Free Standing Semi-Intensive and Fully Supported Intensive Apple Production Systems

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Introduction

In the current apple production business environment there is a greater tendency for more rapid turnover of varieties, more urgency to faster adopt new and more profitable cultivars and production systems. This task is easier with properly planned, designed and managed intensive orchard plantings.

If we have taken the right steps in site selection and site preparation then we have to consider an appropriate growing system which will deliver early and high fruit production and quality.

Orchard Design and Development Considerations

1. Main aims

Fruit productivity

- Very early yields have a marked impact on orchard economics.
- Maximum and regular crop at the full production phase.

Fruit quality parameters

- Size distribution
- Colour and skin finish
- Condition - keeping quality

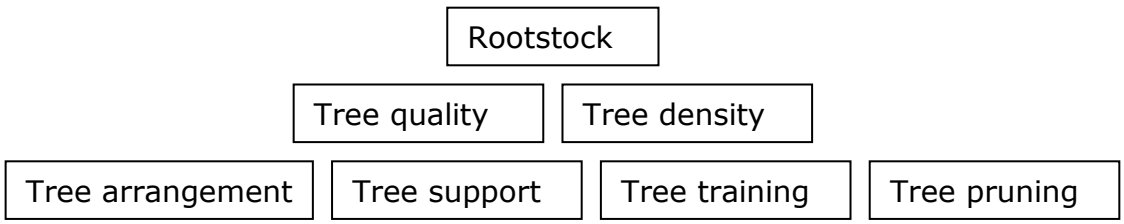
2. Planning - planting and development

Following a major decision on the choice of variety there are two separate stages in this process

- **Preplant and establishment phase:** choice of rootstock, tree quality, tree density, tree arrangement, tree support.
- **Development and management phase:** tree training and pruning.

The preplant decisions have, by far, the greater impact on orchard economic performance than post-plant tree management.

The two main phases of orchard design and development are superimposed over a foundation of critical, interdependent, carefully linked orchard building components.



There are a number of choices for each of the principal building blocks listed here. They must be properly put together - integrated to deliver a successful outcome. These are some of the examples of incorrect options:

- Full spur Red Delicious/Mark planted at 5 x 3m (666/ha) on a very weak site (shallow topsoil, replant) without trellis.
- Standard Golden Delicious/M793 planted at 3.5m x 1m (2857/ha) in a very strong growing location (virgin deep alluvial soil) with post and wire support.

Both plantings will produce poor results, Spur Red Delicious due to a weak root anchorage and very low canopy development - inadequate light interception and Golden Delicious through extreme vigour and overcrowding - unsatisfactory light distribution.

These points lead us to some key principles of orchard design which will touch on all the main building components in a new planting.

3. Principles of Orchard Design

Sunlight is the energy source which produces dry matter for tree development and fruit production. Dry matter manufacture by the tree is related to total light interception. For this reason

The first objective in orchard design is to achieve high light interception.

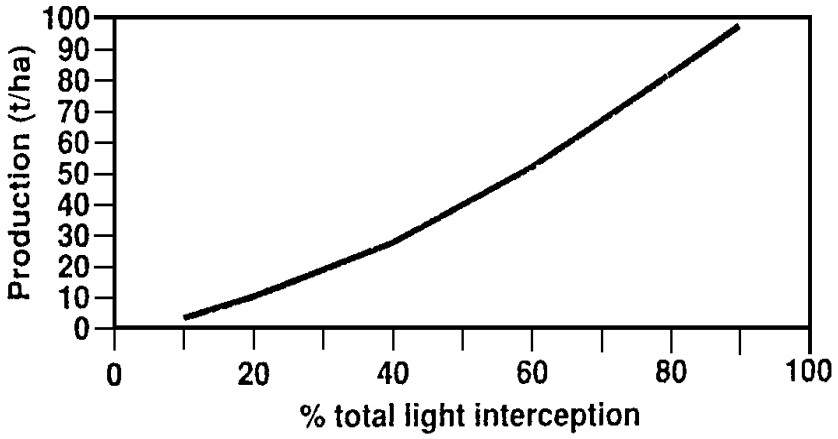
This is clearly illustrated in Figure 1, where fruit production (t/ha) in apples is heavily influenced by the extent (%) of light interception by orchard canopy.

Tree spacing, in particular, tree height/alley width ratio and to an extent tree shape and height determine light interception.

In general, high tree densities greatly influence maximum early yield. This is better than attempting to grow widely spaced trees rapidly to fill the space.

If top quality, large, well-feathered trees are planted at close spacing then the orchard canopy will reach maximum light interception in 3-5 years. **We can choose to plant or grow the canopy**.

Figure 1: Schematic representation of the influence of light interception on apple production for studies conducted at many world locations (after Lakso and Robinson, 1997)



At closer spacings we must use dwarfing stocks. Weaker rootstocks give us more control over tree size in restricted orchard space.

The second objective of orchard design is to uniformly distribute sunlight to all fruiting sites.

Fruit colour, size, soluble solids and return bloom all depend on sufficient localised light exposure.

During the early part of orchard life we are preoccupied with maximum light interception, but as the orchard matures the focus should be on good light distribution within the canopy.

A portion of the available light must hit the orchard floor to provide good levels of light exposure to the lower sections of the canopy.

So the optimum fruit tree canopy design is based on tree forms and pruning systems that combine fast canopy development and high light interception with good light distribution.

4. Light interception in orchard systems

- The usual maximum levels reported are around 60-70% over the orchard lifetime.
- More typical interception for most orchards is 40-65% depending on tree height and alleyway width. Dwarf plantings often achieve low figures at maturity.
- Relatively low light interception in orchards is largely due to the discontinuity of orchard canopy and not because the tree canopies are too open. Tractor alleyways can waste a lot of light.

- **Effect of tree height**

  Increased tree height always increases light interception, particularly at greater canopy discontinuity.

  Tree size and tree arrangement assume less importance within a more continuous orchard canopy.

  Independent of between-row spacing effect on shading, trees taller than 3m will have less than optimum light distribution in the lower sections of the canopy due to self-shading.

  Interception is proportional to area of ground covered by the tree and the hedge height in relation to clear alleyways.

  There are several methods of calculating optimum tree height for optimum light interception:

  - ✖ US formula:
    Tree height = clear alleyway x 2
  - ✖ German formula:
    Tree height = Row spacing ÷2 + 1m
  - ✖ New York formula:
    Tree height = Row spacing x 0.75

- **Effect of tree width**

  Interception is more dependent on the horizontal than vertical elements of tree size.

  Decreasing tractor alleyway is a better approach to improve interception than to increase tree height.

  The trials conducted by the Queensland Department of Primary Industries (QDPI) at Stanthorpe determined that increasing tree height from 2.8 to 4.3m improved light interception only be 6-10%. On the other hand, if alley width was reduced from 6 to 4m light interception was raised by 14-21%.

  Many dwarf plantings have low light interception due to wide tractor alleys.

  It is better to adopt the minimum between-row spacings and use narrow equipment than to plant too far apart to accommodate big tractors.

- **Row orientation -** varies with time of day, and year, latitude and orchard geometry.

  According to the QDPI, Stanthorpe study, north-south row direction is more desirable than east-west rows. Although E-W rows intercept more light in late summer/early autumn, they show more problems in tall trees, narrow alleyways and dense leaf canopies.

- **Canopy density**

  Increase in tree density has a more direct positive effect on light interception than the increase in leaf density.

  The best option is to have many trees per hectare each with relatively open canopies. This will optimise both light interception and distribution.

5. Tree form and light distribution

Apple trees are very amenable to modifications by training and pruning. There is an array of tree forms, planting arrangements, tree heights, widths and geometric shapes. Their application is dependent on orchard production efficiency and light distribution.

There are five basic tree shapes:

- ✖ Cone
- ✖ Cube
- ✖ Rectangular tree wall
- ✖ V or Y planar canopies
- ✖ T or flat top canopy

- **"The major limiting factor in fruit production is the shade the tree casts on itself".**

  Light penetrates about 1m into canopies, so thick canopies have inadequate light distribution.

  The best yield and quality come from many thin canopies.

- The light distribution can be improved by two approaches, first by creating many small openings in the foliage - loose textured canopies in natural tree forms, and second by providing fewer large, permanent openings in restricted geometric shapes (Y & V hedgerows).

  The first method demands high levels of skills, while the second requires high cost for expensive supports and labour.

- **Round crown trees**

  In these trees a large proportion (low and central sections) of tree canopy are under-illuminated.

  30% of full sunlight is below the lower limit of desired light level in apple canopies.

  In thick canopies levels drop to the 30% within 1m of outer edge.

  With the decrease in tree size there is a decrease in the heavily shaded area of the canopy. Per tree leaf area decreases but per hectare leaf area and yield increases.

- **The pyramid shaped tree**

  Cone shaped trees are better suited to good light distribution than rectangular trees with identical height and basal width. Some limb removal and repositioning in mature trees will easily maintain open tree crowns.

- **Thin restricted plan canopies**

  This group includes thin narrow hedgerows, tree walls, Ebro, A, V and T trellises.

  V and Y concepts have produced good results with apples. The same applies to thin vertical canopies which receive good light exposure on both sides of the wall.

  With angled canopies like Tatura and some 'V' Axe variations limbs are usually concentrated in a thin plane. Heavy shading can occur even within a 0.5m wall particularly on the underside of the V profile. Careful limb thinning and the provision of a good gap above the tractor alleyway can minimise shading.

6. Pruning

In intensive orchards we rely on minimal pruning and limb positioning to induce fruiting. This is practised during the early phase of orchard development.

The tree scaffold framework is weak and is fully supported by trellis.

Heavy pruning during the early years of tree development will produce excessive vegetative growth and delay cropping (Table 1).

Table 1

Effect of pruning severity on flowering and fruiting on limb sections of 'Delicious' apple (from Barden et al., 1989)

Pruning severity#	Number spurs flowering	Total number flower clusters	Total fruit number
0	30.4	54.2	21.2
1	23.1	38.6	14.1
2	14.9	33.4	11.2
3	3.7	14.4	3.1

0 = unpruned, 1 = cut to midpoint of past season terminal growth, 2 = cut 5mm below origin of past season terminal growth, 3 = cut to midpoint of 2-year-old section of terminal growth.

Data are means for summer and dormant pruning across five rootstocks.

7. Rootstocks

To achieve productive hedgerows we have to match rootstock with variety, spacing training system and growing conditions.

High tree densities, low height systems and more vigorous varieties need more dwarfing rootstock types - M9, Bud 9, M26, G16, CG202.

Some medium size stocks (M7, MM106, MM111) can be applicable for taller systems, weak locations and low vigour varieties. Their management in intensive plantings is possible but very challenging.

8. Nursery Tree Quality

As stated earlier, high quality planting material is a key pre-requisite for successful intensive and semi-intensive orchards. Most of the following quality parameters can be best achieved by raising benchgrafted two year old nursery trees.

- True to variety and selection
- Free of known viruses
- Minimum tree height of 1.6m above the graft union
- Minimum trunk diameter of 1.4cm at 10cm above the graft union
- The graft union must be positioned at 15-20cm above ground
- Minimum length of main roots should be 25cm
- Minimum of six to eight feathers evenly distributed around the tree stem starting at 80cm above the graft union.

Summary

In modern orchard designs the right combination of the key building blocks - rootstocks, tree density, tree arrangement, tree support, tree quality, training and pruning, can produce early and high production and fruit quality.

To achieve these goals we need to:

- Use high quality nursery trees
- Plant high tree densities
- Use efficient dwarfing stocks
- Adopt a modern tree system based on minimal pruning
- Achieve the maximum 60-70% light interception by year 3-4.

These objectives can be achieved by a number of growing systems.

Intensive System

Tall Spindle

Single row "Tall Spindle" tree training system on M9 rootstock has been very successfully implemented by Italian fruit growers in South Tyrol.

One of the over-riding factors behind excellent orchard results are very high quality nursery trees. Italians only accept two year old benchgrafted "knip" (cut) tree for new plantings – "Tall Spindle". The trees are 1.8m high and have ten to fifteen feathers spread along the leader starting at 80cm above ground.

All feathers are tied down below horizontal during the first season after planting to stimulate fruit bud development and minimise extension growth. During the first three years minimal pruning makes the tree very fruitful, only large branches are removed.

In this type of hedgerow the tree height has been raised to 3.3m with very good results. One metre increase in tree height from two to three metres can raise fruit production by 25-30%.

The top of the hedgerow has sawtooth profile allowing good light distribution. Regular limb thinning along the centre leader also maintains well illuminated tree canopy.

The "Tall Spindle" planted at 3 x 0.9m (3700 trees/ha) can produce 17t in year two, 37t in year 3 and 56t in year 4 and thereafter.

Semi-intensive plantings on medium vigour rootstocks

Fruitful varieties like Gala, Golden Delicious and Spur Red Delicious can be quite effectively managed in medium density orchards with 800-1600 trees/ha.

Some very successful plantings on medium size stocks MM106 and MM111 supported by a simple post and wire trellis have been establish in New Zealand and Australia.

If we choose to plant self-supporting medium density systems then we are going to create some management challenges. In intensive hedgerows the trellis carry most of the crop weight, while in free standing trees we must develop a strong tree frame to take place of the trellis. It is a matter of orchard economics to establish if it is justified to save on the trellis cost.

Free standing trees require stronger stocks for good root anchorage and some degree of tree heading to develop a rigid tree structure. This approach to orchard development will result in delayed fruiting.

Vertical Axis – "French Axe"

This tree type can be adopted over a range of tree densities (800-2500 trees/ha) and hedgerow heights (3-5m) depending on stock vigour and type of tree trellis.

The tree has a dominant single centre leader and many weaker fruiting branches starting at 0.7-1m above the ground. The canopy is permitted to assume a natural tree form, usually a pyramid. Initially minimal pruning is practised and then followed by regular fruiting limb replacement to maintain an open tree canopy. Low, crowing and side branches competing with the centre leader are removed.

There are a few V. Axis variations. The most common types are a natural, more columnar tree shape and a classical pyramid form with a wider base established with more permanent limbs at around one metre above the ground. The latter form is a combination of a 'formal' centre leader set of permanent limbs at the base and V. Axis on top. Centre leader is headed at planting to form a permanent set of branches.

Vertical Axis is a fairly simple tree training method which can deliver impressive yields on medium stocks and low to medium vigour locations.

Solaxe

Another centre leader tree from France developed by J Lespinasse at INRA, Bordeaux. The training method is popular in France and Chile. The Chilean apple growers prefer a 'columnar' shape Solaxe to a more pyramid V. Axis tree because it allows more free space between rows for orchard machinery. Also there are advantages in limb training for vigour control and light distribution.

The tree has a dominant centre leader and fifteen to twenty renewable fruiting limbs evenly distributed along the 4-5m tall leader starting at 1.2-1.5m above ground. The limbs are bent down with a wire to 120 degrees from vertical to control vigour and induce fruiting. The fruit load keeps the branches in place.

The fruiting limbs are pruned in detail. All the shoots on top and underside the limb are pruned off leaving horizontal fan shaped ("fingers") fruiting structures. Shoots and leaves 40-60cm around the centre leader are removed to create a "light tunnel" down the centre of the tree canopy to assist with light distribution.

In Chile's Central Valley, Gala/MM106 planted at 4.5x2.5m and trained on Solaxe averaged 50-60t/ha and in experimental plantings fruit production reached 90t/ha.

If we decide to plant a free standing semi-intensive orchard on medium vigour rootstocks, we should consider weaker soils, productive stocks with good anchorage, minimal pruning and some limb positioning during the establishment phase.

Further vigour control measures can be put in place, ie trunk girdling, root pruning, ethephon sprays and some emerging growth regulators.

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