Training Systems

This is the integration of tree arrangement, planting density, support systems and training schemes. There is no one planting system to suit all situations. Factors such as soil, cultivar, rootstock, management regimes and socio-economic conditions will determine the optimal combination for each orchard. Tree density and light interception are the major factors affecting early production. Trees can be arranged as single rows, multiple rows or bed systems with occasional traffic lanes.

The primary objective of pear tree training is to direct tree growth and develop a strong tree framework that will support quality fruit production. Proper training of pear trees opens up the canopy to ensure maximum light interception and distribution, which is particularly important for the development of red pigmentation on blushed pears. In mature orchards, canopy shape can affect light distribution within the tree canopy. If the intercepted light is not evenly distributed throughout the tree canopy, shading can occur which can inhibit flower bud development, fruit set and fruit colour. Tree designs that maximise exposure within the canopy generally have greater efficiency of conversion of light energy to fruit than canopy designs that allow heavy internal shading. Planting area is expressed as a function of between row spacing and intra-row spacing. The choice of training system is highly dependent on intra-row spacing (i.e. planting density) and is most important at very high densities. Often there can be confusion about the definitions of training systems, particularly between those that appear to apply the same pruning concepts and methods.

Tree training systems for intensive pear production can be:

Systems derived from central leader – conical or pyramidal shaped trees

Figure 1: Central leader: Two year old trees of ANP-0131' on BP1 planted at 4.5m x 0.5m spacing at the DEPI Pear Field Lab, Tatura Victoria

Double leader systems – single trees with two leaders (simulating higher densities)

Figure 2: Double leader: Two year old trees of 'ANP-0131" on D6 planted at 4.5m x 1.0 m spacing at the DEPI Pear Field Lab, Tatura Victoria

Palmette systems – central leader trees with scaffolds in the plane of the row only

V or Y shaped systems - inclined canopies that improve light interception

Figure 3: Open Tatura Trellis: Two year old trees of 'ANP-0131" on D6 planted at an intra-row spacing of 1.0 m with two leaders per tree at the DEPI Pear Field Lab, Tatura Victoria.

Systems Derived from Central Leader

Pear trees are trained as central leader systems to develop a conical shaped tree which can be free standing or supported by a post or wire support system. This tree shape is one of the most efficient for light interception and crop production. There are various systems that use the central leader concept; these consist of tiers of scaffold branches along a straight central axis. The major differences between central leader derived systems include tree density, height, leader management and whether or not permanent scaffold branches are retained.

Spindle Bush

Spindle bush (or free spindle) are best suited to densities up to 2,000 trees/ha at 2 to 3m in height and 3 to 4m x 1 to 2m apart. In Europe, spindle systems are usually planted using well feathered two-year old nursery trees. At planting a number of laterals are selected to form part of the permanent scaffolds in the bottom third of the tree. Competing laterals that develop at the end of the unpruned central leader have to be removed in a very early stage. As the leader grows more scaffolds are selected and spaced equally. Leader dominance is important and if it is lost will result in a reduced tree canopy, whereas if it becomes too strong lateral growth and development will be reduced. These systems can be free standing, however mostly utilise some form of support (either 2 to 3 wire trellis or individual supports).

Modified leader systems are the same as central leader initially; however the leader is removed, tied down, or cut to horizontally growing shoots at the desired tree height. This is mainly to reduce shading and loss of production in the centre of the tree.

As tree densities get higher and row spacings get more restricted, variations on the spindle system such as the vertical axis, slender spindle and super spindle are favoured.

Figure 4: Spindle system: 'Conference' on Quince Adams planted at 4.5m x 1.25m (1,700 trees/ha)

Vertical Axis

A vertical central leader (axis) is developed with relatively 'weak' fruiting branches arising around the leader. Tree density is between 1,000 to 2,500 trees/ha at a spacing of 4 to 5m x 1 to 2m and height can reach up to 3m. Maintaining apical dominance is important in the vertical axis system particularly during early stages of development to ensure weak fruiting branches – therefore no

heading of the leader occurs. Branches are systematically renewed to prevent them from becoming permanent scaffolds. Support of 2 to 3 wire trellis is required. Similar to the spindle system, vertical axis systems are planted ideally using well feathered nursery trees.

Figure 5: Vertical single leader trees spaced at 0.5m (Blush cultivar 'ANP-0131' on D6) in DEPI Pear Field Trial.

Figure 6: An example of Vertical Axis: Conference on Quince C at 3.75m x 1.25m (2,100 trees/ha).

Slender Spindle

The slender spindle system involves more severe pruning than the vertical axis and is suited to densities of 2,000 to 5,000 trees/ha. Planting area is 3 to 3.5m x 1 to 1.5m and tree height is usually restricted to 2 to 3m. The slender spindle is a more conical shaped tree with a distinct, supported, vertical central leader branch. At the base of the tree there is a permanent frame of a varying number of branches, above which exist more or less horizontal fruiting branches shorter in length than the frame branches. Leader control is important. Strong leaders and lateral growth in the top of the trees should be avoided. Generally the leader is headed back to a weaker lateral when it becomes too dominant. Well feathered nursery trees are preferred.

Super Spindle

The super spindle system is utilised for super high-density orchards on weaker rootstocks such as Quince C. Tree height is generally maintained at 2 to 3m. Generally there is a row spacing of ≤3m and a tree distance within the row of less than 0.8m, giving a density of more than 4,000 trees/ha. There are systems in Europe that can reach 12,000 trees/ha when trained as super spindle.

This system has closely spaced compact trees with short fruiting wood or spurs evenly spaced along the central leader. Super spindles require a multi wire support system. The goal of this system is to achieve very high, early yields so that new varieties can be introduced as quickly as possible to meet market demands. An additional benefit is low fruit production cost per hour of labour.

Super spindle orchards usually use whips with a number of short feathers along the leader or even cheaper trees such as budded rootstocks (i.e. sleeping eye trees).

Figure 7: Super spindle: Conference on Quince C at 4m x 0.3m. This orchard is in its fourth leaf and produced 45 to 50 t/ha.

Double Leader Systems

Double leader systems aim to achieve high leader densities whilst keeping tree numbers (and cost) down. Trees are planted at 3 to 4m x 1 to 1.2m spacing giving a tree density of around 3,000 trees/ha. However, the development of double leaders mean that the leader density is 6,000 trees/ha.

Figure 8: Double leader: One year old blushed pear cultivar ANP-0131 on D6 spaced at 1 metre at the DEPI Pear Field Trial, Tatura, Victoria.

The Bibaum® system is a double leader system that was developed in Italy. This system involves planting Bibaum® nursery trees, which are pre-formed with 2 axes in the nursery. Trees are planted at 3.3m x 1 to 1.25m spacing in a single row giving 3,000 trees/ha, with a leader density of 6,000/ha. Leaders are trained parallel to the row and are spaced at about 50 to 60cm apart. Pruning time was reduced significantly for the Bibaum® system compared to both the spindle and candelabro.

Figure 9: Double Leader: Williams trained as Bibaum®.

Palmette

The palmette and its variations are generally limited to wide intra-row spacings (>2.0 to 2.5m) with a tall tree which makes it best suited to planting densities of 700 to 1,500 trees/ha. There are a number of kinds of palmette training all with a central leader with scaffolds in the plane of the row only. Tiers of scaffolds are chosen each season and tied to wires to reduce vigour and promote spurring. These systems have been popular because the bending of branches on trellises controls growth and provides a balance of fruiting and vegetative growth.

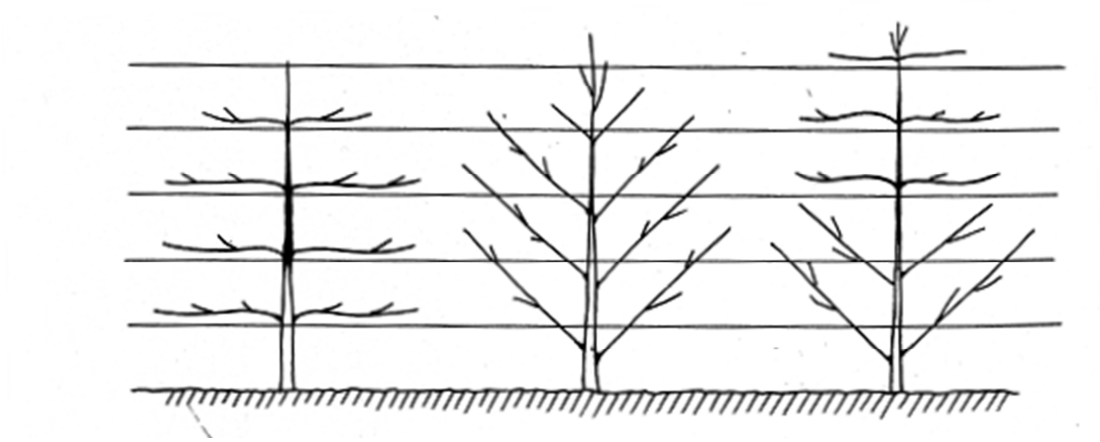

Figure 10: Three kinds of palmette training: (left) horizontal arms, (centre) oblique arms, and (right) a combination of the two (Westwood 1993).

Figure 11: Packham on D6 trained as a palmette in the Perth Hills, WA.

V or Y Shaped Systems

Generally there are 2 basic shapes of canopies – Y shaped trees which have a vertical trunk and two opposing arms of the tree trained to either side of the trellis, and V shaped trees where the whole tree is leaned to one side of the trellis while the next tree in the row is leaned to the other side. The two main V systems outlined here are the V hedge and Open Tatura Trellis.

Figure 12: Open Tatura trellis planting at DEPI Pear Field Lab, Tatura, Victoria.

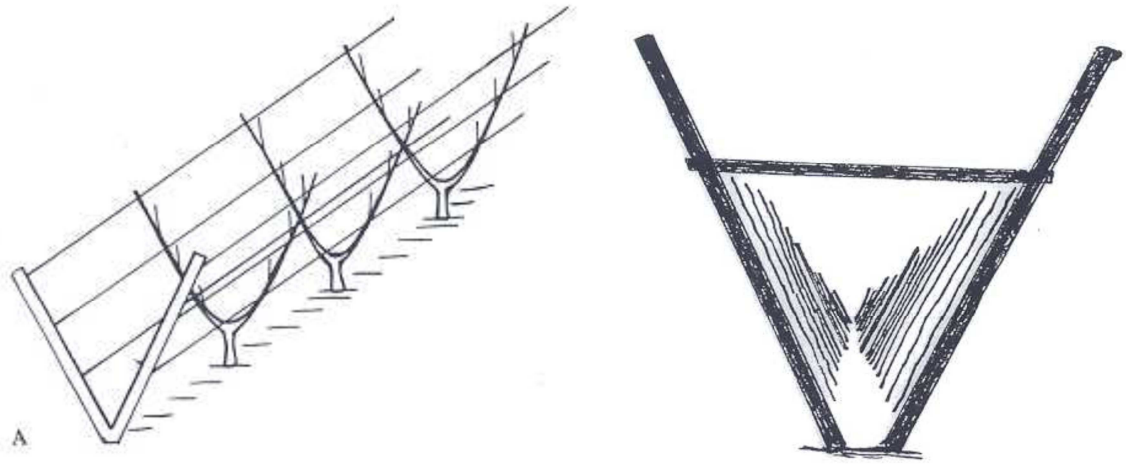

Figure 13: The two basic canopy shapes – The Y shaped canopy (left; from Westwood 1993) and the V shaped canopy (right; from Van Den Ende 1997).

V Hedge

The V hedge system is widely used in the Netherlands and Belgium and is a variation of a Y shaped system. The planting distance in the V Hedge is 3.5 x 1.25m which equals 2,057 trees/ha. These systems are planted using well feathered 2 year old nursery trees. Four feathers are kept as fruiting branches and considered as four central leaders on one stem. Tree height is maintained at 2m with an opening of the V of 1.4m . These systems can be planted more intensively, however light interception can be inhibited. There is no pruning at planting.

Figure 14: Young Conference orchard trained as V Hedge showing bamboo supports.

Figure 15: Detail of V hedge showing the four fruiting units.

Open Tatura Trellis (OTT)

The open Tatura Trellis system is a modification of the original Tatura Trellis (a Y shaped system), developed in the 1970's. In OTT there is a narrow strip of about ½ a meter that separates alternating diagonally planted trees within each row. OTT systems are planted 4 to 4.5m x 0.5 to1 m with 2.000 to 5,000 trees/ha. Trees can be trained in a number of different ways. Three of the most common are: single leader, double leaders (similar to a Bibaum® system) and, more recently, the cordon. Single leader OTT is similar to planting a slender spindle type system, with root systems about 0.5m apart and leaders 1m apart. Double leaders involve training two leaders on each tree (about 1m apart), to establish a high density of fruiting units at a lower tree cost. OTT with cordon allows for a moderately dense orchard of around 2,000 trees/ha with about 8,000 fruiting units growing up the wires. Nursery trees (usually whips) are bent over at planting and trained to the horizontal. Fruiting units are then encouraged at regular intervals along each cordon.

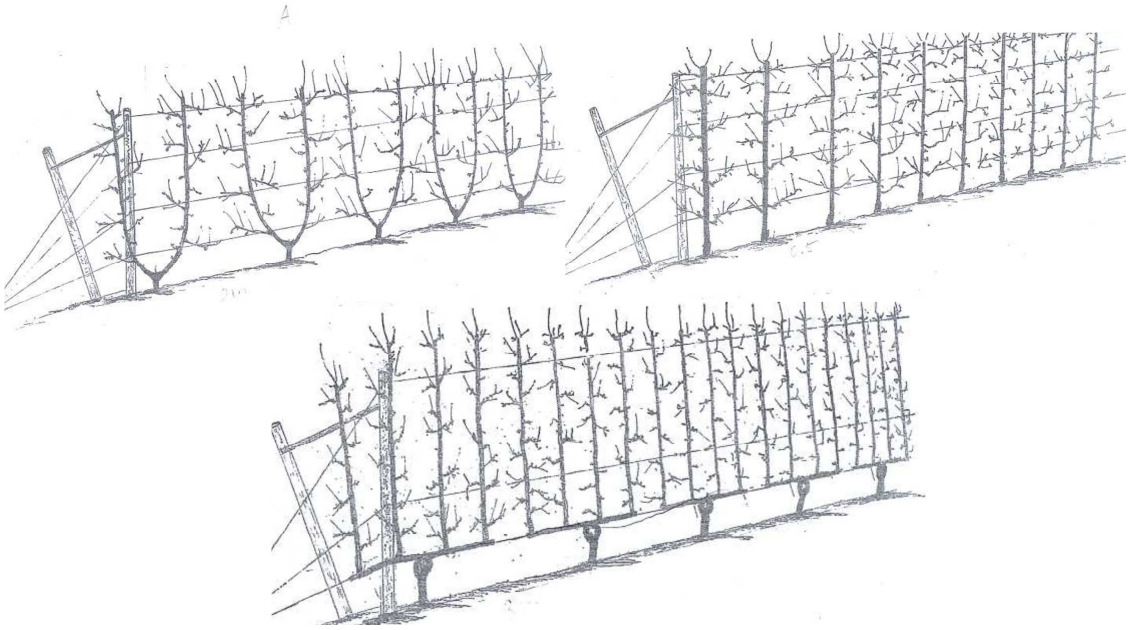

Figure 16: Training types for the Open Tatura Trellis system (only one side of the trellis is shown) – Double leader (top left), Single leader (top right) and Cordon (bottom).

Figure 17: Blush pear cultivar ANP-0131 on D6 trained on Open Tatura Trellis with 6 leaders at a spacing of 1.5 metres.

OTT allows early production and high yields at maturity which means early returns on investment. It also reduces pruning and harvesting costs as the tree structure is simple and can be reached from the ground. However, establishment costs are often much higher than single row systems due to both the trellis construction and the early training of the trees.

Further Information

The following sites may be useful for growers. However they are intended as a general information source only. Any specific chemical or other control recommendations may be outdated or irrelevant for Australian conditions and growers should seek local advice.

Australian Resources

A range of useful articles on training systems for Australian growers can be found in Tree Fruit magazine: http://www.treefruit.com.au/index.php

The Tatura Trellis – Construction: Victorian Department of Environment & Primary Industries: http://www.depi.vic.gov.au/agriculture-and-food/horticulture/fruit-and-nuts/orchard-management/the-tatura-trellis-construction

International Resources

USA: Penn State: http://extension.psu.edu/plants/gardening/fphg/pome/pruning/pruning-and-training-to-a-trellis

References (Note full access may incur a fee)

Deckers, T. and Schoofs, H. (2001) Management of High Density Orchards. The Compact Fruit Tree 34(4): 117–120.

Elkins, R., Klonsky, K. and DeMoura, R. (2006) Comparison of Costs and Returns to Establish and Produce Specialty Pears on High Density Plantings with Sleeping Eye Trees and Standard Trees with Standard Planting - Lake and Mendocino Counties – 2006.

Van Den Ende, B. (2013) Tatura Trellis – from the beginning: http://www.treefruit.com.au/index.php/2012-02-11-05-40-34/tree-training-trellis

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