THE EVOLUTION OF MODERN HORTICULTURAL PRODUCTION SYSTEMS – LESSONS FOR THE DRAGON FRUIT INDUSTRIES OF SOUTHEAST ASIA

Campbell J M¹, Fullerton R A¹,
(john.campbell@plantandfood.co.nz, bob.fullerton@plantandfood.co.nz)

Le Thi Hoang Truc², Nguyen Van Son², Nguyen Ngoc Long² and Nguyen Van Hoa²

¹The New Zealand Institute for Plant and Food Research Limited, Auckland, New Zealand
²Southern Horticultural Research Institute, Tien Giang, Viet Nam

ABSTRACT

Highly perishable products, long transport distances and high production costs are significant challenges to the NZ horticulture industry. Nevertheless horticulture is a major export earner for NZ and the country has a reputation as world leader in horticulture production and postharvest technologies. Lessons learned in the development of the NZ horticultural export industry can be of value to Asian dragon fruit industries seeking to access the high value export markets in Europe and USA. Critical factors in New Zealand’s success have been a focus on consumer and market requirements for top quality produce, and increased production efficiencies to offset costs of inputs, labor and transport. All crops produced in NZ have gone through a production evolutionary process. Kiwifruit, NZ’s largest export crop, is a vigorous vine. Production first started on posts, not unlike dragon fruit. It then progressed to a more intensive T-bar system (limited areas still planted to this system) and then to the full ground cover pergola system. Apple production evolved from large, unpruned, widely spaced trees, to open vase-shaped trees, then to trees with a single trunk closely planted in rows most using wire trellis systems. In all cases intensification of planting has resulted in significantly high yields per unit of land area and very high uniform fruit quality. Similar trend are seen in other crops such as avocado and citrus where mechanical pruning systems are also possible. These advances have been based on innovative research and the rapid adoption of the new technologies by the industry. The dragon fruit industries of the region can learn from the NZ experience particularly in the areas of crop intensification, new plant training methods, and the potential for mechanization of sward management and pesticide application. The first steps in this evolution are occurring with the introduction of the T-bar management system in Vietnam.

Key words: New Zealand horticulture, dragon fruit, kiwifruit, apple, controlled production systems, production intensification, horticultural research, T-bar management system, SOFRI

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INTRODUCTION

Highly perishable products, long transport distances and high production costs are significant challenges to the NZ horticulture industry. Nevertheless horticulture is a major export earner for NZ and the country has a reputation as world leader in horticulture production and postharvest technologies. Lessons learned in the development of the NZ horticultural export industry can be of value to Asian dragon fruit industries seeking to access the high value export markets in Europe and USA. Critical factors in New Zealand’s success have been a focus on consumer and market requirements for top quality produce, and increased production efficiencies to offset costs of inputs, labor and transport. All horticultural crops produced in NZ have gone through evolutionary processes similar to those occurring globally on these crops. The process is marked primarily by intensive in-row planting the target crop and where necessary, the use of trellises to generate open canopies for optimum exposure to light and access for management operations (Mollah M R 1989; Fraser Hugh W 2017).

Kiwifruit, NZ’s largest export crop, is a vigorous vine. Production first started on posts, not unlike dragon fruit. It then progressed to a more intensive T-bar system (limited areas still planted to this system) and then to
the full ground cover pergola system. That system has been further refined by separating new vegetative growth from the current year's fruiting canes.

Apple production evolved from large, unpruned, widely spaced trees, to open vase-shaped trees, then to trees with a single trunk closely planted in rows most using wire trellis systems. In all cases, intensification of planting has resulted in significantly high yields per unit of land area and very high uniform fruit quality.

Similar trends are seen in other crops such as avocado and citrus where mechanical pruning systems are also possible. These advances are based on innovative research and the rapid adoption of the new technologies by the specific industry.

The dragon fruit industries of the region can learn from the NZ experience particularly crop intensification, new plant training methods, and the potential for mechanization of sward management and pesticide application. The first steps in this evolution are occurring with the introduction of the T-bar management system in Vietnam.

THE IMPORTANCE OF EXPORTED KIWIFRUIT AND APPLES TO THE NZ ECONOMY IN 2016

The statistics below show the changes in production and value of two of New Zealand's major horticultural crops (Plant and Food Research 2017).

**KiwiFruit:**

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2016</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export value</td>
<td>US$340M</td>
<td>US$1,200M</td>
<td>253</td>
</tr>
<tr>
<td>Total Production</td>
<td>225,000 tonnes</td>
<td>420,000 tonnes</td>
<td>87</td>
</tr>
<tr>
<td>Area</td>
<td>10,000 hectares</td>
<td>12,000 hectares</td>
<td>20</td>
</tr>
<tr>
<td>Number of growers</td>
<td>1600</td>
<td>2500</td>
<td>56</td>
</tr>
</tbody>
</table>

**Apples:**

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2016</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export value</td>
<td>US$350M</td>
<td>US$500M</td>
<td>43</td>
</tr>
<tr>
<td>Total Production</td>
<td>480,000 tonnes</td>
<td>350,000 tonnes</td>
<td>-27</td>
</tr>
<tr>
<td>Area</td>
<td>1,500 hectares</td>
<td>8,500 hectares*</td>
<td>466</td>
</tr>
<tr>
<td>Number of growers</td>
<td>1500</td>
<td>950</td>
<td>-37</td>
</tr>
</tbody>
</table>

* A large proportion of this area are recent plantings and not in full production in 2016.

In each industry, the export values have increased significantly with proportionately less increase in areas and grower numbers, reflecting greater production efficiency and higher values for exported produce.

DRIVERS FOR MODERN NEW ZEALAND HORTICULTURE

Each crop sector is market driven to produce elite varieties by their respective breeding programmes, elite varieties targeting high quality uniform fruit, of extended storage life and meeting scientifically defined consumer taste profiles for different markets. This policy has provided long term growth for the industries and is the recommended pathway for dragon fruit.

HOW THE NZ HORTICULTURE INDUSTRY MEETS MARKET DEMANDS

- Each production sector (kiwifruit, apples, grapes, berry fruit, etc.) has its own organized structure. The sectors organisations are owned and managed by their growers.
- The grower-elected industry body is responsible for the success of that sector and is resourced through grower levies which are proposed by the sector body and agreed by growers. Ratification of the levy by the Government authorises the industry body to collect the revenue.
- The revenue collected by the levies is used for:
  - Management of the sector on behalf of the registered growers;
  - Research and Development that is of direct benefit to the industry areas such as breeding, pest and disease control, harvest and postharvest technologies;
Networking with research bodies overseas to benchmark the quality of local research and
development, and to promote research collaborations to ensure maximum benefit from research
funding. Marketing and market access compliance;

- Compliance with; in-country Acts, legislation, phytosanitary requirements, global and country
  pesticide MRLs and food safety, etc.; and
- Compliance is independently verified by professional Certifying Bodies

An analysis of the production systems for the New Zealand kiwifruit and apple industries reveals a series of
significant changes in production technology over time.

**EVOLUTION OF KIWIFRUIT PRODUCTION METHODS**

The key stages in the evolution of kiwifruit production in New Zealand and the significant features of each are:

**Stage 1.** Vines grown on posts with very little pruning and training;
- A vigorous vine growing out of control
- Little or no summer pruning
- Winter pruning was major and difficult, with very high labour costs and high volumes of prunings to
dispose of
- Poor quality and size range of fruit – large numbers of small to medium fruit with low prices

**Stage 2.** T-bar trellis systems and improved management; (Fig. 1)
- Male polliniser plants, with specific pruning management, separated from female plants
- Female plants managed intensively with the fruiting canes tied down separately to wire supports
- Annual pruning programmes defined to result in heavy yields of uniform high market value fruit
- Crop loads managed through dormancy breaking treatments, artificial pollination, fruit thinning for
crop load, fruit size and quality
- Summer pruning for optimum light interception and leaf to fruit ratios
- Good yields of quality fruit in the size ranges to maximise market returns

**Stage 3.** Pergola full overhead canopy systems and high quality management; and (Fig. 2)
- Male polliniser plants grown on their own; with some the males interspersed with the females in a
defined pattern then heavily pruned to free up canopy space while others preferring a cross block,
overhead trellis system and managed separately of the female pergola – e.g. heavily pruned after
flowering
- Female plants managed intensively with specific distances between the fruiting canes – a uniform and
specific area of the pergola allocated to each fruiting cane
- Crop loads managed through: dormancy breaking treatments, artificial pollination, fruit thinning for
crop load and fruit size and quality. Annual pruning programmes defined in which lead to high yields
of uniform fruit
- Improved access to the canopy for summer pruning with lower labour costs
- Research defined summer pruning protocol to achieve optimum leaf to fruit ratios

**Stage 4.** Pergola full overhead canopy systems and high quality precision management with annual
vegetative growth separated from fruiting canes; (Fig. 3)
- Basically the same as the number 3 above system but the annual vegetative growth is separated from
the fruiting canes
- The vegetative canes produced during the growing season are trained on twine at an angle of 45
degrees above the horizontal fruiting canes. The separation of two cane types ensures the canes for the
next year’s crop are of optimum diameter are relatively straight and easy to identify and tie down to
the pergola trellis for the following year’s crop.
- The separation of the two cane types also simplifies winter removal of the of past years canes with
significant benefits in labour costs
- Fruit size, yield and quality is significantly increased.
Fig. 1. Kiwifruit Tee Bar training system with male polliniser vine on cross trellis

Fig. 2. Kiwifruit Pergola training system – underside of canopy showing fruit

Fig. 3. Kiwifruit Pergola training system with overhead trained seasonal vegetative growth separated from fruiting vines
EVOLUTION OF APPLE PRODUCTION METHODS

The key stages in the evolution of apple production in New Zealand and the significant features of each are:

**Stage 1.** Widely spaced trees of natural growth habit and canopy structure with little or no pruning which produced:
- Low yields;
- Fruit of mixed sizes but predominantly small – partially due to older variety types;
- Poor colour fruit due to poor light interception;
- Poor pest and disease control because of canopy density and poor spray penetration of pesticides applied by hand spray from the ground; and
- Low quality fruit with short storage life.

**Stage 2.** Vase shaped apple trees with planned pruning and improved management: (Fig. 4)
- Improved fruit yields;
- Reduction in differences in fruit size particularly when fruit thinning was carried out;
- Improved fruit colour especially when summer shoot pruning of the canopy provided better light penetration;
- Improved pest and disease control resulting from better spray penetration thought the more open canopy;
- Progression to from hand held to mechanical pesticide application; and
- Fruit quality improvement and longer storage life.

**Stage 3.** Single leader, high density, trellis supported, precision managed trees:
- High yields of fruit per hectare;
- Uniform fruit size which is predetermined by crop load management in relation to tree age / size / trunk cross sectional area and thinning (chemical and hand);
- All fruit on the tree has access to light resulting in fruit of uniform colour an essential requirement of modern varieties;
- Mechanized targeted application of pesticides applications which are very effective because of an open canopy, accurate application rates; and
- Fruit quality is managed to meet individual customer specifications.

**Stage 4.** Modern single leader, very high density planted, trellis supported, very well managed apple trees (Fig. 5 & Fig. 6)
- Higher trellis supported plant populations and greater in precision management in management operations than in Stage 3

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Fig. 4. Apple vase shaped tree and low tree density
COMPONENTS OF CHANGE (IMPROVEMENT) AND LESSONS FOR DRAGON FRUIT

The New Zealand experiences mirrors that elsewhere revealing many similarities in the evolution of production systems in horticultural crops with many production and value chain management similarities across most fruit crops. Features common to that evolution are increases in plant density, support of fruit bearing branches on trellises, canopy management practices to limit the amount of non-productive canopy (resulting in a simple open canopy), and orchard layout to facilitate mechanisation of as many orchard operations as possible.

By comparison with advances in other crops, the dragon fruit production system in Vietnam has not progressed beyond widely spaced single productive units. (Fig. 7, Fig. 8 & Fig. 9) This is in many ways similar to the earliest methods of apple and kiwifruit production in New Zealand. It was considered therefore that significant advances in yield, fruit quality and plant management of dragon fruit could be achieved by the adoption of a trellis systems. In particular it was designed to eliminate the massive build-up of redundant old cladodes in the canopies of the conventional production system and to facilitate disease control. After an evaluation of various canopy designs (Mollah M R 1989; Fraser Hugh W 2017) a modified T-bar system was adopted. The paper of Truc et al. (2018 this proceedings) describes the basic structure of the system, the plant training method, and the advantages gained in yield, access for pruning, disease control and options for mechanisation of sward management.

The T-bar system has sparked widespread interest among many dragon fruit growers in Vietnam. (Fig. 10) While its advantages are likely to be most benefit to larger growers who are in a position to mechanize many operations including pesticide spraying, small growers will achieve immediate benefit from higher plant populations, higher yields per unit of land area and lower labour costs. It is recommended as the ‘starting point’
for all fledgling dragon fruit industries in the region if they wish to achieve maximum production efficiency from the outset.

Fig. 7. Dragon fruit grown on live support

Fig. 8. Dragon fruit grown on brick column support
Fig. 9. Dragon fruit conventional production - Mop Top

Fig. 10. Dragon fruit T-bar

The current implementation of the T-bar system represents the first stage in the evolution of dragon fruit production putting it on a similar basis to many other horticultural industries globally. Experience with other industries tells us that progress will not stop there and inevitably other innovations will add further efficiencies. Ongoing research will be necessary to achieve that progress. That will, in turn require significant funding. Government-funded research support for growers is decreasing globally as Governments increasingly require research institutions fund their own activities. This is precisely the case in New Zealand where the Government-owned Research Institutes (of which Plant and Food Research is one) are required to run as private
companies and operate at a profit. In New Zealand, and increasingly elsewhere, the research that drives horticultural development is funded by the sectors themselves via producer levies. The Vietnam dragon fruit industry with a value rapidly approaching US$1.0B should seriously consider developing an industry structure which can support its own research and development.

CONCLUSIONS

New Zealand horticulture industry is a major export earner for New Zealand and the country has a reputation as world leader in horticulture production and postharvest technologies. Critical factors in New Zealand’s success have been a focus on consumer and market requirements for top quality produce, and increased production efficiencies to offset costs of inputs, labour and transport.

All horticultural crops produced in NZ have gone through evolutionary processes similar to those occurring globally on these crops. The process is marked primarily by intensive in-row planting the target crop and where necessary, the use of trellises to generate open canopies for optimum exposure to light and access for management operations.

Lessons learned in the development of the NZ horticultural export industry can be of value to Asian dragon fruit industries seeking to access the high value export markets in Europe and USA. Implementation of the T-bar dragon fruit production system represents the first stage in the evolution of dragon fruit production which will put it on a similar basis to many other horticultural industries globally.

In New Zealand, and increasingly elsewhere, the research that drives horticultural development is funded by the sectors themselves via producer levies. The Vietnam dragon fruit industry with a value rapidly approaching US$1.0B should seriously consider developing an industry structure which can support its research and development.

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Fraser Hugh W. OTB Farm Solutions St. Catharines, Ontario hughfraser13@gmail.com otbfarmsolutions.ca
