Litchi and Longan

Botany, Production and Uses
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About the Editors

Christopher Menzel is a Principal Horticulturist with the Queensland Department of Primary Industries and Fisheries at Maroochy Research Station, Nambour, on the Sunshine Coast of Australia. Chris completed his Bachelor of Agricultural Science at the University of Queensland in 1977, and then enrolled for a PhD, where he studied the growth of potato, *Solanum tuberosum*, in tropical climates. He has conducted research for the Australian Litchi Industry for 22 years and has written about 80 papers and book chapters. Some of these research papers have been translated for the benefit of litchi specialists in China.

Chris has been a guest speaker at national and international tropical fruit conferences, and has supervised several postgraduate students who have studied litchi physiology. Chris was leader of the canopy management project with CSIRO Plant Industry in Brisbane, which developed canopy management strategies for commercial litchi growers in Australia. His early work explored the factors affecting flowering and fruit set, suitability of cultivars for commercial production, along with recommendations for nutrition and water management.

In 1991, Dr Menzel reviewed the developing litchi and longan industries in northern Viet Nam for the United Nations Development Programme (UNDP) and in the following year spent 6 months at the Institute for Tropical and Subtropical Crops in Nelspruit in South Africa. In 1998 and 1999, Chris undertook consultancies for the Food and Agricultural Organization of the United Nations in China. He was co-organizer and editor of the First National Litchi Conference in Nambour in 1986, and the Fifth National Litchi Conference in Maroochydore in 1999. He was a keynote speaker and editor for the First International Litchi and Longan Symposium held in Guangzhou in 2000. In 2001, he represented Australian growers at an international workshop on litchi sponsored by the Food and Agricultural Organization of the United Nations in Bangkok. In 2002, he produced a technical guide for litchi producers in South-east Asia and the Pacific. Chris has also visited the litchi industries in Thailand, South Africa, Mauritius, Réunion, Hawaii, Florida and South America, and was senior contributor to the DPI & F's *Litchi Growing Guide* produced in 2002.


Geoff Waite is Principal Entomologist with the Queensland Department of Primary Industries and Fisheries at Maroochy. He commenced his professional career with the Department in Toowoomba
in 1969, where he conducted research on lucerne, soybean and pasture pests. In 1973 he transferred to Emerald in central Queensland as the first entomologist to be stationed there, to manage an outbreak of the spur-throated and migratory locusts. At this time, the first farms in the Emerald Irrigation Scheme commenced production, and Geoff conducted research in cotton, developing an integrated pest management (IPM) system for the fledgling industry.

Geoff transferred to Maroochy in 1980, where he began research to develop IPM systems for several subtropical crops, especially litchi, longan, avocado, macadamia and strawberry. He has also conducted research on low-chill stonefruit, persimmon, mango, custard apple and pineapple. He has visited the tropical fruit industries in China, Thailand, Taiwan, Hawaii and South Africa, chiefly to survey and acquire natural enemies of litchi erinose mite, *Aceria litchii*, and macadamia nut borer, *Cryptophlebia ombrodelta*. Pest management in Queensland’s strawberries relies almost exclusively on the IPM system Geoff developed, which uses the ‘pest in first’ strategy in conjunction with the predatory mite, *Phytoseiulus persimilis*, to control spider mites, the major pests of the crop. The subject of his current research is to find an effective, environmentally friendly, control for fruitspotting bugs, major pests of tropical and subtropical fruit in Queensland.

Maroochy Research Station
2 June 2004
Preface

Litchi and longan are indigenous to South-east Asia and make significant contributions to the lives and economic health of millions of people in the region. These fruit originated in southern China and northern Viet Nam, but their culture has now spread to most countries that experience a subtropical climate for part of the year. Litchi is most important in China, India, Viet Nam and Thailand, while longan is produced mainly in China, Viet Nam and Thailand. There is also interest in these two fruit in southern Africa, Madagascar, Réunion, Israel, Spain, the USA, Mexico, Brazil, Australia, Bangladesh, Nepal, the Philippines and Indonesia. Production in the Asia-Pacific region accounts for more than 95% of world cultivation, at about 3 million tonnes, more than world avocado production but less than citrus, banana, pineapple, mango and papaya.

Most of the fruit is produced by small landholders, with fewer than 100 trees each. Orchards with more than 1000 trees are rare, except in southern China, where there are single plantings of more than 10,000 trees, and in southern Africa and Australia. The fruit have a high value, and can significantly add to the income of small landholders, with a few trees doubling the income of some families in Asia.

Despite the long history of litchi and longan cultivation, many areas experience low productivity, with average yields being less than 5 t/ha due to a number of factors such as warm weather at flowering, reliance on inappropriate cultivars or lack of tree care. In Israel and some other countries, yields of up to 15 t/ha have been achieved, indicating that there is a large gap between actual and potential yields. Prospects for increasing production and marketing of these crops are high if some of the growing, postharvest handling and marketing issues are resolved. Inter- and intra-regional cooperation in this area would assist the development and status of these crops in many local economies.

Litchi requires temperatures of around 15°C or lower to flower, with a period of dry weather sometimes being beneficial. Once trees have set fruit, warm weather and good soil moisture are associated with heavy yields. Cropping is thus limited to areas that experience some cool weather before flowering. Production in litchi is very erratic in the true tropics where nights seldom fall below 25°C, with the majority of the industries based in environments where nights fall below 15°C. However, there are examples of industries such as that in central Thailand, which is based on cultivars that can flower at temperatures slightly higher than those normally considered ideal. These areas often supply early season fruit and return higher incomes than fruit from ‘traditional’ subtropical orchards, but can fail in some years. The quality of some of these cultivars is often inferior compared with the traditional types, indicating that new varieties that have better fruit quality need to be developed for these environments.

Longan has both subtropical and tropical ecotypes. The bulk of the crop in China and Thailand is still produced in cooler areas, whereas the main industry in Viet Nam is based in the Mekong Delta. More research is required to define the optimum temperatures for flowering in both species.
are also some growing techniques that can assist cropping in the warmer areas, but they have not been evaluated across many diverse environments. The other constraint related to climate is poor fruit set during cool, damp weather, and damage to trees and fruit after typhoons or hurricanes in China, Viet Nam, Madagascar, Mauritius, Australia, Hawaii and Florida.

Despite the long history of litchi and longan cultivation in Asia, there is a paucity of information concerning the yield of the major cultivars in different environments. The performance of some cultivars is disappointing, and production is unprofitable, with many industries based on only one or two cultivars. A lack of suitable cultivars limits production in many countries, because the existing varieties are low-yielding or are not well regarded in the market place.

Limited plant breeding and selection, facilitated by the exchange of germplasm, would increase the production of the crops. Some countries, such as India, China, Nepal and Viet Nam, have many seedling trees, which could form the basis of industry expansion. Breeding programmes are required in the long term to develop better cultivars, and this is best implemented with a regional focus. In the interim, the current gene pool should be more systematically evaluated. Standardization of cultivar names and descriptions would assist in this endeavour and encourage cooperation amongst producing countries. Based on the above, it can be concluded that there is a need for a much stronger varietal improvement programme.

Propagation is well described, most commercial orchards being planted with air-layers, with grafting and budding being popular in China and Viet Nam. It is reported that grafted trees are more drought- and wind-resistant, but little experimental evidence for this is available. Grafting also uses less planting material than air-layering. However, there are some disadvantages with grafting; it is not as easy to accomplish as air-layering, and requires the growing of seedling rootstocks. Grafted trees also take longer to develop to the stage where they can be planted out. There is little information on the graft compatibility between different cultivars, and the impact on production and fruit quality. Newly established young plants require regular watering, and many orchards in Asia experience serious losses at this stage due to a lack of irrigation facilities. The provision of irrigation, along with education of nursery workers and growers in tree care, would overcome this problem. It is apparent that further work is required in order to standardize nursery techniques.

Litchis and longans can be grown on a range of different soil types, including soils with a pH from 5 to 8. In very acid or alkaline soils, there can be problems with iron, zinc, boron and other nutrients. The soil must be freely draining, although the trees can tolerate a wet profile for part of the day. Tree health and production are best on sandy, sandy loam and clay loam soils, while heavy clay soils should be avoided.

Optimal production is achieved with irrigation, especially during the fruiting cycle, with rainfall varying from month to month across the different growing areas. Most of the orchards in Asia are not irrigated and are dependent on regular rainfall. Experiments in Australia and South Africa have shown that drought can reduce growth and fruit production, but the significance of this research for local producers in South-east Asia is not known. Most growers cannot afford the cost of irrigation and, in any case, irrigation is generally not available. Mulching and cover crops can assist water conservation in the absence of irrigation, although new orchards should be irrigated if possible.

Most growers apply fertilizers to their orchards. Tentative leaf and soil standards are available for both crops, but the tests are too expensive for small landholders. Local government extension staff could provide this service on a regional or district basis. Growers generally use a mixture of organic and chemical fertilizers, although the source of the fertilizer does not affect production. In contrast, the effect on cropping of the timing of fertilizer application is yet to be resolved. Crop nutrient removal data should be used for estimating fertilizer requirements.

High-density orchards are becoming popular, and should increase returns to growers, especially in the early years of a planting. There is evidence that these orchards have double the returns of traditional low-density plantings. Considerable experience has been acquired in China, with closer plantings expected to increase returns for both small and large landholders.

High-density plantings require canopy management to control the size of trees, and close attention to water and nutrient management is also essential. Experiments in China and Australia
have shown that the optimal time to prune trees is during the first few weeks following harvest, and this research needs to be repeated in the other growing areas. Extension staff also need training in the various aspects and benefits of canopy management. Drought, girdling, pruning and chemical defoliation can improve flowering, and need to be evaluated across different environments.

Many insects and other pests affect the trees, leaves, flowers and fruit, and their impact on grower returns varies from orchard to orchard. Each country’s local industry needs to develop its own system of integrated pest management. Pest management approaches, along with other methods of tree care, must be suited to the needs and abilities of small landholders. Diseases do not generally affect litchi production, apart from downy blight and anthracnose in China, and pepper spot in Australia. The main disorder affecting longan is witches’ broom, endemic to much of South-east Asia.

Litchi and longan fruit are highly perishable and have short shelf-lives, which seriously limits marketing and expansion of the crops. Attempts have been made to reduce postharvest fruit browning and rotting, by heating and cooling the fruit, the use of various packages and packing materials, and application of fungicides and other chemicals. However, the protocols established for the use of these cannot guarantee fruit quality for more than a week or two. Some export industries are based on the treatment of the fruit with sulphur, but this chemical may soon be withdrawn. The development of new postharvest treatments is thus more urgent.

Most of the litchis and longans produced in Asia are marketed locally, with some exports to Hong Kong, Malaysia and Singapore, and to a lesser degree Europe and the Arab States. There are also exports of litchis from southern Africa, Madagascar, and Australia to Europe. Most of the fruit is sold fresh, with one-third of the Chinese crop being dried, and some being processed and canned.

Quarantine issues relating to fruit flies cause problems for exports from Australia and South Africa to Japan and the USA. Disinfection protocols need to be established for the various markets. The market potential within Asia is strong because of the rising affluence in many of those countries. Good-quality fruit from the region is also highly regarded in Europe, although very little market intelligence has been collected. The preferred cultivars, packaging, etc. for the different markets are not known. The potential size and value of each market is also unknown. Restricted freight space is a limiting factor for countries such as Australia, which are some distance from overseas markets. Quality standards are not used in all countries, despite their demonstrated benefits in several markets.

This publication presents the current state of knowledge concerning the history, physiology, culture, and marketing of litchi and longan throughout the world. Although it contains a wealth of documented information from the literature, and the extensive personal experience of the authors within their respective disciplines in association with the crops, it can be concluded that further research into all aspects of these two tropical fruit is required.

Acknowledgements

We thank the authors and external reviewers who contributed to this publication. Special appreciation is given to Professor Sisir Mitra from India, who recognized the importance of a publication on these two crops. Geoff Waite, Lindy Coates and Neil Greer provided the funds for inclusion of the coloured plates.

Christopher Menzel and Geoff Waite
Maroochy Research Station
31 May 2004
Dedication

My first encounter with the tropical fruit litchi, *Litchi chinensis* Sonn., was in July 1977 when I visited northern Queensland during a study tour for fourth-year Agricultural Science students from the University of Queensland. I remember visiting an orchard owned by Ed Brittain and his family in the outer suburbs of Cairns. The trees were quite large at the time, all ‘Mauritius’ or ‘Tai So’. Ed was one of the pioneers of the industry in northern Queensland, and now has a property on the Atherton Tableland, growing mostly ‘Fay Zee Siu’ (‘Feizixiao’), which fruit much earlier than the other cultivars grown. Like many litchi growers, Ed has always had a thirst for information about the crop. To satisfy this, he has read widely, and has organized regular workshops for local enthusiasts.

It was not until the summer of 1980, when I was studying for my PhD, that I eventually experienced the delights of litchi. While on holiday at Noosa on the Sunshine Coast just north of Brisbane, I saw these strange-looking fruit, selling for what I thought was an outrageous 50 cents each. Curiosity got the better of me, and I purchased a few to share with friends, creating a desire to get closer to this little bit of heaven, and initiating a close relationship with the crop that has persisted to this day.

In May 1982, I was fortunate to obtain a research position with the Department of Primary Industries at the Subtropical Fruit Research Station at Nambour, also on the Sunshine Coast. Keith Chapman had left Maroochy to take up a temporary position in Sri Lanka to help the local sugarcane industry. Keith is well known to horticulturists throughout South-east Asia, and is currently based in the Food and Agricultural Organization of the United Nations (FAO) Regional Office in Bangkok, Thailand. In the period before he left, there was a change in the direction of research at Maroochy, with an expansion into exotic tropical fruit such as avocado, mango, litchi, longan, custard apple, kiwifruit, persimmon and macadamia. Up until the late 1970s, the research group had focused primarily on traditional crops such as pineapple, banana, citrus and papaya.

In my first 18 months with DPI, I worked with Brian Paxton, an experimentalist at Maroochy. Brian was very meticulous, and quite experienced at propagating litchis by air-layering. I quickly learned that not all cultivars were the same: ‘Tai So’ (‘Mauritius’, ‘Dazao’) had good fruit but didn’t crop very regularly in the district. On the other hand, ‘Bengal’ looked attractive to the inexperienced litchi consumer, but had a large seed. It was at this time that the ‘Salathiel’ trees on the Research Station started to crop. We were lucky to have received two air-layers from the Department’s Kamerunga Tropical Fruit Station near Cairns. The original tree at Kamerunga was quite large by this time, but had rarely fruited in the tropical environment. It was only when air-layers were brought to the Sunshine Coast that the commercial potential of the cultivar was realized. Andi and Annabel Flower, who owned a litchi orchard at Eudlo near Nambour, propagated and distributed trees to many of the new growers in the district.
The other cultivar gaining popularity at this time was ‘Kwai May Pink’, selected and promoted by Herb Bosworth and his family at Ingham in northern Queensland. This cultivar now dominates litchi plantings in Australia, and fruits regularly in most districts. There was quite a lot of activity in importing and evaluating new cultivars at this stage. Many varieties were introduced by Keith Chapman, Brian Watson from Kamerunga, Don Batten from New South Wales Agriculture at Alstonville, and private nurserymen such as Gordon Vallance. The Australian industry owes a considerable debt to the efforts of these pioneers. Many cultivars such as ‘Salathiel’ and ‘Kwai May Pink’ have now been exported to places as far afield as South Africa, the USA, Israel and Viet Nam.

Brian Paxton left the Department in 1983, and eventually moved to Hawaii, where he operated a very successful tropical fruit business. Brian was replaced at Maroochy by Don Simpson, who had been working with the Department’s postharvest group in Brisbane. The success of the litchi programme at Maroochy was due, to a large degree, to Don’s commitment and enthusiasm. At this time, we were very lucky to receive most of our research funds from the Government, whereas since the 1990s all of our operating and travel costs have been funded by industry levies. The programme was very active, with research into cultivars, flowering, fruit set, nutrition and water management. Geoff Waite has also been active in the litchi research programme at Maroochy, and has developed strategies for controlling the important insect pests.

I have been very lucky to have Geoff as my co-editor. Geoff has visited many countries in the search for predators and parasitoids to control pests such as macadamia nut borer, Cryptophlebia ombrodelta, and erinose mite, Aceria litchii. We were always keen to visit research centres and commercial farms in other districts, especially at the beginning and end of the litchi season, when the fruit was not available on the Sunshine Coast. The other member of the team at Maroochy was Neil Greer, who compiled the first growing guide for litchi producers. Neil was also instrumental in the establishment of ‘Living Lychee’, the national industry newsletter, and edited the first issues.

In February 1986 the group at Maroochy, along with local producers, held the First National Litchi Conference. Key outcomes from this event were the formation of the Australian Lychee (Litchi) Growers’ Association (ALGA), and the establishment of a research and promotion levy to assist industry expansion. This association was modelled on the work of the late Dr Lindsey Milne and his team from the South African Litchi Growers’ Association (SALGA), which coordinates litchi R&D in southern Africa. This group holds an annual research symposium, regular grower meetings, and produces an annual yearbook. There are similar successful grower organizations in China, Thailand, Hawaii and Florida. We were very lucky to have the renowned litchi researcher, Professor Qiming Zhou from Guangzhou, attend our industry meeting in 1986, when he presented a paper on litchi-growing in China. Professor Zhou was one of the original students of George Weidman Groff, who wrote the famous litchi and longan text in 1921.

It was not until June 2000 that the First International Symposium on Litchi and Longan was held, and it was fitting that it was hosted by Drs Huibai Huang and Xuming Huang from the South China Agricultural University in Guangzhou. Both Professors have contributed chapters to this publication, along with Drs Chengming Liu (Cultivars and plant improvement), Erxun Zhou and Hetong Lin. The Second International Symposium was held in Chiang Mai, Thailand in 2003, and was expanded to include other members of the Sapindaceae such as rambutan, Nephelium lappaceum. The late Professor Suranant Subhadrabandhu from Kasetsarit University in Thailand has contributed chapters on production and taxonomy, while his countrymen, Dr Chatree Sittigul and Saichol Ketsa, have assisted with reviews on diseases and postharvest physiology.

I have been fortunate to have had the opportunity to visit the litchi industries in China, Viet Nam, Thailand, Hawaii, Florida, South Africa, Mauritius, Réunion and Central America. These visits have contributed to the exchange of germplasm and ideas about litchi cultivation, between Australia and other countries. I thank my fellow litchi specialists for their collaboration and friendship, especially Trevor Olesen from Australia (external referee), Raffi Stern from Israel (chapters on production, taxonomy and flowering), Tom Davenport from Florida (flowering physiology), and Xuming Huang from Guangzhou (chapters on production, cultivars and fruit disorders). Special mention should be made of Professor Sisir Mitra from India, who had the original idea for a technical publication on
litchi. I have been fortunate to meet Sisir at symposia in Guangzhou, Bangkok and Cairns, and with his colleague, Pravat K. Ray from Rajendra Agricultural University, he has contributed a chapter on propagation for this book. I have also appreciated the support of growers and other colleagues in Australia who have contributed to our research programme, and of PhD students such as Suwit Chaikiattiyos and Susanna Hieke, whose work is cited in this volume (see References).

Dr Deirdre Holcroft has no direct link with the litchi and longan industries, but has contributed an excellent review on postharvest physiology, in collaboration with Professor Hetong Lin from the Fujian Agriculture and Forestry University, and Professor Erxun Zhou from the South China Agricultural University. Deirdre has wide experience in the storage and handling of fruit, with part of her recent career spent at the University of Michigan, and in Stellenbosch, South Africa.

Dr Richard Litz has a long history of research in biotechnology, and has just edited a publication on the topic for CAB International. With his colleagues, Kazumitsu Matsumoto, Simon Raharjo and Witjaksono from Homestead in Florida, he has provided a comprehensive review of activities in litchi and longan.

Dr Lindy Coates is a Principal Plant Pathologist with the Queensland Department of Primary Industries and Fisheries in Brisbane, and has extensive experience in the management of diseases of tropical fruit. She has travelled to Asia, and presented the results of her research at workshops organized by the Australian Centre for International Agricultural Research (ACIAR). In 2003, she published a chapter on tropical fruit diseases in Randy Ploetz’s CABI monograph, and, with colleagues from Thailand and China, has contributed to this volume with a review of litchi and longan diseases.

Dr Ruth Ben-Arie from the Fruit Storage Research Laboratory at Kiryat Shmona in Israel, with assistance from her colleague, Raffi Stern, has contributed to this publication by reviewing litchi and longan processing.

Chinese researchers have produced some excellent publications on litchi and longan, including Ling Yuen Fu’s *An Album of Guangdong Litchi Varieties in Full Colour* (1985), and Zhan Wei Zhang’s *Litchi – Pictorial Narration of Cultivation* (1997). Publications for growers have also been produced in Australia, South Africa, Mexico and India. Victor Galán Saúco and U.G. Menini produced a growing guide for FAO in 1989, but it did not detail the information being collected by litchi specialists in China, Thailand or Viet Nam. There has been a significant expansion in production and knowledge gained of these two tropical fruit in the past 20 years in South-east Asia. This publication is the first text to provide a global overview of litchi and longan cultivation.

References to litchi and longan in China are numerous, and many have been quoted by researchers and enthusiasts. Guangdong, Hainan, Fujian and Guangxi are well known for these fruit, which invariably evoke a Chinese connection for most Western horticulturists. According to Groff (1921), Chinese writers and poets have sung the praises of litchi and longan for centuries, and written about their medical and commercial value. Government officials have encouraged the cultivation of the fruit, protected ancient trees, and disseminated information about their propagation, cultivation, and insect pests and diseases. From the earliest times, travellers to China have reported on the merits of these fruit, and encouraged their introduction into Europe and the USA. It is only in the past 200 years that commercial production has spread to the rest of South-east Asia, India, southern Africa, the Mediterranean, Australia and America.

Sung Chio (Sung Ta-mo) from Fujian, in his 1608 treatise, details 33 auspicious occasions that add to the pleasure of eating litchis. These include ‘the coming of agreeable friends’, ‘facing flowing water’, ‘examining treatises on the litchi’ etc. Then, under ‘Sombre happenings in eating litchis’, he lists 34 unfavourable circumstances such as ‘heavy rains’, ‘having people about who do not like to eat litchis’, ‘listening to bad poems or songs’, ‘appearance of the pine cone variety’ (marking the end of the litchi season), etc.

Groff’s (1921) publication also mentions a ‘Litchi Club’. Part of its by-laws read, ‘Each day, one member acts as Director and procures three thousand fruit as an average, but if there are more, then the pleasure is greater.’ It was suggested that, ‘At the meeting time, members will devote themselves to eating and drinking, and not occupy themselves with poems and songs, but each follow his own
inclination, may either take the tripod for warming tea, play chess, recline upon a pillow or mat, enjoy
fragrant incense, chat, laugh and not bother about anything else. Those who disturb our ideas and
who shirk should be dealt with strictly, while the dilettanti (amateurs) who enter uninvited shall not be
excluded.'

This book is a thank-you to litchi and longan specialists and producers throughout the world.
I hope that it might lead to collaborations with friends and colleagues who appreciate the delights of
these two tropical fruits. On a personal level, I dedicate this book to Sue Ruming. This publication
would have not occurred without her love and support.

Christopher Menzel
Maroochy Research Station
7 June 2004

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1 Origin, History, Production and Processing

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Introduction

Litchi, Litchi chinensis Sonn., and longan, Dimocarpus longan Lour., the two most popular members of the Sapindaceae, produce arillate fruit with sweet, translucent, juicy flesh. The fruit are high in sugar and contain several vitamins and minerals (Table 1.1), and can be eaten fresh, frozen, canned, dried, or processed into juice, wine, pickles, preserves, ice-cream and yoghurt. Both species have a long history of cultivation in China and throughout much of South-east Asia, but only litchi is well known in Europe, Africa and North America. The production of both crops is much less than that of the main tropical fruit such as banana, citrus and mango. However, each constitutes a very lucrative commodity and contributes significantly to the livelihood of several million people throughout South-east Asia.

Litchi and longan share many similarities in origin, history and environmental requirements, as well as in the utilization of the fruit. Except for China, the two crops are relatively new in most countries. Commercial cultivation of litchi was limited to China and Viet Nam before the 17th century and has spread slowly over the past 400 years, whereas longan has developed outside China only in the last 250 years. There has been a very rapid development of both crops in South-east Asia since 1980.

Litchi and longan are adapted to the warm subtropics, cropping best in climates with hot, humid summers and dry, cool winters. Flower initiation in litchi is best below 20°C, while the optimal temperature for leaf and fruit growth is about 30°C (Menzel and Simpson, 1994).

<table>
<thead>
<tr>
<th></th>
<th>Litchi</th>
<th>Longan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (g)</td>
<td>84</td>
<td>81</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>4</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 1.1. Nutritional value of litchi and longan per 100 g fresh weight (Deng et al., 1999).
Temperatures below 2°C damage new leaves, while those below −2°C can kill trees (Ni et al., 1998). The limited environmental adaptability of both crops has confined commercial production mainly to the subtropics (Fig. 1.1).

About 95% of litchi production is in Southeast Asia, with China, Viet Nam, Thailand, India, Bangladesh and Nepal being the most important (Table 1.2). Australia, South Africa and Madagascar are the major players in the southern hemisphere. Countries with smaller production include the Philippines, Indonesia, Israel, the USA, Brazil, Mexico, Canary Islands, Mauritius, Réunion, Zimbabwe and Mozambique. The production season for litchi in different regions is shown in Fig. 1.2. The industry has expanded rapidly in the past 20 years because of increasing interest in exotic fruit in Europe and increasing affluence in Asia, which in turn have provided lucrative returns to growers. However, productivity is low in many countries. Most industries are based on one or two major cultivars, which limits the production season. The fruit also have a relatively short shelf-life, which existing technologies have not been able to improve substantially.

Fig. 1.1. Litchi- and longan-growing areas around the world. 1 = China, 2 = Viet Nam, 3 = Thailand, 4 = Nepal and Bangladesh, 5 = India, 6 = Israel, 7 = Spain, 8 = South Africa, 9 = Madagascar, 10 = Mauritius and Réunion, 11 = Australia, 12 = Indonesia, 13 = the Philippines, 14 = Florida, 15 = Mexico and Costa Rica, 16 = Brazil. Hawaii is not shown.

Table 1.2. Litchi acreage and production in different countries.

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>Production (t)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainland China</td>
<td>588,000</td>
<td>1,280,000</td>
</tr>
<tr>
<td>Taiwan</td>
<td>12,000</td>
<td>108,000</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>30,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Thailand</td>
<td>23,000</td>
<td>81,000</td>
</tr>
<tr>
<td>India</td>
<td>56,200</td>
<td>429,000</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>4,800</td>
<td>12,800</td>
</tr>
<tr>
<td>Nepal</td>
<td>2,380</td>
<td>14,000</td>
</tr>
<tr>
<td>South Africa</td>
<td>1,500</td>
<td>8,000</td>
</tr>
<tr>
<td>Madagascar</td>
<td>3,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Israel</td>
<td>300</td>
<td>2000</td>
</tr>
<tr>
<td>Australia</td>
<td>1,500</td>
<td>5000</td>
</tr>
<tr>
<td>Florida, USA</td>
<td>240</td>
<td>1000</td>
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