Designing labour efficient canopies

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June 2016 AgFirst NZ

These notes are intended to support the power point presentation that contains photos and figures that demonstrate the text.

Last winter we discussed several canopy options particularly in regard to their productive performance. This year we really want to focus on the labour costs of growing pomefruit and encourage forward thinking into how we need to change, to ensure the industry is globally efficient with labour input.

Australia, according to Wikipedia, has one of the highest labour costs per hour in the world. To compete on the global stage, Australian orchardists will need to be very efficient users of labour.

What do we mean by labour efficiency. In my mind the grower of the future must:

1. Ensure a reliable trained labour supply
2. Be able to carry out the on orchard labour functions cost effectively

Acheiving these two goals is easier said than done, each goal requiring a matrix of management inputs to acheive. One of the key requirements of a labour efficient orchard into the future is the "design of the orchard canopy". This is the subject of this presentation.

A labour efficient canopy has been described in the past by my colleque Craig Hornblow as a SNAP canopy.

S imple

Simple canopies attract workers, the work is less demanding, the skills are more easily trained and each staff member knows they can be more productive

N arrow

All parts of the canopy need to be less than the reach of an arm (40cm). This allows all sorts of mechanisation including mechanical trimming and thinning, platforms, robots, cameras, overrow sprayers etc and produces high quality consistent fruit.

A ccessible

Accessible to the human arm without any wasted movement. Also allows excellect canopy texture for consistent light distribution maximising fruit quality

P roductive

To keep the costs of labour down per kg, the canopy must be capable of high volumes of Class 1 fruit.

Fundamentals

To be able to design a canopy that fits your needs, you first need to understand the fundamentals that a canopy must be able to achieve.

Light interception drives yield

Sunlight energy is the key driving force of photosyntheses and therefore productivity. Many research studies have shown a direct relationship between the amount of intercepted light and gross yield.

Australia as a country has very high levels of sunlight energy however one of the reasons for poor productivity in the past was that the canopies were just not intercepting enough of that light.

Dr Simon Middleton found that the highest performing canopies in Australia were intercepting 65% of total incoming radiation, the other 35% hitting the unproductive orchard floor. Current industry thinking is that any new canopy design should have a minimum target of 70% light interception. For a standard slender spindle canopy this is achieved when tree height equals row width and the canopy is consistent.

Light distribution impacts quality

To grow good quality fruit, research has shown us that each apple or pear needs to receive a minimum of 20-30% of the total incoming light. If fruit is grown in locations where light levels are lower than this, quality parameters will crop off including; fruit colour, size, pressure, brix, dry matter, taste and spur bud development for the following year.

Large deep trees have a higher proportion of their canopy with < 30% light, hence one of the reasons for the move with modern canopies to smaller narrow dwarfing systems.

Labour efficiency is critical

The cost of labour is higher in Australia than most other pomefruit growing countries around the world (Source Wikipedia).

The supply of labour is also continually under threat. Harvesting pomefruit in the traditional way is a physically demanding job. If we really analysed it, the current picking job can probably only be carried out by 10% of the able workforce. Hence in most growing regions around the world, growers are reliant on an outside workforce. In Australia, young back packers are critical and pending tax changes may impact their supply.

Labour is the single largest cost on the orchard accounting for 57% of total orchard costs including overheads. In 2014 the average wage cost on-orchard was $0.50 per gross kg ($0.73 per C1 kg).the range amongst the 26 businesses surveyed was $0.28-$0.99 per gross kg.

Labour efficiency and labour supply are imperative requirements for a sucessful orchard of the future.

Therefore the fundamentals of an apple canopy of the future are:

- A canopy that intercepts a minimum of 70% of total available light (TAL)
- A canopy that has light distribution (>20-30% (TAL) throughout the entire canopy capable of colouring fruit to market specification
- A canopy that gives a low vigour, calm tree at maturity with good precocity and high yield efficiency
- The combination of rootstock, system and density that is able to fill the allotted space quickly ie within 6 years
- A canopy that allows for maximum labour efficiency = Total labour cost below 40c/kg
- Tree density/canopy option must make good economic sense i.e. IRR > 15%
- A canopy that can be cost effectively covered in net

CURRENT CANOPIES

The 1990 Design

The 1990 typical planting in Australia was 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 market standard. On most sites, 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 is very high.

This is not the canopy of the future, however we need to make it work now to pay for our future plantings

Upright Spindle

The upright spindle has been the preferred canopy option in Australia over the past 5-10 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 on most varieties 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 C1 recovery. In Australia there is now an expectation that 80 to 100 tonnes per ha is sustainable.

Various iterations of the slender spindle are possible particularly the number of stems per ha and the plant spacing.

Although it is currently one of the most labour efficient can we do better? At a standard 3.5 or 4.0 m row spacing, the tree needs to be quite tall to maximise light interception. it also has a tendancy to become wider than the average arm making full mechanisation difficult. To overcome the challenges of height and width but still maintain good light interception, we need to consider narrower row spacings.

Doregoni upright multi leader fruit wall

We have recently had the privilege of working with Dr Alberto Doregoni from the Instituto Agrario di San Michelle in Italy. Dr Doregoni 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 2016 includes mechanical trimming, mechanical thinning, and over row spraying. He also wants the system he plants today capable of being mechanically or robotically 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 Doregoni system is that he has moved the row spacing's down 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 Doregoni and his colleagues have refined the use of summer mechanical trimming to be able to maintain the canopy within this spacing.

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 Australia with its high labour costs and for regions where it is hard to encourage staff to climb ladders, this is a real advantage.

Canopies of the future

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 & Food Research physiology team in New Zealand.

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.

A few years ago we said the concept of a pedestrian orchard was foolish as at traditional row spacings , the light interception is just too low however Alberto is reducing row spacing to 2.25m meaning that

tree height can also be reduced to 2.25 m and still intercept 65% of light. A 2.25 m canopy can be classified pedestrian. Multiple leaders per tree are to be used to not only lessen the capital cost but also to spread the vigour over more stems, keeping the tree calm. The current training system being trialed is what the Europeans call a double gouyot. This involves laying down 2 leaders per tree and training uprights at a 40-50 cm spacing.

Each upright will only contain small fruiting branches. The canopy will be kept very narrow (max 0.8 m total width), with the help of summer mechanical hedging.

On the other hand the Plant and Food team have a different objective and are planting canopies that will test the boundaries of light interception. They propose that its possible for an upright canopy to 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. Their goal is 170 tonnes per ha of good quality fruit. Not only will their canopies be highly productive, they will also be narrow planar canopies giving very real labour efficiences down the track.

Their research will test if they can go to 90% light interception and still maintain 30% light distribution in the lower parts of the canopy. To achieve this goal, they also believe narrower row spacings are criticial (1.5-2.5m) and multiple stems (10) per tree. They believe that mechanical trimming will not be needed, preffering to work on branch selection and natural tree physiology to keep the canopy calm and narrow.

Future Technologies

There is a lot of interest in platforms, robotics and other mechanised technologies to assist growers with labour efficiency. As labour costs increase and the reliability of these technologies improves, more and more adoption of them will occur.

For these new technologies to be effective, you must first have a canopy that suits. By implementing an efficient modern orchard, you will be best placed to take advantage of these new technologies into the future.

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