9. ECONOMICS OF PRODUCTION

Overview

Average yields in the Region are about 4 tonnes per ha, although some orchards in Australia, China and elsewhere can produce 15 tonnes per ha, under close spacings and intensive tree management. The price for fruit varies with year, season and cultivar. Early fruit in Guangdong fetch US$2 per kg, whereas the bulk of the crop is sold at half this price in the middle of the season. Premium cultivars with small seeds such as “No Mai Chee” and “Kwai May” can sell for US$10 or more per kg in a light year. Prices for export fruit are normally higher than those sold locally. In both markets, lychees are also more expensive than the related longan. Little information is available on the profitability of enterprises within the Region. An analysis in Australia showed that trees could be as profitable as alternative crops such as avocado, macadamia and mango. Picking, packing and marketing are the most expensive part of the operation, and account for 65 percent of total costs. There is little benefit in trying to reduce growing costs, whereas there are financial rewards to be gained by improving the efficiency of harvesting and packing. It is not known whether similar improvements are possible in Asia, with lower labour costs.

9.1 Productivity

Yields vary widely with cultivar, season and country. In China, a ten year old tree can carry 100 kg of fruit. Average yields range from 2 to 5 tonnes per ha, although well-managed, high-density plantings can yield 15 tonnes per ha. Production is generally more consistent in Guangdong than in Fujian or Guangxi. Over-crowding, inadequate watering and fertilizing, stink bug and fruit borer lower productivity in neglected orchards. Warm temperatures during winter can also reduce flowering across the production areas.

Average yields in Viet Nam are a low 2 tonnes per ha, but only about half the plantings are of bearing age.

Average production in Thailand is 3.5 tonnes per ha, with the highest yields in Chiang Mai and Chiang Rai in the north, and the lowest in Samut Songkhram in the south. Longan generally has higher yields than lychee, but fetches a lower price.

Lychee is quite productive in India, especially under irrigation. Average yields have increased by 50 percent in the past ten years to 7 tonnes per ha. Productivity is highest in Bihar, followed by West Bengal. Some well-grown orchards in Bangladesh can be just as productive, however, average yields here are lower than in India. Production in Nepal ranges from 40 to 100 kg for ten year old specimens. The higher yields are usually associated with more intensive tree management, including irrigation.

In Australia, ten year old trees can produce 80 kg of fruit, although average yields are half that. An early economic analysis of production on the Atherton Tableland with “Fay Zee Siu” assumed average yields of 55 kg for ten year old trees, but this was too optimistic. A recent economic analysis in the same region used average yields of 24 kg per tree. In southern Queensland, yields are 40 kg per tree or 11 tonnes per ha for “Kwai May Pink”. Some orchards are more productive. Protection from bats and birds can double yields in many areas.
9.2 Prices

Early cultivars such as “Sum Yee Hong” from Guangdong fetch US$2 per kg, even though fruit quality is only average. When production is heavy, the price in the middle of the season falls to US$0.50 per kg, although sought after cultivars such as “No Mai Chee” and “Kwai May” may fetch US$15 per kg. Growers in Guangxi generally receive US$1.50 per kg for lychee and a little less for longan. For comparison, apples are US$1 per kg and bananas US$0.25 per kg. Prices in the export markets are much better, normally US$5 to 15 per kg.

Lychee is a lucrative crop in Viet Nam. In Luc Ngan District, each farmer has about 100 trees with half of these of bearing age. Average income is US$1,400 to 2,200 or US$700 to 1,100 per labourer. This is a high income compared with Local Government workers who earn US$400 per annum.

The average farm price in Thailand is US$1.50 per kg, with longan receiving only half of this. In 1997, fresh exports of 11,000 tonnes sold for US$13 million, while 27,000 tonnes of canned fruit sold for US$38 million.

The Philippines is a net importer of lychees that normally sell for only US$0.30 per kg. The price has fallen in the last year or two, but is still higher than that obtained for some of the more common local fruit.

Prices in Australia range from US$1 to 6 per kg, depending on quality, demand and time of year. Average prices are US$2.50 per kg, somewhat above US$1.50 predicted in 1986 when the industry was just starting to expand. The highest prices are normally received for early-season “Fay Zee Siu” from northern Queensland.

9.3 Profitability

Tthew examined the profitability of orchards in southern Queensland, with average yields of 4.6 tonnes per ha and a price of US$1.50 per kg. These yields and returns are on the low side for orchards in southern districts. Nevertheless, his analysis is useful for examining the effect of picking rate, price, and variable costs. He found that a 10 percent increase in price improved profitability more than a 50 percent reduction in growing costs. This analysis suggests that there are more gains to be had in improving the handling of fruit than in reducing growing costs.

Hassalls and Associates studied the profitability of an 11 ha “Kwai May Pink” orchard in southern Queensland over 20 years, assuming yields of 11 tonnes per ha (275 trees per ha), a price of A$5 per kg and netting costs of A$16,500 per ha. Picking, packing and marketing were the most expensive part of the operation, and accounted for 65 percent of total costs. These data further illustrate that there is little benefit in trying to reduce the costs of watering, fertilizing and spraying, while there are potential benefits to be gained by improving the efficiency of harvesting and marketing. Gross margin was A$34,000 per ha, after subtracting recurring costs of A$21,000 per ha from revenue of A$55,000 per ha.
Table 11. Effects of netting, pruning and plant spacing on yields and returns in Australia.

<table>
<thead>
<tr>
<th>Potential yield (kg/tree)</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual yield (kg per tree)</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>Actual yield (tonne per ha)</td>
<td>0.90</td>
<td>1.80</td>
<td>2.70</td>
<td>3.60</td>
<td>4.50</td>
</tr>
<tr>
<td>Returns ($'000 per ha)</td>
<td>4.50</td>
<td>9.00</td>
<td>13.50</td>
<td>18.00</td>
<td>22.50</td>
</tr>
<tr>
<td>Low-density planting without pruning or nets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual yield (kg per tree)</td>
<td>7</td>
<td>14</td>
<td>21</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Actual yield (tonne per ha)</td>
<td>1.05</td>
<td>2.10</td>
<td>3.15</td>
<td>4.20</td>
<td>5.25</td>
</tr>
<tr>
<td>Returns ($'000 per ha)</td>
<td>5.25</td>
<td>10.50</td>
<td>15.75</td>
<td>21.00</td>
<td>26.25</td>
</tr>
<tr>
<td>Low-density planting with pruning and nets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual yield (kg per tree)</td>
<td>7</td>
<td>14</td>
<td>21</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Actual yield (tonne per ha)</td>
<td>2.10</td>
<td>4.20</td>
<td>6.30</td>
<td>8.40</td>
<td>10.50</td>
</tr>
<tr>
<td>Returns ($'000 per ha)</td>
<td>10.50</td>
<td>21.00</td>
<td>31.50</td>
<td>42.00</td>
<td>52.50</td>
</tr>
<tr>
<td>High-density planting with pruning and nets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(The analysis assumes 30 percent loss of fruit to birds and bats and a 10 percent extra loss to insect pests in the traditional orchard. Yields of pruned trees are 30 percent lower than the yields of non-pruned trees (similar yields on a canopy area basis). There are 150 trees per ha in a traditional planting and 300 trees per ha in a high-density planting. The price for fruit is A$5 per kg. Data from Menzel et al. 2000).

Hinton examined costs and returns for a 13 ha “Fay Zee Siu” orchard in northern Australia, assuming yields of 3.7 tonnes per ha (154 trees per ha) sold at A$8 per kg. Nets were hung over the trees at a cost of A$6,000 per ha. The gross margin was A$19,000 per ha after subtracting recurring costs of A$11,000 from the gross revenue of A$30,000 per ha. Harvesting and marketing accounted for 87 percent of variable costs. The two most critical factors affecting profitability were yield and price. At yields of 12, 24 and 36 kg per tree, farms were profitable above A$10.20, A$6.00 and A$4.60 per kg, respectively. Capital outlays were not included in the analysis, but were A$1,200 per ha for each year of the 30-year project. Land was only A$3,000 per ha, about a third of the cost in southern Queensland.
The costs of production are much lower in South-East Asia than in Australia. There are also differences in capital outlays for land and equipment. However, some of the principles discussed in Australia have application elsewhere.

9.4 Profitability of high-density plantings

Menzel et al. (2000) undertook an analysis of returns for three different orchards in Australia. They compared:

- a traditional non-netted orchard with 150 trees per ha and trees not pruned,
- a netted and pruned orchard with 150 trees per ha, and
- a netted and pruned orchard with 300 trees per ha.

The analysis assumed 30 percent loss of fruit to birds and bats and a 10 percent extra loss to insect pests in the traditional orchard. Yields of pruned trees were 30 percent lower than the yields of non-pruned trees. However, yields were similar when expressed on a canopy surface area basis. The price for fruit was A$5 per kg.

Returns were greater after pruning and netting, especially when trees were planted at close spacings (Table 11). Some existing orchards suffer losses of up to 60 percent due to birds and bats, so the net impact of pruning/netting would be substantially greater. There are of course additional costs associated with this system, including A$1,650 per ha for extra plants, A$1,875 for extra irrigation and A$16,500 for nets. Not taken into account in this analysis were the savings associated with harvesting smaller trees. Harvesting is very expensive in Australia, due to the high costs of labour.

Bibliography


10. PROSPECTS FOR INDUSTRY EXPANSION

Overview

Although lychee has a long history in Asia, it is a relatively new species in most countries, and efforts to increase production have been relatively small compared with the more established tropical fruit such as citrus, banana, pineapple and mango. There are many recipes for growing the crop, although not all agronomic recommendations have been based on the results of research. There has also been much speculation on the factors controlling growth and cropping. The main reason for low yields is failure to flower, although in some seasons, the trees may flower heavily, but carry few fruit at harvest. The yield of cultivars varies greatly from district to district, so cultivars must be evaluated for their cropping in different areas.

There are opportunities to increase production with new cultivars, and appropriate watering, fertilizing and pruning. Girdling and growth regulators can also increase flowering and fruit retention under some circumstances. Improvements in integrated pest and disease management, post-harvest treatment and marketing are required. These developments are more likely to succeed if countries across the Region remain united in their vision for the future of this crop.

10.1 Cultivar improvement

The industry in Asia has a narrow cultivar base. Most countries apart from China use one or two cultivars, even though many more are available. A single cultivar may become popular because of its consistent cropping, easy management or good quality. There are few cultivars that have developed in tropical parts of Thailand and Indonesia; however, the bulk of production is in the sub-tropics. Cropping is much more consistent in cooler areas, with winters below 20°C.

Future expansion of the industry in the Region is dependent on the development of new ecotypes with better production and fruit quality. New cultivars are still being released to the industry in China; however, most other countries cannot afford a large breeding effort. The main focus of a breeding programme would be to produce cultivars with regular and heavy yields, good tree shape and small seeds, and earlier or later harvests. In the short-term, it might be advantageous to link existing programmes from different countries, or at least exchange some of the better cultivars. It would also be useful to evaluate the performance of existing cultivars in a systematic way.

10.2 Canopy management

Many countries are moving towards close plantings of 3 to 5 m between trees and 6 to 8 m between rows, whereas older orchards were up to 12 m x 12 m. Desktop calculations indicate that close plantings are more profitable, especially in the early life of an orchard. There is probably no advantage in very close plantings where the trees start to crowd each other before they begin to bear. Guidelines are available on the optimum time to prune trees after harvest along eastern Australia and these could be applied to much of Asia. In contrast, optimum tree shape and canopy size have not been established. Many of the existing cultivars have a considerable number of shaded leaves that contribute little to overall productivity. Studies in
this area have increased yields in temperate deciduous fruit orchards, but are rare in tropical trees.

10.3 Water and nutrition management

General guidelines are available for water and nutrient management. Most orchards in Australia are irrigated, whereas those in Asia are dependent on rainfall. Yields and fruit quality are undoubtedly affected in some seasons. It is recommended that new plantings be irrigated if possible.

Drought could be used to control flushing patterns and improve flowering in localities with dry winters such as India and Thailand; however, the timing and duration of the water deficit for success are not known. There is also some evidence from Australia that a light drought after flowering could increase fruit production, but commercial recommendations are not available.

Growers generally irrigate their orchards on the basis of long-term evaporation data from a Class A pan, or just from experience. This easily translates into under- or over-watering. Research indicates that irrigation once a week is more than adequate for established trees in most areas. Maximum water use would be about 60 mm per week. Soil water can be monitored with the various electronic devices, but these are expensive and impractical for most growers. They also need to be calibrated. Water management is much easier on deep well drained soils.

Australian growers base their fertilizer applications on soil and leaf tests; however, these are less common in Asia. Samples could be collected by Government horticulturists and used to monitor potential nutrient problems in a particular growing area. It is unlikely that the standard values will change significantly with new cultivars or growing areas. It is possible that increases in yields could occur with higher tree nitrogen concentrations, above 1.8 percent, whereas there is probably little benefit in increasing the application of other nutrients. Both organic and chemical fertilizers are effective. In contrast, there is no evidence that the rate or time of nitrogen applications affect flowering. Foliar applications are less effective than soil applications. Most nutrients are probably best applied to the soil.

10.4 Manipulating flowering and fruit set

Research on flower and fruit physiology was active in the 1980s and early 1990s, with glasshouse and field experiments conducted in Australia and elsewhere. Vegetative growth is greater at 30°C than at lower temperatures. In contrast, flowering is poor with days above 25°C and nights above 15°C. Flowering is usually best with at least three weeks of low temperatures. Small buds only a few millimetres long flower when exposed to a few weeks of cool weather, whereas longer buds remain vegetative. Australian workers also showed that the number of days suitable for floral induction in an average year was about 200 in sub-tropical districts such as Ballina (latitude 29°S) and below 20 in tropical areas like Cairns (latitude 17°S). This analysis can be used to predict relative cropping at different elevations in parts of Asia. There is no evidence that strategic pruning, girdling, drought or withholding fertilizers can induce flowering in the tropics.

Auxins have been shown to increase fruit retention and yield in Israel and China. It would be interesting to evaluate this technology in other countries, although there could be problems with registering the chemicals. It is quite possible that other chemicals have similar
benefits, without the risks to human health. The long-term effects of girdling on flowering, fruit set and tree health should also be explored.

10.5 Control of pests and diseases

The main insect pests are erinose mite, fruit-sucking bugs and fruit borers. There can also be problems with scales, stem borers, leaf- and flower-eating caterpillars and beetles, and fruit-piercing moths in some areas. Current strategies generally employ calendar sprays with little monitoring, although there is some effort to control stink bug in China and Viet Nam with parasitoids. There has also been a change in the chemicals used with strong interest in the use of insect growth regulators. In the future, there will probably be a shift to monitoring and strategic applications, with possible biological control for some pests. There also needs to be a change in pesticide label directions for tree crops, which are currently based on application rates rather than on dose per tree.

Exclusion nets are the most effective control for birds and flying foxes in Australia, but orchards must be productive for the system to be economically viable. This can be a problem in tropical areas with irregular flowering. These pests are less of an issue in Asia. With a small aperture, the netting can control fruit-piercing moths and possibly even macadamia nutborer.

Strategies need to be developed to control brown blight, *Peronophythora litchii*, and anthracnose, *Colletotrichum gloeosporoides*, which affect orchards in China, India and Australia. Current systems of control are not always successful. There are a few diseases killing individual trees or whole orchards in the Region, but the causal organisms have not been identified. No chemicals are currently registered for these diseases.

10.6 Post-harvest technology and marketing

Research into extending shelf life has been active since the 1980s. Fruit deteriorate rapidly after harvest. Several strategies have been developed to reduce the considerable wastage that occurs through the marketing chain. Fruit dipped in hot benomyl and stored in punnets with PVC wrap keep for several days at room temperature, but the technology is not practicable. Many countries just cool the fruit with cold water or ice.

Experiments have been conducted with sulphur, acid dips, hydrocooling, heating and other techniques to maintain the red skin, but none of this research has improved eating quality. New approaches based on a better understanding of fruit physiology need to be developed. The emphasis needs to be on reducing water loss, and then the build-up of diseases under the higher humidity. This work will become more important as trade within Asia expands. It can be concluded that research into extending the shelf-life of fruit is a priority for the Region.

Most of the fruit produced in Asia is sold on the domestic markets. There is also some trade within the Region to Hong Kong and Singapore, and some exports to North America and Europe. The majority of the crop is sold fresh, with a little drying and canning as well.
Table 12. Factors limiting expansion of production in different countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Factors limiting expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Short shelf life, inefficient marketing system, variable fruit production and quality from small orchards, irregular flowering and fruit set, and frost and wind damage.</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>Irregular flowering, narrow cultivar base, and lack of equipment for maintaining shelf life after harvest.</td>
</tr>
<tr>
<td>Thailand</td>
<td>Alternate bearing, short shelf-life, poor marketing system, high cost of fertilizers and other chemicals, and strong competition from longan in the market.</td>
</tr>
<tr>
<td>India</td>
<td>Narrow cultivar base, poor growing techniques, high incidence of insect pests, poor post-harvest management, shortage of planting material, and lack of irrigation.</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Narrow cultivar base, short production season, variable quality of planting material, inappropriate pruning, and lack of technical information.</td>
</tr>
<tr>
<td>Nepal</td>
<td>Large seed in current commercial cultivars limits marketing, shortage of planting material, inappropriate pruning, harvesting and post-harvest management, and inadequate industry research and extension.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Narrow cultivar base, variable yields, poor quality fruit, short harvest season, and lack of planting material and growing technology.</td>
</tr>
<tr>
<td>Philippines</td>
<td>Irregular production in existing cultivars, high cost of planting material, high growing costs, lack of technical information for new growers, lack of irrigation, and limited research and extension.</td>
</tr>
<tr>
<td>Australia</td>
<td>Many orchards in northern districts are inherently low yielding, harvesting and packing expensive, and fruit susceptible to browning and rotting and thus have a relatively short shelf life.</td>
</tr>
</tbody>
</table>

Marketing groups are well established in Australia, and are now the largest exporters from that country. They typically have a market coordinator, rigorous grade standards and quality assurance training, and pack their fruit into distinctive cartons that are readily identifiable in the marketplace (Plate 10). The groups achieve a premium of US$1 per kg above the average market price. These ideas need to be developed throughout the rest of the Region, especially for the lucrative export trade. Quarantine issues associated with fruit fly also need to be resolved.

10.7 Factors constraining production in various countries

Profitable lychee growing starts with the identification of a market opportunity either internationally or locally. The site and cultivar determine the time of production and hence average prices. There are also important agronomic decisions associated with site
selection. The site should be frost-free and yet have a dependable period of cool weather to induce flowering. There should be a reliable supply of good quality water and suitable soil. The slope of the land should allow safe use of vehicles for tree maintenance and harvesting. Selection of regular heavy-yielding cultivars, with good quality fruit is essential. In establishing orchards, closer planting to produce high early returns should be considered, but sufficient space for access should be maintained.

Planning for netting of trees when production commences should be considered in some locations such as Australia. High-density orchards need to be pruned regularly to keep trees small and allow space for machinery. Trees have a range of serious pests that must be controlled, and require regular water and fertilizer applications. However, these do not appear to be major costs. All cultivars have a short production season and short shelf-life so that picking and packing need to be efficient. Marketing decisions will determine the success or failure of an enterprise. Marketing groups in Australia have improved returns to growers, but their full potential will only be reached with the development of better post-harvest technology. These strategies need to be considered by the expanding industry in Asia.

Table 12 lists some of the factors constraining the expansion of cultivation in Asia. Production in most countries is limited by the narrow cultivar base, with a lack of suitable planting material an issue in some areas. There are concerns about the regularity of cropping throughout much of the Region related to irregular flowering or fruit set. This can be due to poor growing techniques especially on the smaller farms, or just due to weather. Some growers do not have ready access to advice on the best watering, fertilizing or pruning programmes for their area. There is much wastage of fruit after harvest, even in countries like Australia where hydrocooling and post-harvest technology are available.

Many growers are hampered by a lack of capital and access to finance. There is inadequate Government support for research and extension in many countries, considering the potential value of the fruit in the Region and the number of families involved in growing, marketing and supporting the crop.

**Bibliography**


Plate 1. Cultivar “Tai So”

Plate 2. Cultivar “Wai Chee”
Plate 3. Cultivar “Kwai May Pink”

Plate 4. Cultivar “Salathiel”
Plate 5. Marcots or air-layers

Plate 6. Pruned orchard in Australia
Plate 7. Fruit borer in Australia

Plate 8. Erinose mite
Plate 9. Fruit harvest in China

Plate 10. Quality assurance in Australia