THE POTENTIAL FOR SUPER-HIGH-DENSITY OLIVE OIL ORCHARDS IN CALIFORNIA

Paul Vossen

History of Olive Orchard Planting Density

Old traditional olive production systems in dry-farmed areas around the Mediterranean range in tree spacing from as much as 60 feet apart (12 trees per acre) down to a spacing of about 24 feet apart (75 trees per acre) with most spaced somewhere in the middle, around 28 to 30 feet apart (50 trees per acre). Many of the old orchards in Spain were planted with 3-4 trees per hole in hopes of having at least one survive. When more than one survived, they were all trained out at an angle to create an open center "tree". These spacings and training systems were needed to maintain good tree health and olive fruit turgor in very dry climates with shallow soils or gravely soils that held very little water. Their yields were all that could be expected (around 0.5 - 2 tons per acre with a very long waiting period to come into full production and severe alternate bearing.

Starting around the early 1980's several researchers and astute farmers, primarily in Spain and Italy, developed irrigation systems for oil olives and began to plant trees closer together in order to fill the orchard faster and have the orchard reach full production quicker. In some cases, traditional orchards have been interplanted to double the tree density. They called these "High-Density Orchards". The mono-cone or central-leader system of training was developed to accommodate even more trees spaced closer together with the idea that more fruit might come off the tree with trunk shakers, though most were still trained to the open-center form. Many orchards have been planted at different spacing combinations, usually with the in-row spacing closer than the between-row spacing to create a hedgerow. Some typical spacings are: 8 ft. x 16 ft., 12 ft. x 18 ft., 10 ft. x 20 ft., 11 ft. x 22 ft., 15 ft. x 18 ft., 16 ft. x 20 ft., 18 ft. x 22 ft., 13 ft. x 23 ft. and so on with tree densities per acre of about 150 to 300 trees. Some orchards were planted with the intention of removing every other tree or every other row once the trees became too crowded.

Though factors such as irrigation, variety, pruning method, and site vigor have strong influences on these plantings, the overall benefits were significant increases in yields per acre (double to triple), full production in fewer years (7-10), and more efficient harvest, usually with trunk shakers. The old traditional systems essentially became less viable economically.

The high-density system of olive production has been working effectively for over 20 years and good orchard managers can predict tree performance based on the soil type, climate, varieties chosen, training system, and harvest method. Reliable annual yields of around 3-4 tons per acre can be achieved in irrigated orchards with moderate sized trees planted at densities of 90 to 200 trees per acre. We know this works, we know that those trees can reach full production in about 8 years with good management, and the orchard life is almost indefinite. In high-density plantings, the fruit is primarily harvested with trunk shakers. There are some growers planning to use other types of very large, single sided or over-the-row comb type harvesters, but these harvesters really have not been adequately developed yet and in most cases require smooth hedged surfaces to get good fruit removal on such large trees.

The problems with the high-density system are: that 8 years is still a long time to wait for full production (return on investment), harvest costs with trunk shakers is still not very efficient, other extremely large, cumbersome harvesters that harvest one side of a large tree at a time are not very efficient either, and the use of mechanical pruners to shear or hedge trees essentially removes too much of the tree's productive wood. All of the aspects of dealing with a relatively large tree for pruning and

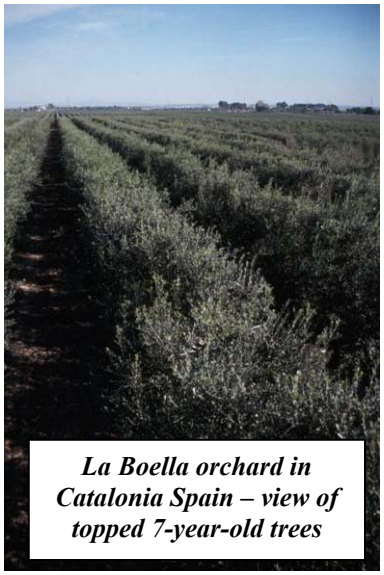
pest control spray coverage are also less efficient than for smaller trees. Almost everyone agrees that what is needed is a dwarfing rootstock for olives to limit vegetative tree vigor and to maintain tree size down to about 9-10 feet just like many other fruit crops. The cost for shaker harvest and various combinations of shakers and hand harvest is the number one production expense for traditionally spaced and for high-density orchards; in many cases exceeding 50% of the total production costs.

High Density Fruit Orchards of All Kinds

In the late 1960's, high-density systems for tree fruit production really began to take off with the development of dwarfing rootstocks in apples. Virtually every tree crop has followed suit by either developing size controlling rootstocks, varieties with greater lateral fruiting capabilities, or training systems that bend or shape trees to limit their size. The benefits have usually been increased production, early bearing, more efficient harvest, chances to try new varieties, and greater financial returns. The difficulty, however, is that these orchards require much more management skill to train and prune plus the use of trellis systems in some cases. They require much more knowledge of variety growth habit, rootstock influences, and site vigor evaluation. A high-density orchard also requires very precise irrigation, good fertility management, and sometimes, more careful pest control, plus greater investment costs for the greater number of trees, trellis system, and tree training.

The Super-High-Density Oil Olive Production System

So here come the high-density olives. In this case the "Super-High-Density" olive production system with tree spacings of about 3 to 4 feet within the row to about 12 to 14 feet between rows (778 to 1,210 trees per acre). The oldest super-high-density orchard system in the world is going into its 9th season in 2002. The technology has been pioneered by producers in Catalonia, Spain and upon close inspection has been quite successful, but not without a very difficult learning curve.



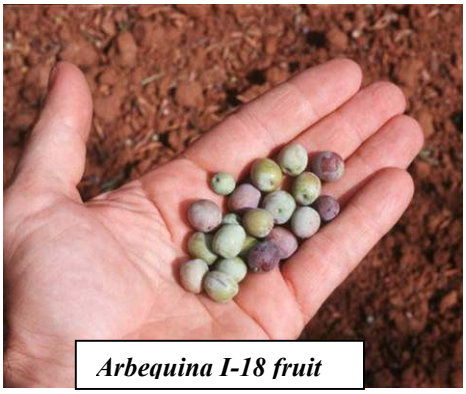
La Boella orchard in Catalonia Spain – view of topped 7-year-old trees

The initial super-high-density orchard planting was mistakenly oriented East-West and the trees were planted too close together for the deep moist soils and very vigorous site. Since the orchard was essentially an experiment, the orchard managers tried several different pruning methods, none of which were exactly what they are doing now after 8 years of experience. One of the very common mistakes they committed was to get greedy the 3rd and 4th years and not prune the trees adequately, but to leave them full of excessive large lateral wood for maximum production, which shaded out the lower branches leaving little yield in the 5th year. Since that time, they have modified and somewhat automated their pruning to remove any large lateral branches or overly vigorous sucker growth to the extent that newer orchards have not experienced the same reduction in yields in the 5th year. They also managed to bring the overly dense orchards back into production that had been inadequately pruned and trained in the early years.

To their credit, the pioneers of the super-high-density olive oil production system have been very open to creative criticism and open to research on their orchards, including the evaluation of varieties and pruning and training trials. Part of that openness has been their desire to demonstrate the potential of the system in order to sell trees as a nursery. Fortunately, much has been learned from those first plantings. Another problem the initial orchard experienced was severe defoliation from the foliar

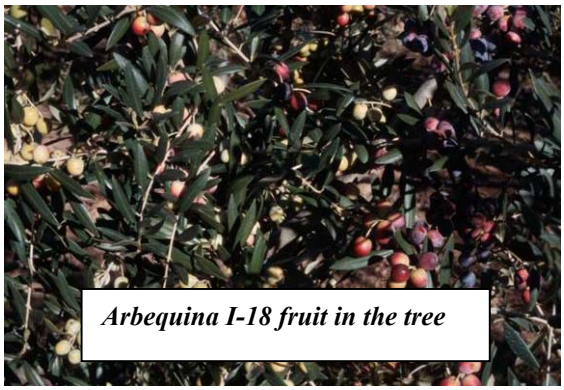
disease called peacock spot (Spilocaea oleaginae) due to the lack of airflow and ventilation in the dense foliage and the very moist site. In newer orchards that are oriented North-South, with drier soils, planted at slightly wider spacings, and treated with well-timed preventative copper fungicide sprays, the problem does not exist.

Varieties for Super-High-Density Plantings



Arbequina I-18 fruit

The three best varieties for super high-density systems, observed to date, are Arbequina, Arbosana, and Koroneiki. They grow naturally in an upright fashion with a central leader, throw few large lateral branches, and yet are compact compared to other varieties. They are self-fruitful, very precocious, and have excellent oil quality characteristics. The compact habit and heavy crop load, almost every year, limits tree size compared to other varieties (they are not dwarf varieties), and the upright branch connection limits damage from the beater bars of the mechanical harvester.



Arbequina I-18 fruit in the tree

The Arbequina variety has been the most widely planted variety in Spain for several years in both high-density and especially in the super-high-density systems. It is likely made up of several clones, one of which is the I-18 that in some trials came into bearing earlier and produced heavier yields. The oil produced from Arbequina is quite aromatic and fruity with very little pungency or bitterness. It has a short shelf life of about 1 year.

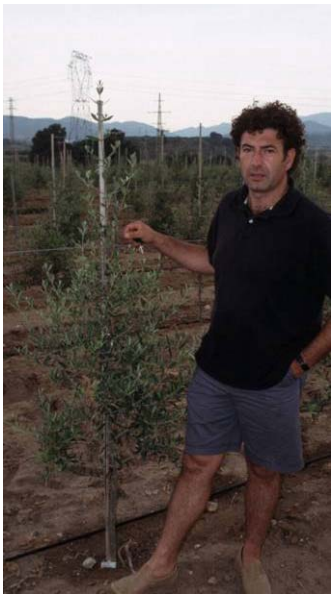
The Arbosana variety has fruit that looks very much like Arbequina fruit and the tree originates from the same region, but it matures about 3 weeks later and the foliage is slightly different in color. Overall, it is about 25% less vigorous than Arbequina, but re-growth from pruning cuts is more vigorous and it is more sensitive to water stress. Oil from Arbosana is more pungent and bitter than Arbequina; it is also quiet fruity and pleasant. Since this variety is relatively new, there is a lack of historical data on quality and performance.

Arbosana fruit

Koroneiki fruit

Koroneiki is the primary oil variety of Greece with well-recognized quality characteristics, very heavy fruit set, but very small fruit. Koroneiki oil is generally quite green in color, very fruity with an emphasis on herbal-green fruitiness and it has medium bitterness an pungency. It has a long shelf life of 2 or more years. It really could only be considered for planting if picked with some type of mechanical harvester.

Planting, Training, and Pruning Super-High-Density Orchards



Josep Baiges, the orchard manager standing next to a one-year-old tree in Catalonia Spain

In frost-free areas, the best time to plant the trees is in the fall, because they get a huge jump in spring growth. Frost prone areas are taking a risk and probably should wait to plant until the danger of spring frost is passed. Arbequina and Arbosana are quite cold hardy compared to Koroneiki, but can be severely injured, when young, if the temperatures get below about 24°F for significant lengths of time. The super high-density orchard training system requires a trellis system, or at least a stake by each tree, for central leader training. Most or the orchards use a single wire that helps support a low cost stake of some sort. The young trees should be tied to the stake about every foot and not be pruned in the first 2 years at all, except to maintain the central leader. At the end of the 2nd year, the lower 3 feet of branches and any suckers should be removed along with any excessively vigorous lateral branches that might interfere with the central leader.

The central Leader tied to a bamboo stake

Each orchard needs to be evaluated, but for most orchards, at the end of the 3rd year and first harvest, the trees need to have all the large (greater than ¾" diameter) lateral branches cut out. This removes some fruitwood but maintains good light penetration into the trees for subsequent years. The skirts also should be trimmed up with a sickle bar type cutter. Starting, most likely, in the summer of the 3rd year and 4th year for sure, the trees need to be topped at 9-10 feet tall. The topping prevents excessive shading of the lower branches and adjacent rows. It is done in the mid summer (July) so that very little re-growth occurs at the cuts.

Each year after that, the trees are pruned by hand to keep the lower 3 feet clean in order to get good harvester catch frame closure around the trunks. Large 3-year-old lateral branches are removed with 2-5 quick cuts per tree leaving all the fine fruit bearing shoots that grew from the two previous growing seasons emanating directly from the central leader trunk. Most of the fruit is produced on drooping wood that is only about 2-2.5 ft. long.

Paul Vossen pruning out a large lateral branch on a well shaped, seven year old, central leader Arbequina tree

Over-The-Row (Straddle) Harvest

Gregoire harvester on 7-year-old

One problem that never surfaced, but was predicted by many to limit the success of the super-high-density system, was the harvest method. Just about everybody was skeptical, but frankly most people are flabbergasted at the efficiency of the over-the-row modified grape harvester that has worked remarkably well. Two people can manage harvest, one operator driving the harvester and another transferring the fruit from the harvester in the field to the mill for processing. Straddle harvesters can harvest about two acres per hour and can reduce the cost of harvest by approximately 80%, plus eliminate labor availability problems. For super-high-density plantings using the over-the-row harvesters, the cost of harvest becomes only about 20% of the total cost of production. This most likely will be the key factor in the potential development of olive oil plantings in California.

The most common over-the-row mechanical harvester observed in Spain is the Gregoire brand (www.kvernelandgroup.com). It has beating bars that hit the trees from both sides simultaneously and knock the olives down onto a moving conveyor belt that transports them to holding bins, which are emptied periodically at the end of the rows. Tree damage from the Gregoire harvester was documented to be minimal on the three prominent varieties described above. Other brands of straddle harvesters include: Korvan (korvan@korvan.com), Agright (559-674-2421), Braud – New Holland, and Pellenc

Yields

The production aspect of super high-density orchard systems is still new and not completely worked out yet, but to date has been a great success, especially the first 7 years. Everyone is wondering what will happen as the trees get 20 years old. The main problems seem to be how to maintain the light exposure into the closely spaced trees to maintain production, because after the 4th year or in some cases the 3rd year the orchard canopy is completely filled.

The best super-high-density orchards are located on uplands with deep, well-drained soils. Those orchards are coming into bearing in the 2nd year with full production in the 4th year. In Spain, the average production measured from 45 orchards was: 1.9 tons/acre in the 3rd year, 2.5 tons/acre in the 4th year, 2.7 tons/acre in the 5th year, and 3.3 tons per acre in the 6th and 7th years after planting. In any average, there are orchards with better and worse results. Yields from orchards that are 5-8 years old are more variable and very dependant on light manipulation. Their yields ranged from 1.2 to 7.8 tons/acre. It is very likely that production levels of about 4 tons per acre can be maintained with this system, which is very acceptable, especially considering that there is little alternate bearing, the harvest cost is so low, and the return on investment is so much more rapid.

Key Points

There has been some consternation at destroying the beloved traditionally shaped olive tree that has existed for centuries and growing "industrial-looking" orchards that are harvested with a combine, but system efficiency, cost reduction, and rapid return on investment have won the day. The super-high-density system is not simple; it requires a great deal of skill, and more investment capital, but with the following main points correctly observed, it can be successful:

Three-year-old Arbosana trees

- ***The site:*** should be on well-drained soil that is not excessively steep in order to accommodate the mechanical harvester. Excessively fertile "bottom" ground that is very deep will likely not limit the vigor of the olives and could lead to poor fruiting and excessive shading.

- ***The varieties:*** Select the appropriate varieties (we know Arbequina, Arbosana, and Koroneiki work, but there may be others).

- ***Tree spacing:*** is determined by matching the variety with the inherent vigor of the ground along with climatic influences. If the soil is deep and fertile, the trees should be planted at a slightly wider spacing. Minimum spacing = 3 ft. x 12 ft. - Maximum spacing = 4 ft. x 14 ft.

- ***Push the young trees:*** start them off with plenty of moisture, adequate fertility, and good weed control so they grow rapidly and fill their allotted space within the first 3-4 years.

- ***Train the trees***: to an upright central leader form that keeps the lower 3 feet clean of all lateral branches for good closure of the mechanical harvester catch frame. Very little pruning is done in the first 3 years; the central leader is simply tied to a support as it grows vertically. No large lateral branches are ever allowed to grow. Trees are mechanically topped in the summer to maintain a maximum height for the straddle harvester.

- ***Fertility levels:*** especially nitrogen, are reduced after the 3rd year in order to create less vegetative vigor.

- ***Controlled deficit irrigation:*** management practices are followed after the 4th year to limit vigor, save water, and maximize oil quality.

- ***Monitor carefully for diseases:*** peacock spot should never be allowed to develop.

The Author

Paul Vossen was in Spain last year on sabbatical leave studying olive oil production, processing, and sensory evaluation. Attempting to live the life of a Spanish Extension Agent was quite an enriching experience for him and his family. There are 3.5 million acres of very productive orchards in the Andalucian region of southern Spain around Sevilla, Jaén, Granada, and Malaga; all within a 1.5 to 2 radius of where he lived in Córdoba. He took a masters level course in olive culture and oil processing; spent time evaluating and working in mills; evaluated many of this year's oils with official taste panels; and worked in a laboratory analyzing olive oil. He also had several opportunities to learn about pruning trees in traditional, high-density, and super-high-density plantings; scout the olive fruit fly to determine economic thresholds for damage; and document olive harvest with shakers and over-the-row harvesting machines.

California Olive Ranch – spring growth (May) from fall planted trees