Orchard Density and Canopy Design in 2015 and Beyond

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These notes are intended to support the power point presentation that contains photos and figures that demonstrate the text. The presentation uses Cripps Pink and red strains as the case study scion variety however these notes apply to all varieties.

One thing that you notice when you travel the world and observe various apple canopies is the amazing range of systems that growers are using. It is my firm belief that there are a range of ways an orchard canopy can be designed, that can all be financially successful. This flexibility makes the world of apple growing exciting. We are not clones of each other, we have the ability to use our own initiative, to design a canopy that is specific to the environment we grow under, and the markets we serve.

Each region within a country and each individual country has its own unique mix of macro and micro factors that all have an influence on what is likely to be the optimum density, rootstock and canopy design. Such things as; microclimate, soil, labour availability, labour cost and market preference.

In Washington State USA, the market requires large highly coloured fruit, in South Africa there are good markets for small fruit, Australia has very high summer temperatures, New Zealand is export orientated and has a high cost of labour, Europe is highly mechanised. These are examples of the factors around the world that will all have an impact on what is the optimum density and canopy for your region.

Fundamentals

However although there is a range of canopy options, the fundamentals of an effective apple canopy are no different anywhere in the world.

To be capable of producing high-volumes of high-quality fruit, we need to have a rootstock and density that provides a low vigour, calm tree at maturity, with good precocity and high yield efficiency. The canopy system must be able to fill its allotted space within 5 years. We need a rootstock/density/tree form combination that intercepts a minimum of 65% of total available light. A canopy that also has light distribution throughout the entire canopy, that is capable of colouring fruit to market specification even in the lower canopy. And finally the density/canopy option must make good economic sense i.e. achieve internal rates of return of the greater than 15%.

Rootstocks

To achieve a canopy that is low vigour and calm at maturity requires the use of low vigour, precocious and efficient rootstocks. The market place is looking for quality Pink Lady® apples. These are apples that have good colour, good pressure and great taste. To achieve these attributes, the apples cannot be grown in a shady environment, it cannot be grown in an environment where active shoot growth is competing strongly with the fruit for carbohydrates.

Labour costs are forever increasing wherever fruit is grown in the world. Modern canopies need to factor in the labour dynamic ensuring that the canopy and fruit can be managed as efficiently as possible It is for these reasons that the world has shifted towards dwarfing rootstocks.

Each country has a variety of root stocks available, each combining characteristics of vigour control and pest and disease tolerance/resistance. In New Zealand and Australia the rootstocks of choice at the moment are virus free M9 (and clones) and CG202. Due to the limited available of these stocks in Australia there is also still widespread use of M26.

There is still a high proportion of the Australia/NZ Cripps Pink industry that is planted on the semi-intensive rootstock, MM106. This rootstock requires aggressive vigour control on most sites to enable high-quality Pink Lady® production. It is almost as though the grower needs to get the more vigorous rootstocks to perform as though they were a dwarf, to be successful.

Early Canopy Design

The 1990 typical planting in Australasia was Cripps Pink on MM106, planted at 4.5 x 2.5 m. To achieve 65% light interception this canopy needs to be 4.5 m tall and 3.0 m wide. The tree contains a lot of secondary structural wood and has a high percentage of the canopy volume receiving insufficient light levels to colour fruit to Pink Lady® standard. On most sites, particularly in New Zealand, the grower is forever battling high vigour with the MM106 root stock. Typically Pink Lady® packouts off blocks such as this are often as low as 50 - 60% and the costs of labour and other inputs are very high.

2015 Density/Canopy Options

As mentioned earlier in this paper, is my firm belief that provided the fundamentals of the apple canopy are adhered to, there are numerous canopy/rootstock/density options. I will now discuss the ones that I have personally witnessed that are currently in existence and are working well. I will also describe the very latest in scientific developments that are still in the experimental stage but offer some really interesting and exciting developments.

The 7 options I will discuss are summarised in Table 1 below. The two experimental canopies are shown in orange at the bottom of the table.

Table 1: Some Density/Canopy Options for 2015

System	Rootstock	Density Range	Typical Row Space (m)	Typical tree Space (m)	Stems per ha
Upright single leader spindle (now the NZ/ Aust Std)	M9, CG202, M26	1500-3000	3.5-3.8	0.8-1.7	1500-3000
Upright twin stem spindle	M9,CG202, MM116	1250-2500	3.5-3.8	1.5-2.5	2500-5000
Doregoni upright multi leader	M9	1850-2500	2.7	1.5-2.0 (2-4 stems/ tree)	7400
2 Dimensional V with vertical branches	M9	3136	4.2	0.75	9408
2 Dimensional V with horizontal branches (Auvil)	M9	2778	4.0	0.9	2778
Doregoni pedestrian	M9	2666	2.25	1.5 (3 stems/ tree)	8000
Plant and Food "Super Orchard" (Tustin et al)	M9	1667-2222	1.5-2.0	3.0 (10 stems/ tree)	16670-22220

Upright Single Leader Spindle

The upright single leader spindle has been the preferred canopy option throughout the world over the past five years. It is planted on a dwarf rootstock typically at approximately 1500 to 3000 trees per hectare. Good fencing support is required with the recommendation being posts less than 10 m apart and wires every 50 to 60 cm. Tree height is grown to 1 to 1.2 times the row width. This tree height maximises light interception without jeopardising too much fruit colour in the bottom of the canopy. However this is dependent on keeping the upper canopy open.

Branch bending or training is required in the first few years of canopy development. Pruning practices aim for minimal to no branch shortening with the mature tree containing 7 to 9 fruiting branches per running metre of trunk.

This system as shown in the presentation photographs ends up a canopy full of calm fruiting branches. This canopy type in my opinion works well with the natural growth habit of the tree and is therefore relatively easy to maintain. Records have shown this system is able to achieve very good yields of high Pink Lady® recovery. In both Australia and New Zealand there is now an expectation that 80 to 100 tonnes per ha is sustainable and in New Zealand we even have some blocks of Lady in Red they have recently achieved 140 tonnes per ha of high quality fruit. These production levels are all with good Pink Lady recoveries of anywhere between 80 and 90%.

Upright Twin Stem Spindle

There has recently been a move around the world towards upright twin stem spindle trees. The purpose of the twin stem is two-fold. The twin stem effectively halves the tree cost of the block and it also induces a lower vigour than if you planted the same density of single stem trees.

The disadvantage of the twin stem is that it requires even better tree support than the single leader spindle as there's no natural downward strength in each leader. It also requires the nursery to produce a different style of tree as the worst thing that you could do with a new planting is to cut a beautiful feathered tree off at 50 cm above ground to grow up 2 new leaders. The twin stem spindle system also has a real place in re-working scenarios where the old tree spacing is too far apart.

Dorigoni upright multi leader fruit wall

I have recently had the privilege of working with Dr Alberto Dorigoni from the Instituto Agrario Di San Michelle in Italy. Dr Dorigoni advocates a system using multi leader trees in a single row system. He is a real advocate of an upright system over V system as he is adamant that he wants to be able to manage the trees from both sides. Management in 2015 includes mechanical trimming, mechanical thinning, and over row spraying. He also wants the system he plants today capable of being mechanically harvested, should that technology become commercially available in the future.

The multi leaders (3-6 per tree) are used, not so much to reduce tree cost, but more to induce a lower vigour status of each stem. The other fundamental of the Dorigoni system is that he has moved the row spacings in to 2.7 m apart. This means that to achieve 65% light interception the canopy only needs to be 2.7 m tall. At this narrow row spacing you might consider that vigour into the inter-row space would be a problem however Dr Dorigoni and his collegues have refined the use of summer mechanical trimming to be able to maintain the canopy within this spacing and keep it low vigour.

The final result as shown in the photographs in the accompanying presentation is very impressive. Good yields of very high-quality fruit are being achieved. As with the twin stem, this multi-leader canopy requires very good tree support. It undoubtedly requires the nursery to produce a different style of tree and it probably requires the investment in specifically designed apple tree trimming equipment. The real advantage that I can see with the system is its ability to intercept the required levels of light for high yield and still have a maximum canopy height of only 2.7 m. For countries with high labour costs and for regions where it is hard to encourage staff to climb ladders this is a real advantage.

2 dimensional V with vertical branches

I would now like to discuss two V systems that I have witnessed that are producing exceptional results. The first system is planted at 4.2 x 0.75 m ~ 3136 trees per ha. It is planted on an open V with every second tree planted 30 cm offset from the centre of the row. Each tree has 3 uprights trained up one side of the V and they alternate each side of the V as you go down the row. In the example that I show in the presentation the grower has used three leaders per tree each being 50 cm apart. The canopy is kept as narrow as possible aiming for a loose 2D type system.

V systems are renowned for being able to intercept high levels of light in excess of 65%. To achieve these very high light interception levels, the trees do not need to be as tall as a single upright system. These systems in my opinion are probably the best canopy forms for capturing light.

The challenges that the grower faces with the V system is a bigger setup cost and difficulty managing both sides of the canopy. However in saying that, there are many growers around the world who have mastered V systems and their results speak for themselves.

2D V with horizontal branches.

One of the best worldwide examples of this type of canopy is the Auvil Fruit Company in Washington State, USA. Here the trees are planted at approximately 4 m x 0.9 m or 2778 trees per ha. Instead of multiple upright leaders per tree as in the previous example, this system has one leader per tree, with the fruiting branches been trained down onto horizontal wires.

Through many years of experimentation, the Auvil Fruit Company have come up with tree heights and wire spacings that can produce amazing crops of very high quality fruit. The market they are targeting is largely the domestic USA market that pays a premium for larger fruit sizes of high coloured fruit. To achieve this fruit quality a rigid management plan is put into place that includes considerable tree detail including hand thinning flower clusters down to one flower per cluster.

The V system that they use, allows the canopy to be segmented and managed very precisely. The combination of market demand and the need for precise canopy management really makes the V system with horizontal branches ideal for this objective.

To manage the tree on this system requires a lot of horticultural expertise and application. Tree manipulation in the establishment phase is extremely precise. The vigour control of the horizontal branch units also requires excellent horticultural application. When this is able to be achieved, the resulting fruit is simply stunning.

Experimental Canopies

Two experimental canopies that we are aware of look very exciting. One is being developed by Dr. Dorigoni in Italy and one is being developed by the Plant and Food physiology team in New Zealand led by Dr. Stuart Tustin.

Dr Dorigoni is aiming to create a true pedestrian canopy that is capable of current yield potential i.e. 80 to 100 tonnes per ha.

The Plant and Food team are planning canopies that will test the boundaries of light interception. Is it possible to develop a canopy that can intercept 90% of available light rather than the current industry accepted 65%?If it is possible to harness more light, it makes logical sense that marketable yields can be taken to a new plateau. The goal is 170 tonnes per ha of good quality fruit. To avoid stealing these fantastic scientists thunder, you'll need to be present at the presentation where these leading scientists' current thinking and experimental canopies will be presented.

Summary

The ultimate canopy design, rootstock and plant density is a subject where there is no right or wrong. The options are endless. They always have been and they always will. Each option allows the individual grower to express his/her individuality, which makes the job of fruit growing interesting the world over.

It is my opinion that provided the fundamentals are adhered to, you will be able to grow good volumes of high quality fruit. In summary my fundamentals are:

- Use dwarfing rootstocks
- Grow a canopy full of calm low vigour fruiting units
- Canopies should be narrow not deep
- Canopies that minimise the need for structural wood are ideal
- Canopies must be able to intercept a minimum of 65% of light, preferably more
- Choose one that suits your environment and gives your business the best economic return
- Choose the one that you can make work
- The one that will get you out of bed every day with a spring in your step.