High Density Planting for Avocado Production:

A Chilean Perspective

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To remain profitable and competitive within the marketplace, California avocado growers must maximize productivity and lower production costs. But several factors limit the productivity, profitability and competitiveness of the California avocado industry — the rising price of irrigation water, salt toxicity, shortage of qualified labor and pests and diseases.

One business model used by several crops within the agricultural industry is to increase productivity per acre by planting trees at a higher density. While one could argue that the challenges of high-density planting (HDP) are greater for avocado due to its growth habit and the lack of dwarfing rootstocks, several countries have shifted the industry standards towards higher planting density for avocado. In this article, we highlight the numerous advantages and challenges of HDP for avocado production — a practice largely adopted by the Chilean avocado industry.

In May, Dr. Mary Lu Arpaia and I (Dr. Philippe Rolshausen) visited six Chilean orchards with different planting densities, under the management of Francisco Mena Volker and Juan Enrique Ortuzar, two consultants for GAMA and Agricom, respectively. In addition, UC Cooperative Extension Advisor Ben Faber and I had the opportunity to visit three California orchards that are evaluating HDP. In light of our observations, we discuss some of the hurdles for implementing this strategy on a large scale under current California standard practices.

HDP in Chilean Avocado Groves

In Chile, there are approximately 70,000 acres of avocados planted in a range of latitudes similar to those in California. Chile has pushed

Figure 1: Ultra High Density Planting (4x4 feet; 2700 trees per acre) in a Chilean orchard (Mexicola x Hass) planted in 2013. Look how crowded, compact and short the trees are next to Mary Lu Arpaia. Production in 2015 was 17,000 lbs. per acre.

for higher levels of production efficiency by increasing tree density and lowering labor costs. Planting at 7.5 x 7.5 feet (774 trees per acre) is the current standard density in Chile for new plantings. We also observed densities as high as 4 x 4 feet (about 2700 trees per acre; Fig. 1). Obviously, at that spacing trees are very crowded, compact and short. Tree height is managed from the time of orchard establishment. Orchard management practices include removal of water shoots, tree topping and cutting side branches to reduce shading (Fig. 2).

Pruning is commonly done in spring right after harvest and again in the fall to ensure pruning does not stimulate vegetative growth during summer and early autumn that can affect flower bud induction. Failure to follow those guidelines implies that severe tree pruning would need to be done later on, which in turn would have a short-term negative impact on productivity. But with tree heights of only six to eight feet, fruit harvest is more cost effective. At 5-6 cents per pound (vs. 25-30 cents per pound for California), pickers can make $50 per bin (versus $80-100 per bin in California) and at these attractive prices owners can secure and retain their workforce.

At an ultra HDP (4 x 4 feet) grove, trees come quickly into production (20,000 pounds per acre, two years following planting in one orchard) with yield expectations of over 30,000 pounds per acre at full production after four years

Figure 2: Post-harvest hand pruning of lateral shoot in an HDP orchard (Mexicola x Hass; 7.5 x 7.5 feet; 700 hundred trees per acre) to keep tree height under control and limit shading effect.

(Fig. 3). At lower planting densities, maximum productivity is reached after six years with yields of at least 10,000 pounds per acre.

In HDP, managing tree vigor is key, therefore growers have adopted several practices, including girdling, selecting rootstocks with low vigor and applying plant growth regulators (PGRs). The application of commercial PGRs that inhibit gibberellin production is standard practice in Chile. A PGR foliar spray in the spring at flowering (around peak bloom) increases fruit size in the "on" flowering year and increases yields in the "off" flowering year. A second PGR application through the irrigation system in late spring also is recommended to manage tree vigor. PGR application also influences the growth habit of the tree with treated trees typically having a "bushier" growth habit and reduced internode distance, as well as a downward or weeping growth habit. There also is a tendency for increased branching (Fig. 4). One additional advantage for using a soil application of PGR is that it appears to increase salinity tolerance and allows growers to reach higher production under saline water conditions. PGR application timing is critical because some PGRs stay in soil for up to 140 days and residual product in the plant in the fall could have a negative effect on flowering the following spring.

Figure 3: Orchard 7.5 x 7.5 (Mexicola x Hass). Note the large amount of fruit in a small window. Depending on planting densities these orchards average 15,000 to 30,000 pounds per acre.

Some growers also girdle scaffold branches to reduce vigor. Girdling starts in year three of the orchard, on established trees. The girdled branch will typically flower more heavily than a non-girdled branch and ultimately set more fruit. It is common for girdled branches to look more yellow in the spring — the reason for this is unknown. In some situations the girdled branch is removed following harvest of the fruit to allow increased sunlight penetration into the tree. Girdling is currently practiced in the California industry by some growers as well.

We also saw plantings of 'Hass' on seedling selections of West Indian rootstocks. In Chile, the problem of avocado root rot is considered to be minimal, and currently there is little use of clonal rootstocks. West Indian rootstocks are considered to have a higher level of salinity tolerance as compared to rootstocks derived from the Mexican or Guatemalan race.

Figure 4: A) Nabal x Mexicola orchard planted at 18 x 7 (350 trees per acre) and soil treated with high rates of PGRs to manage the elevated levels of salt. Look at the stunted and droopy aspect of the trees. Note the lack of salt toxicity on leaves. B) In contrast, note the salt toxicity (marginal leaf burn) on trees from the same orchard treated with lower rates of PGRs. C) Note the branches with short internodes caused by the PGR treatment.

Tree vigor on some of the West Indian rootstocks is lower while we observed other seedling lines to be more vigorous. These West Indian rootstocks are gaining popularity in Chile since salinity is a problem in some production areas, as well as perennial water shortages in some areas.

In Comparison: California Avocado Groves

California growers have traditionally planted at a 20 x 20 foot spacing (109 trees per acre), and have thinned trees when the canopy closed. Closer spacings have been used, especially on steep slopes where trees tend to grow smaller, but with varying success. Under California conditions, HDP has displayed different optimal planting densities (300-500 trees per acre) in part because of the limited number of cost-effective strategies to manage tree vigor.

In California, PGR treatments are not registered and growers are mostly left with pruning, girdling and selection of varieties with lower vigor such as 'Gem' or 'Lamb Hass'. These varieties can be planted at higher densities such as 12 x 15 or 12 x 12 feet. Trees are pruned once or twice a year, in the winter and after harvest, depending on planting densities, tree vigor and market conditions. In addition, girdling is implemented at an earlier age than in Chile with California girdling typically occurring the first or second year following planting. One HDP in California that we visited yielded 18,000 pounds per acre at 6 x 15 foot spacing (484 trees per acre), comparable to similar planting densities in Chile. However, California growers do not typically plant at high densities and one can argue that the absence of a registered PGR may be a limiting factor. All the growers we visited unanimously said they would consider using a PGR if it were registered for California avocado production.

We could certainly speculate about the benefits and implications for the California industry of HDP managed with PGR applications:

- Higher productivity per acre with higher tree density
- Lower labor costs with less pruning
- Faster, safer harvest because of smaller trees
- Increased salt tolerance especially in areas that use reclaimed irrigation water

Together, these factors would increase California growers' competitiveness in the marketplace.