage (like the spring of 2012 east of the Rockies happening every year) and more extreme weather events such as hail, derecho storms and hurricanes. Orchards of the future (and in some regions, the orchards of today) will need to use protective structures such as hail nets and rain covers to contend with some of these impacts. Later-blooming apple cultivars might become desirable for frost avoidance, according to Peck's team.

– *Matt Milkovich, Fruit Grower News, November 9, 2015*