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## Orchard Spacing for Oil Olives

By Paul Vossen & Alexandra Devarenne

One of the early decisions that faces the new olive grower is tree spacing. The decision will be influenced by a number of different factors: terrain, economics, soil quality, olive variety and so on. This article will look at the various options and some of the theory behind orchard spacing. Some of the choices the grower faces are purely personal (which varieties you chose to grow, for example) but others can be guided by the research and experience of others.

### Spacing options

Oil olives were traditionally spaced very far apart to compensate for the fact that they were dry-farmed. In such orchards it is not unusual to find trees on 30 x 30 ft. spacing or greater. Virtually all new plantings of olives are spaced more closely, anticipating more efficient management practices and hence, greater yields.

Modern high-density (HD) plantings space the trees closer together within the row than between rows, creating a hedgerow configuration. The distance between trees ranges from 8 ft. to 20 ft., and between rows from 16 ft. to 25 ft.; the average is about 10 ft. x 20 ft. This spacing has been in use in Europe for

about 30 years and is suited to all olive cultivars. It can be hand harvested, with or without mechanical assistance, or with a truck shaker. Hilly terrain is not an obstacle, although extreme slopes will require terracing or hand harvest.

The super-high-density (SHD) system is a fairly recent innovation, dating back to the early 1990's in Spain.



In this ten-year-old orchard planted on modern high-density spacing, the trees just touch within the row.

In SHD orchards, the trees are planted very close together, intensively managed, and mechanically harvested. The spacing is 4-5 ft. between trees and 12-13 ft. between rows. The trees are topped at about 9-10 ft. to accommodate an over-the-row mechanical harvester. This system is very attractive for its greatly reduced harvest costs and early return (orchards come into full production in 4 years instead of 8 to 10), but it does have limitations. Only three varieties have been proven in the SHD system so far, Arbequina, Arbosana and Koroneiki, and the terrain (*Spacing, cont. on p.2*)

## Frost or Freeze?

Record cold temperatures in January have severely impacted the citrus crop in the Southern San Joaquin and wreaked horticultural havoc in other parts of the state. Fortunately this time the cold snap came well after most olives were safely harvested. But that isn't always the case, and it is worth looking at the different degrees of damage that cold can inflict on olives.



The olives at the bottom left of this cluster escaped freezing; the others did not.

A frost does not necessarily mean a freeze. A light coating of frozen condensate (frost) on the outside of an olive will form at 32° F. The interior of an olive, however, contains various sugars and other compounds that freeze at a slightly lower temperature than water. So a frosted olive might not be frozen. Cutting into the fruit to look for ice crystals will give you a better indication than outside appearance. Once the olives thaw, damage will become obvious in a hurry; within hours, frozen fruit begins to turn brown and soften.

Freeze damage strikes (*cont. on p.4*)

### In this issue

Orchard Spacing	1
Frost or Freeze?	1
Nitrogen & Oil Quality	3
Calendar of Events	4

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(Spacing, cont. from p.1) must be fairly level to accommodate the over-the-row harvester.

### Horticultural considerations

Although HD and SHD spacing have some different requirements, many of the same principles will apply. Some of these theories are backed up with extensive research, others are more anecdotal and speculative in nature, but all are worth considering. Understanding these horticultural concepts will help you make an informed decision for your particular situation.

#### North-south row orientation is best

It provides a more even distribution of sunlight to both sides of the hedgerow. Orchards that have been planted east-west have had more problems with lower production and foliar diseases on the north sides of the hedgerow. Many examples in other tree crops like apples, pears, and citrus have documented benefits from a north-south orientation. Wider spacing may overcome some of the disadvantages of east-west orientation, but that lowers production efficiency per unit area.

#### Only about 80% of the orchard floor should be shaded in mid summer

This is based on the fact that there is more surface area exposed to direct sunlight if the tree canopies are not allowed to touch between rows. If



In super-high-density production, trees are mechanically topped to permit over-the-row harvester access.

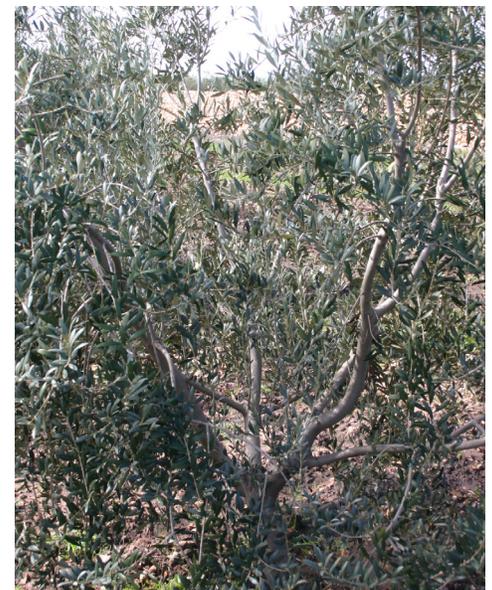
the trees are allowed to grow laterally enough to shade 100% of the orchard floor (when the sun is high in the sky) then only the upper portion of the canopy is exposed to light, which shades the lower canopy and significantly limits fruit production. A SHD row spacing of 12 ft., with the trees allowed to grow about 5 ft. laterally in each direction, would result in about 83% shade in the orchard. However, the 2 ft. space left between rows is too narrow to accommodate the harvester and other vehicles. The minimum amount of space needed for equipment is about 5-6 ft. and depends on the width of the equipment. The widest the tree rows should be allowed to grow in the SHD system is about 3.5 ft. in each direction or 7 ft.

In a HD orchard, the trees can be expected to be somewhat larger, but the same 80% rule applies. If a tree has a diameter of 15 ft., then its shadow at high noon covers about 176 ft<sup>2</sup>. An acre is 43,560 ft<sup>2</sup>, so 80% coverage would be 34,848 ft<sup>2</sup>. At 176 ft<sup>2</sup>/tree, that would be 198 trees to the acre. A nifty tree spacing chart on the University of Georgia website (<http://warnell.forestry.uga.edu/service/library/for96-054/index.html>) tells us that this is achieved with 20 ft. x 11 ft. spacing. If you are counting on keeping your trees smaller, say about 13 ft. in diameter, you could fit 263 to an acre (within your 80% coverage rule) on 9 ft. x 18 ft. spacing.

#### The closer the tree spacing, the greater the early production

This is true, within reason, and has been demonstrated in super-high-density olives and many other tree crops. Closely spaced trees fill the orchard surface area sooner with fruit bearing foliage. But SHD trees spaced too close together, less than about 3 feet within the row and 10 ft. between rows, can quickly start to shade each other out and become difficult to manage. Pruning costs go

up in these excessively close orchards, and those high early yields cannot be maintained. In HD spacing, the situation is similar; even though the early yields may be higher, the trees eventually get too tall and shade each other out. One option in a HD orchard is to plant a little tight with the intention of removing



Open center vase-pruning allows better light penetration in high-density orchards.

every other tree in the row eventually. There is a market for large olive trees, so it is possible to think of the extra trees as a crop in themselves, knowing that they will be removed when they start to shade out their neighbors. Plan so that the ultimate row spacing (cont. on p.3)

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## The Disadvantages of Excessive Nitrogen Fertilization

Several recent scientific papers written by a group of olive researchers in Spain (headed by Ricardo Fernández-Escobar) have clearly demonstrated the negative effects of over-fertilization with nitrogen. Nitrogen applied at high rates is expensive, wasteful, and does not significantly improve yield, shoot growth, oil content, or fruit size. They also showed that olive oil quality decreases significantly with nitrogen over-fertilization.

Part of their work compared the "conventional treatment" – annual fertilization at a rate very commonly used by farmers of 75 lbs. of actual nitrogen per acre (500 lbs/acre of 15-15-15) – with "diagnostic need" treatments, which applied nitrogen only when foliar tissue analysis indicated that the trees were deficient.

Over five years, one of the four trial orchards received no nitrogen, because the trees never showed any deficiency in the leaf tissue analysis. In the other three orchards, based on need, the trees received from 10-20% of what the conventionally treated orchard received. Overall the treatments based on need reduced fertilizer costs by 90%. The only other difference between the treatments was that the polyphenol levels in the oils were 1.5 times higher in the trees receiving less nitrogen fertilizer.

In another trial, similar results were observed in orchards given different rates of nitrogen. The total polyphenol content of the oils from trees given excess nitrogen were 20–40% lower, with corresponding decreases in bitterness and stability. The fatty acid profile and pigment content, however, of oils made from trees given large or small amounts of nitrogen were not significantly different.

—Paul Vossen

(Spacing, cont. from p.2) between trees at 15–20 years is about 18–24 ft. It is very difficult and more expensive to maintain trees in the HD system much below about 14–18 ft. in height.

Row Spacing (ft.)	Tree height (ft.-in.)	Row Spacing (ft.)	Tree Height (ft.-in.)
10	7' – 6"	16	12' – 0"
11	8' – 3"	17	12' – 0"
12	9' – 0"	18	13' – 6"
13	9' – 9"	20	15' – 0"
14	10' – 6"	22	16' – 0"
15	11' – 3"	24	18' – 0"

*The most productive fruiting area is within 3 ft. of the outer edge of the tree canopy*

We know that little fruit production occurs on interior branches, because insufficient sunlight penetrates beyond that to grow fruitful buds. This has been very well documented in many tree crops including olives. Hedgerows beyond about 6 ft. wide require another opening (such as that provided by open vase form pruning) in order to allow for sufficient light penetration. The open vase has become more or less standard in HD olive orchards, after some unsuccessful attempts at central leader pruning. In the SHD system, trees that are allowed to grow excessively wide (more than about 3 ft. growth in either direction) require secondary scaffold branch formation and are complicated to prune.

*The height of hedgerow trees should be  $\frac{3}{4}$  the row spacing*

Again, this "rule of thumb" has been documented in studies with other tree crops. As with any fruit crop, the most important aspect for good productivity is high light exposure throughout the entire canopy. In order to assure good light exposure into the lower foliage in a hedgerow system, the adjacent row cannot be so tall or so close as to create significant shading. Table 1 shows some selected row spacings and tree height in feet and inches. In SHD

production, the maximum height allowed by the harvester essentially dictates the row spacing. If the maximum height of the over-the-row mechanical harvester is 9 feet for example, that means that the rows should be spaced 12 ft. apart. In HD orchards, the height of the trees is usually dictated by management practicality; harvest is much easier if trees are kept lower. Most people like to keep their HD trees to a maximum height of about 14–16 ft., which dictates a row spacing of about 18½ to 21½ ft. apart. In places with fertile, deep soils and high rainfall, olive trees in this system can grow very vigorously and get quite tall. This requires heavy pruning to keep them shorter, which is expensive and can cause trees to bear poorly.

*SHD in-row spacing should be close enough that fruiting branches growing directly off the central leader just touch*

This is a theory unique to olives in the super-high-density system. It exists to simplify hand pruning, which is the most costly cultural practice once the harvest is mechanized. Olive trees send out new shoots at about a 45° angle directly from the central leader, if there is sufficient light there. 'Arbequina' and 'Koroneiki' shoots grow about 1 to 2 ft. long and droop from the weight of the fruit. In the 2<sup>nd</sup> year, at the terminals and shoulders of the drooping branches, secondary fruiting branches grow about



Shoots that will bear the following year's fruit grow from the "shoulder" of drooping branches in the SHD system.

6 inches to 1½ ft. long. They ultimately droop from the weight of that year's crop at a distance of about 2 ft. from the central leader. That distance x 2 is the ideal tree spacing within the (cont. on p.4)

## UPCOMING EDUCATIONAL EVENTS

- **Sensory Evaluation of Olive Oil—Mar. 30 & 31, 2007 at UC Davis**  
For info or to register: [www.extension.ucdavis.edu](http://www.extension.ucdavis.edu) or call 800-752-0881
- **Ecoliva (Organic Olive Conference)—Mar. 22–25, 2007**  
Puente de Génave (Jaén, Spain) For information: [www.ecoliva.info](http://www.ecoliva.info)
- **Italio-californian Olive Oil Conference—May 22–25, 2007 at UC Davis**  
For more information, contact Sharon Shoemaker ([spshoemaker@ucdavis.edu](mailto:spshoemaker@ucdavis.edu))

(Spacing, cont. from p. 3) tree row, because then the fruiting shoots are just touching and plenty of sunlight can still penetrate into the canopy. Maintaining the fruiting wood directly off of the central leader for two years eliminates the need for complicated pruning and branch structure formation. In the winter, old thick shoots should be removed near the central leader leaving a short stub to encourage new shoots to develop there. The shoots that have already fruited for two years have probably grown poorly anyway and offer little production potential for the 3<sup>rd</sup> year. The cultivar 'Arbosana' is less vigorous and should be planted closer relative to the other varieties.

HD in-row spacing should be from about 8 ft. up to the row spacing (usually 18–24 ft.)

Spacing using multiples such as 8 x 16 ft., 9 x 18 ft., 10 x 20 ft., 11 x 22 ft., etc, allows for the removal of alternate trees if crowding is a problem later on leaving a square planting pattern. Trees should just touch each other within the row, and be vase-pruned to open up the centers for light penetration.

### Conclusions

The ideal tree spacing for the super-high-density (SHD) system is 4 x 12 ft. The trees should be oriented north-south and allowed to reach a height of about 9 ft. The trees are trained up a stake into a mini central leader form and allowed to develop laterals freely for the first four years. The trunks below 28"– 32" are



SHD trees are pruned leaving stubs to encourage regrowth from the same point.

kept clean of water sprouts to prevent interference with the harvester catch frame. Pruning individual trees can be easily and inexpensively accomplished by cutting back the larger diameter, weak, third-year wood on the central leader to short stubs. The skirts can be trimmed each summer mechanically with a sickle bar mower to allow for good closure around the canopy by the harvester, and topped mechanically every two years also to keep the height within the limits of the harvester.

Modern high-density (HD) orchard spacing will depend somewhat on the anticipated vigor of the trees. In a location where vigorous growth is likely, it makes sense to allow more space between trees rather than continually fight to keep them small. 10 ft. between trees and 20 ft. between rows will permit trees to reach a size of about 14 ft in diameter, and up to 15 ft. tall. This is a common spacing in European HD orchards; it allows for an open center area of about 3 ft. across and good light exposure into the trees. The option of removing every other

(Freeze, continued from p.1) rather like a tornado, nailing some fruit in a cluster and sparing others. Slight differences in air flow and terrain can be significant when a few degrees will make a difference.

Olive fruit that has been frozen produces oil with a distinctive defective quality. It is described as unpleasantly sweet and reminiscent of vanilla custard or stewed prunes. A small percentage of frozen fruit will taint an entire batch of oil, so be on the lookout for such damage.

The trees themselves are broadly considered hardy to about 15° F, but this is extremely variable depending on how low the temperature and for how long, the variety of olive, and the age of the tree. The best thing to do if you suspect cold damage is nothing: wait until spring. The first symptom of frost damage is leaf drop, so give the trees time to put out new foliage. In extreme cases trees will resprout from roots, so don't rush to judgement. Bark cracks from cold damage may appear, but are significant primarily because they can provide an entry point for olive knot bacteria and may warrant preventative copper treatment.

tree down the pike means you could eventually let the trees get very large if you desired. In a spot where tree vigor is more easily controlled, 9 ft. x 18 ft. spacing gives you room for trees about 13 ft. in diameter and 13 ½ ft. high. Again, removing every other tree in the future would allow the trees to spread in both directions.



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