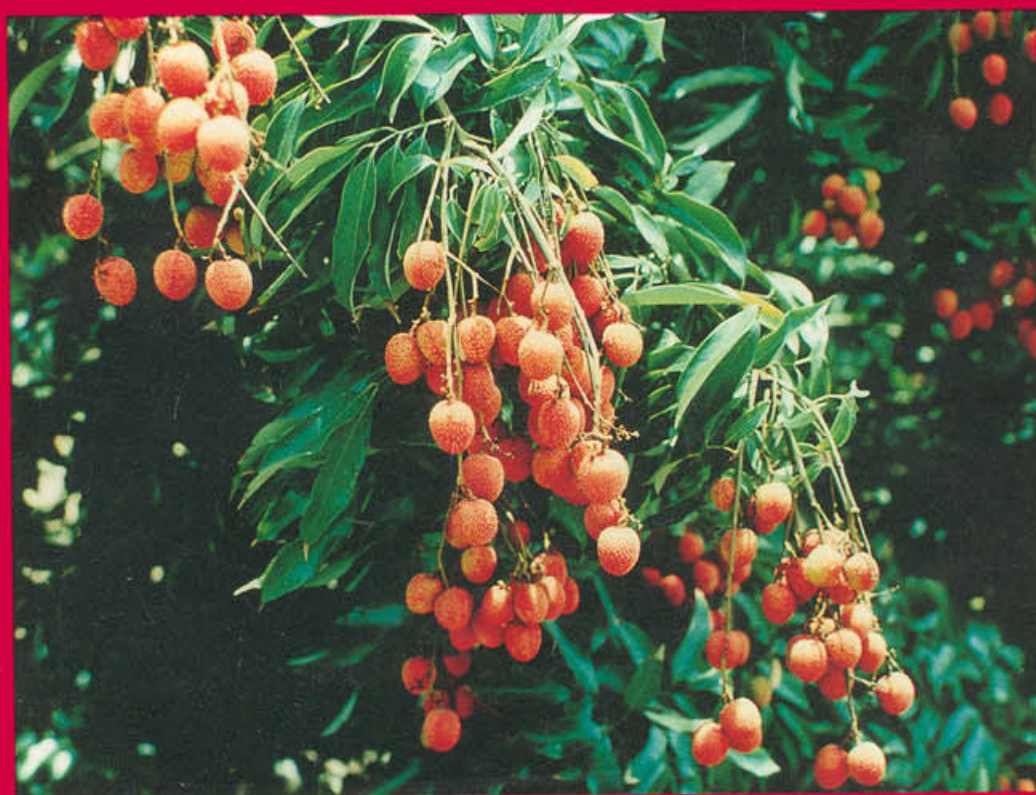




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# LYCHEE PRODUCTION IN THE ASIA-PACIFIC REGION



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
REGIONAL OFFICE FOR ASIA AND THE PACIFIC  
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## FOREWORD

Lychees are cultivated for their very popular fruit and have a long history of acceptance in China and many parts of Southeast Asia. The cultivated lychee originated in the region between southern China, northern Viet Nam and Malaysia. Lychee has a long history in Southeast Asia with unofficial Chinese records going back to about 2000 BC. From about 1600 AD, the species was distributed to much of the tropical and sub-tropical world, but it is currently not widely grown as it does not flower and crop successfully over a wide range of climates.

The major production problems are irregular flowering and poor fruit retention, while alternate bearing and small fruit size can also reduce grower returns. Trees take three to five years to come into production, and will not produce substantial crops until year seven or eight. They require regular chemical control measures for pests and suffer heavy losses to birds and fruit bats in some areas if not netted. The fruits only ripen on the tree and have a very short shelf-life without refrigeration as the crop deteriorates very quickly after harvest.

It was not until the mid- to late-1960s that the first information was collected indicating the effects of climate on flower initiation, pollination and fruit set. During the 1980s and 1990s, there was renewed interest in the crop, especially the effects of temperature and water supply on flower initiation. There was also some effort to develop guidelines for plant protection, watering, fertilizing and canopy management. Various attempts were also made to improve storage and marketing. However, in spite of these efforts much more remains to be done as there is room for more production in the region, but only of the best varieties that can be grown.

Against this backdrop, FAO organized an Expert Consultation on Lychee Production in the Asia-Pacific Region at the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, from 15 to 17 May 2001. Experts from concerned countries participated in the consultation. They were able to identify critical issues needing attention. The report of the consultation was published as RAP publication No. 2001/09 in July 2001, highlighting the major recommendations. This publication collates further useful information in the form of proceedings.

Appreciation is expressed to the participants for their presentation of papers and contribution to the discussions. In particular, sincere thanks must be accorded to Messrs. M.K. Papademetriou and F.J. Dent for compiling and editing this valuable document. Also, the unfailing support of Mrs Valai Visuthi, who provided assistance in formatting the manuscript, is greatly appreciated.

R.B. Singh  
Assistant Director-General  
and FAO Regional Representative  
for Asia and the Pacific

# INTRODUCTORY REMARKS

Minas K. Papademetriou \*

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Welcome to the FAO Regional Office and to this Expert Consultation. This consultation has been organized and sponsored by the FAO Regional Office for Asia and the Pacific. I am grateful to all of you for coming here to contribute to this meeting.

The lychee is one of the popular fruits in many countries of the region. Production is expanding in several countries but more rapidly in China, Viet Nam and Australia, where there is strong demand for exotic fruit and fruit with export potential.

Good progress has been made in lychee development in certain countries of the region, while in others the progress is very limited. The opportunities for further development of the lychee industry appear to be good. However, at the same time there are various and serious problems to be addressed. I am sure that production issues will be adequately deliberated during this consultation and some useful conclusions and recommendations will be drawn.

Strengthening cooperation among countries, institutions and individual scientists in lychee development is very important. This forum will allow us to learn from each other. We must explore the possibilities of sharing our experiences for mutual benefit. It is in this context, that this consultation has been convened. Briefly, its objectives are the following:

- a) To review the status of lychee production in Asia and the Pacific and discuss the problems faced as well as strategies required to overcome existing problems.
- b) Elaborate on the potential and opportunities for lychee development.
- c) Discuss ways and means of strengthening collaboration on lychee research and development.

I wish you all productive discussions and good contacts among one another for the exchange of information, experience and expertise.

Thank you for your attention.

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\* Senior Plant Production and Protection Officer, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

## WELCOME ADDRESS

Ram B. Singh \*

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It is a great pleasure and privilege for me to welcome you to the Expert Consultation on Lychee Production in the Asia-Pacific Region. May I take this opportunity to extend to all of you warm greetings on behalf of the Director-General of FAO, from my colleagues in the Regional Office and myself. Special thanks are due to you all for gathering here to contribute to this meeting.

I am happy to see the positive response which we have received from scientists working on lychee in the Asia-Pacific region. Considering the importance of this crop for many countries in Asia and the Pacific and the need for inter-country cooperation on problems of common interest, we have decided to hold this Expert Consultation in order to elaborate on issues relating to the development of this crop in the region. While appreciating your response to our invitation, I hope this meeting will prove to be productive and beneficial for all the participating countries.

The cultivated lychee originated in the region between southern China, northern Viet Nam and Malaysia. Wild trees can still be seen growing in elevated and lowland rainforest, especially in Guangdong and Hainan Island where lychee is one of the main species. Lychee has a long history in Southeast Asia with unofficial Chinese records going back to about 2000 BC. From about 1600 AD, the species was distributed to much of the tropical and sub-tropical world, but it is currently not widely grown because it does not flower and crop successfully over a wide range of climates.

The lychee is one of the most environmentally sensitive of the fruit tree crops. It is adapted to the tropics and warm subtropics between 13° to 32°N and 6° to 29°S. It crops best in regions with winters that are short dry and cool (daily maximums below 20° to 22°C) but frost free, and summers that are long and hot (daily maximums above 25°C) with high rainfall (1200 mm) and high humidity. Good protection from wind is essential for cropping.

Lychees are cultivated for their very popular fruit and have a long history of acceptance in China and many parts of Southeast Asia. The demand is for large bright red fruit with small seeds and crisp, sweet flesh. China, Taiwan Province of China and Thailand have substantial canning industries. A large proportion of the crop in China was traditionally dried as "dried lychee nuts", and this is the form that many people are familiar with. However, the present destination of the crop is 60 percent fresh, 20 percent canned and 20 percent dried. Fruit can also be processed into pickles, preserves, ice-cream, yoghurt, juice and wine.

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The food value of lychee lies in its sugar content that ranges from 7 to 21 percent, depending on climate and variety. Fruits also contain about 0.7 percent protein, 0.3 percent fat, 0.7 percent minerals (particularly Ca and P) and are reasonable sources of vitamins C (64 mg/100 g pulp), A, B<sub>1</sub> and B<sub>2</sub>.

There are approximately 1,700,000 tonnes of lychee produced in Asia. Total production in the Southern Hemisphere (mainly Africa, Madagascar and Australia) is around 50,000 tonnes. There are also small industries in the USA and south America. This is the reverse situation to the avocado, indigenous to central America, which is popular in northern, central and southern America, and much of Africa.

The largest producers in Asia are China (1,000,000 tonnes), India (430,000 tonnes) Taiwan Province of China (110,000 tonnes), Thailand (85,000 tonnes) and Viet Nam (40,000 tonnes). Further expansion is occurring in these as well as other countries to meet demand generated by the increasing regional affluence. In some of the traditional growing countries of Asia, production is easily outstripped by local demand, although expansion is limited by available horticultural land.

In Southeast Asia, there are about 50,000 tonnes of lychee traded as fresh fruit during the season. Thailand is a major exporter, although longans are more important. Trade is important and expanding in China, Taiwan Province of China and Vietnam. Fresh fruit dominates trade, although there are also exports of dried and canned fruit. In contrast, about 15,000 tonnes are exported to Europe from Madagascar and South Africa.

The crop can be difficult to grow and yield consistently. The major production problems are irregular flowering and poor fruit retention, while alternate bearing and small fruit size can also reduce grower returns. Trees take three to five years to come into production, and will not produce substantial crops until year seven or eight. They require regular chemical control measures for pests and suffer heavy losses to birds and fruit bats in some areas if not netted. The fruits only ripen on the tree and have a very short shelf-life without refrigeration.

Commercial production requires an experienced horticultural manager able to deal with appropriate crop management practices such as irrigation, tree nutrition, considerable pest load etc. There is also a need to have an efficient packing and cool room or other facility to export fruit as the crop deteriorates very quickly after harvest.

The crop has undergone intensive selection in China and there are about 26 cultivars grown commercially. However, four cultivars account for most of the production in Guangdong and Fujian (Fay Zee Siu, Souey Tung, Haak Yip and Wai Chee). Production in other countries is also generally based on Chinese cultivars e.g. Tai So (Hong Huey) and Wai Chee (Kim Cheng) in Thailand; and Tai So, Kwai May (Pink) and Wai Chee in Australia. The only major exceptions are India and the warmer lychee areas of Thailand, where local selections of Chinese imports predominate. During the last 50 years, a few improved cultivars have been bred or selected for commercial release (Sah Keng in Taiwan Province of China, Chacapat in Thailand and Salathiel in Australia). There are limited breeding programmes in Southeast Asia.

Although lychee has a long history in southern China, it is a relatively new crop in most other countries. The amount of research on production is rather small compared with the more established fruit crops such as citrus, banana, pineapple, mango and others. There has been

much speculation regarding the response of the tree to environmental conditions and the implications for productivity.

It was not until the mid- to late-1960s that the first information was collected indicating the effects of climate on flower initiation, pollination and fruit set. During the 1980s and 1990s, there was renewed interest in the crop, especially the effects of temperature and water supply on flower initiation. There was also some effort to develop guidelines for plant protection, watering, fertilizing and canopy management. Various attempts were also made to improve storage and marketing. However, in spite of these efforts much more remains to be done as there is room for more production in the region, but only of the best varieties that can be grown. In this regard, stronger varietal improvement programmes are needed to identify/develop superior varieties for each agro-ecological zone of each country. At the same time, efforts to expand the harvesting season will be of paramount importance.

Development of the lychee industry in the region will require concerted efforts on the part of the governments and the growers. Collaboration between countries is important and rewarding. In view of the commonality of problems and issues, sharing of information and experience on various aspects of lychee production could lead to quicker and less expensive redressals.

Distinguished participants, we in FAO look forward to your advice and guidance concerning an appropriate strategy for the development of the lychee industry in the region. I can assure you of our full support to your efforts.

I wish you success in your present endeavor and a very pleasant stay in Bangkok.



# OVERVIEW OF LYCHEE PRODUCTION IN THE ASIA-PACIFIC REGION

S. K. Mitra \*

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## 1. INTRODUCTION

Lychee (*Litchi chinensis* Sonn.), which originated in southern China and possibly northern Viet Nam belongs to the *Sapindaceae* family. The *Sapindaceae* is a relatively large family containing at least 125 genera and 1,000 species, which are widely distributed in the tropics and warm sub-tropics. The most widely cultivated fruit trees in this family other than lychee are rambutan (*Nephelium lappaceum* L.) and longan (*Dimocarpus longan* Lour.).

The main centre of origin of lychee is believed to be between latitudes 23° and 27° north in the subtropical parts of southern China, northern Viet Nam, and Malaysia. It seems to have been in cultivation since about 1500 BC by people of Malayan descent and has since been subjected to intense selection. China has a long history of lychee cultivation for more than 2000 years and from China it reached Burma (Myanmar) by the end of 17<sup>th</sup> century and was introduced in India and Thailand about 100 years later. Lychee reached Madagascar and Mauritius around 1870 and was introduced in Hawaii in 1873 by a Chinese trader. It arrived in Florida, from India, between 1870 and 1880 and was introduced in California in 1897. Lychee was probably brought to Australia by Chinese migrants in 1954 and arrived in Israel sometimes between 1930 and 1940. China, Taiwan Province of China, Thailand, India, South Africa, Madagascar, Mauritius and Australia are now major lychee producing countries in the world.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN THE ASIA-PACIFIC REGION

Lychee is widely spread across south China, between latitudes 31° and 18°N and longitudes 101° and 120°E, whereas the commercial production zone lies between latitudes 19° and 24°N (Wu, 1998). In south China lychee has become a major industry since the 1980s. It provides huge scope for employment of the local populace and about 320,000 people are involved in this industry. In 1999, lychee output was about 950,000 tonnes from 530,000 hectares for China as a whole. Guangdong Province is the most important area for lychee production in China. Other provinces where lychee grows well include Guangxi, Fujian, Hainan and Yunnan (Chen and Huang, 2000).

In India lychee is grown mainly in the states of Bihar, West Bengal and Uttar Pradesh. It is also grown in limited scale in Tripura, Orissa, Punjab, Himachal Pradesh,

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Assam and the Nilgiri hills in the south. Current production of lychee is about 429,000 tonnes from an area of about 56,200 hectares (Ghosh, 2000).

Lychee is mainly grown in the northern part of Thailand where the climate is classified as sub-tropical. The major concentrations are in Chiang Mai, Chiang Rai, Phayao and Nan provinces in the north and Samut Songkhram in Central Thailand. The production of fresh lychee fruit in Thailand during 1999 was 85,083 tonnes from 22,200 hectares.

Northern Viet Nam includes part of the geographical area where lychee originated. This species has been grown commercially for many centuries near Hanoi, but production has only expanded rapidly in the past five years. The total area under cultivation is about 25,000 hectares, with 10,000 hectares under bearing trees and the total production in 1998 was 27,000 tonnes (Ha Min Trung, 2000).

Lychee is mostly grown in central and southern Taiwan Province of China. The total area under cultivation in 1999 was 11,961 hectares, with 11,580 hectares of bearing trees and 108,668 tonnes of total production (Anon., 2000).

In Bangladesh, lychee is grown in Dinajpur, Rangpur and Ragshahi districts. The total area under cultivation in 1998 was 4,750 hectares with 12,755 tonnes of total production.

Although lychee was introduced into Australia about 60 years ago, major commercial plantings commenced only from the 1970s. Currently, there are about 350 growers with an annual production of about 3000 tonnes. About 50 percent of commercial plantings are found in northern Queensland, 40 percent in southern Queensland, and the balance in northern New South Wales (Menzel, 2000).

### **3. CULTIVARS**

The Chinese consider that the lychee has more cultivars than any other fruit crop. Although over 200 cultivars are grown, only about eight are commercially important in China. In Guangdong Province, the cultivars Baila, Baitangying, Heiye, Feizixiao, Gwiwei, Nuomici and Huaizhi are being cultivated commercially and each of these cultivars covers more than 20,000 hectares. However, Guiwei and Nuomici are most widely cultivated (more than 60,000 hectares under each cultivar). In Fujian Province, Lanzhu is the main cultivar covering about 25,000 hectares (Chen and Huang, 2000).

The most important cultivar of Taiwan Province of China is Hap Ip, which accounts for about 90 percent, and is followed by Yu Her Pau (in the southern area) and No Mi Tsu (in the central area) (Yen, 2001).

The dominant lychee cultivars of India are Shahi, Bombai, China, Deshi, Calcutta, Rose Scented and Mazaffarpur (Ghosh *et al.*, 2000).

There are over 40 cultivars of lychee in Australia. Cultivars currently being planted in northern Queensland on the Atherton Tablelands and coast include Kwai May Pink, Fay Zee Siu and Souey Tung. Kwai May Pink is also popular in central and southern Queensland and in northern New South Wales, along with Salathiel and Wai Chee.

In Thailand the main cultivars are Haak Yip, Tai So and Wai Chee (locally known as Baidum, Hong Huey and Kim Cheng). The lychee cultivars of Thailand are, however, divided into two groups, namely the lowland lychee or the tropical lychee and the sub-tropical lychee. The tropical lychee is well adapted and commercially grown in the Central Region with warm winter months. Almost 20 cultivars are known in this group. The sub-tropical group of lychee grows in the northern part of the country where the winter months are rather cool. About 10 cultivars are known in this group (Yapwattanaphun and Subhadrabandhu, 2000).

A number of local cultivars are found in the northern mountainous provinces of Viet Nam, but most of these are low yielding and sour. There are a number of local cultivars in Ha Tay province (Trang Cat, Yang Anh and Vai Do). The main cultivars are Thiew Thanh Ha, hybrid lychee and Phu Ho. Thiew Thanh Ha is the most popular and more than 90 percent of the production is from this cultivar. Seven cultivars were also imported from Australia and planted in the Luc Ngan District and Ha Giang Province of which Wai Chee and Salathiel appear the most promising.

#### **4. CLIMATIC REQUIREMENTS**

The lychee is adapted to the warm sub-tropics, cropping best in regions with brief, dry, frost free winters and long, hot summers with high rainfall and humidity. Poor production is experienced in most countries. This is often because winters are not cool or dry enough to induce a growth check prior to flowering. Irregular flowering in lychee is related to variations in the timing of flushing. If early flush development, when buds swell, coincides with days of 20°C or cooler, then flower panicles will be initiated. On the other hand, if the warm or the cool weather arrives when the buds are longer than a few millimeters, then the flush will be vegetative (Batten and McConchie, 1995; Menzel and Simpson, 1994). In some parts of southern Queensland, Australia, winter frosts may damage the panicle and developing flowers and limit fruit production in that season. In China, conditions during flowering are often cool and overcast. This can prevent pollination and fruit set. More frequently, conditions during spring and early summer in Australia are hot and dry. Similar conditions are found in the lychee areas of northern India. Flowers may dehydrate and fail to develop, while fruit may drop or split. This is because lychee has a low ability to transport water from roots to leaves. Wet soil alone cannot prevent the development of tree water stress. In Thailand, however, the cultivars are divided into two groups according to temperature requirements for flowering: (i) the cultivars that require no or only a short cool period for flowering (for the central part of Thailand); and (ii) the cultivars that require a longer cool period for flowering (for the northern part of Thailand). In India, the major producing state is Bihar (more than 40 percent of the total area under lychee in India) where a longer cool period before flowering is available in most years. In West Bengal, occasional hot and dry conditions prior to flowering restrict production.

#### **5. PLANTING DENSITY**

Traditionally, lychee trees were planted with wide spacing of 9 or 10 m x 12 m or even 12 m x 12 m, with about 70-80 trees per hectare. Such plantings can have very high yields on a tree basis after 10 or 15 years, but are wasteful of land in the early years. Also, with large trees there are problems with harvesting, spraying and protection from birds and

bats (Menzel *et al.*, 2000). The old plantations in India, Australia, Thailand, and China were planted at a density of 80 to 150 trees per hectare. New orchards in Australia are planted at a closer spacing of 6 m x 8 m or 4 m x 6 m or 7 m x 3 m, equivalent to 200 to 600 trees per hectare (Menzel *et al.*, 2000). In China, starting from the 1980s lychee trees were planted in closer spacing, popularly 5 m x 4 m or 6 m x 5 m, i.e., 330-500 trees per hectare. There are also some extra dense orchards containing 1500 trees per hectare (3 m x 2.5 m) (Chen and Huang, 2000). In India different planting systems (square, hedge row, double hedge, paired planting and cluster planting) as well as density (204 to 453 plants per hectare) are now being investigated under the All India Coordinated Research Project in different locations. Initial results have shown that hedgerow planting is more remunerative during early fruiting years.

## 6. NUTRITION MANAGEMENT

One of the major factors limiting fruit production in lychee is lack of a suitable nutrition programme. Yields may be low because of excessive vegetative growth in winter following late or heavy N fertilization. Deficiencies of N and K, and to a lesser extent of B, Zn and Cu, may limit yield by restricting the set and subsequent development of fruit. Although leaf nutrient standards are available for China, Australia, Thailand and India lychee growers usually apply fertilizers based on canopy sizes, fruit loads or tree age. In China the recommended annual dosage is 0.6 kg urea, 1.2 kg super-phosphate and 0.6 kg of potassium chloride on a five-year-old tree basis, with the N:P:K ratio of 1:0.96:1.3. Fertilizers are generally used separately in three stages, i.e. inflorescence emergence (early to mid-January), rapid fruit growth (early to mid-May) and the time to stimulate autumn flushing (late June to July). However, in most orchards fertilizers are applied frequently and in small doses each time (in many cases over 10 applications of both soil and foliage sprays). A fertilizer schedule based on tree age and canopy size is available for Australia (Menzel and Simpson, 1989). However, these rates are considered as a guide and should be supported by leaf and soil analysis. The suggested rates for a 10-11-years bearing tree with 4.0-4.5 m canopy diameter and 12-16 m canopy cover are 500 g N, 170 g P<sub>2</sub>O<sub>5</sub> and 700 g K<sub>2</sub>O. The recommended application schedule being half the annual amount of nitrogen after panicle emergence and other half after fruit set. The other nutrients (P and K), are supplied in two equal applications, after panicle emergence and after harvest. In India, a fertilizer schedule based on tree age is available which, however, varies in different growing regions. Bearing trees of 7 to 10 years in age usually receive 400-600 g N, 200-300 g P<sub>2</sub>O<sub>5</sub>, 400-600 g K<sub>2</sub>O and 40-50 kg organic manure annually. The full dose of organic manure and three fourths of the total inorganic fertilizers are applied in June-July after harvesting. The remaining one-fourth inorganic fertilizers are applied in early April when fruits grow to pea size.

Tentative leaf nutrient standards based on survey of high-yielding trees in southern Queensland, Australia are available for lychee. Leaf nutrient levels for Guangdong and Guangxi Province of China and for India are also available.

Tentative standard leaf nutrient levels for Australian lychee orchards after panicle emergence during May-August are: 1.50-1.80 percent for N, 0.14-0.22 percent for P, 0.70-1.10 percent for K, 0.66-1.00 percent for Ca, 0.30-0.50 percent for Mg, 50-100 µg/g for Fe, 100-250 µg/g for Mn, 15-30 µg/g for Zn, 10-25 µg/g for Cu, 25-60 µg/g for B, <500 µg/g for Na and <25 percent g for Cl. The suitable leaf nutrient levels for Guangdong Province of China are suggested as 0.93-2.10 percent for N, 0.08-0.21 percent for p and 0.12-0.33

percent for K. In Guangxi, suggested levels are 1.766-1.78 percent for N, 0.25-0.28 percent for P and 0.75-0.92 percent for K. The suitable levels for microelements are 1.5-5.0 mg/kg for available Zn, 1.5-5.0 mg/kg for exchangeable Mn, 1.0-5.0 mg/kg for available Cu, 0.40-1.00 mg/kg for water soluble B and 0.15-0.32 mg/kg for available Mo.

## **7. IRRIGATION MANAGEMENT**

In Australia, India and northern Thailand, trees are irrigated from flowering onwards until the completion of the post-harvest flush. Many orchards in Australia are watered two to three times per week, but this may be excessive. Indeed, in wet growing areas, such as those around Ballina and Nambour, irrigation might be ineffective in many years. In somewhat drier areas however, such as those around Mareeba and Bundaberg, irrigation is likely to be far more important, especially for successful panicle growth, flowering and fruit development. In India, trees it is suggested that trees be irrigated at 30 to 45 percent available soil moisture depletion. However, the growers practice is to irrigate the tree at 7-10 day intervals from panicle emergence to fruit harvest or until the post-harvest flush appears. While drip irrigation is in practice in most of the lychee orchards in Australia, northern Thailand and in some areas in China, surface irrigation (basin irrigation) is followed in India, Viet Nam, Bangladesh and Taiwan Province of China.

## **8. MANIPULATING FLUSHING CYCLES AND FLOWERING**

Lychee trees initiate flowers when early flush development coincides with low temperatures. Consequently, flowering only occurs if new flushes develop during cool weather. Olesen and his co-workers (2000) from Australia suggested four possible ways to alter flushing and induce flowering in lychee. Trees can be hedged to induce one or two vegetative flushes over summer and autumn, and a second or third in winter or droughted in autumn to prevent more than one or two leaf flushes after the preceding harvest. They can also be pruned going into winter to induce flowering directly below the pruning cut. There is also the possibility of using ethephon (1 to 3 l of ethephon and 5 kg of urea per 1,000 l of water) to selectively remove the young red flushes in winter. Full recommendations (Agrilink) for the strategy will be available for Australian growers this year. However, a good flowering is no guarantee of fruit set or a good crop. Investigations by Yuan and Huang (1993) in China found that an extra peak of root growth in May was the characteristic of young 'Nuomici' lychee, which caused serious fruit drop. Zhou *et al.* (1996) found absence of this root growth peak in young 'Huaizu' and also bearing trees of 'Nuomici' showed less fruit drop. Positive response of spiral girdling was observed in China in speeding up the maturation of autumn flushes and in inhibiting winter flushing in favour of flower initiation, in increasing percentage of pistillate flowers, in overcoming excessive fruit drop and in improving fruit size and quality. It is recommended that for flowering, girdling should be made at a stage between the turning green of leaves and flower initiation during the winter, and for fruit setting, immediately after bloom. To promote flowering, 'Feizixiao' lychee trees are usually spiral girdled in mid-November, but 'Nuomici' and 'Guiwei' are spiral girdled in late-November/early December on trunks or scaffold branches 10 cm in diameter. However, to improve fruit set in 'Nuomici' and 'Guiwei' girdling is usually made in early May on branches 5 cm in diameter. The girdling width is 2 to 4 mm, with 1-2 spirals and the distance between two neighbouring spirals is about 6-10 cm. Experimental evidence is available from Thailand for flower induction of lychee in cv. Hong Huay by use of ethephon (100 ppm)

(Subhadrabandhu and Koo-Duang, 1987) and in cv. Bombai by ethephon, potassium nitrate and TIBA spraying in the months of October-December (Mitra and Sanyal, 2000), however, large scale field testing is needed before any commercial recommendations can be made.

## **9. PROBLEM OF FRUIT CRACKING**

Fruit cracking is a major problem of lychee in many lychee growing areas in India and China. Among the cultivars grown in India, Early Large Red, Deshi, Muzaffarpur and Elaichi are more prone to crack (Mitra and Ghosh, 1991) while the high priced Nuomici and Gwiwei cultivars in China are susceptible to cracking (Chen and Huang, 2000). Plant growth regulators and integrated management showed some positive results in lowering the cracking rate (Li *et al.*, 2000).

## **10. MAJOR PESTS AND DISEASES AFFECTING PRODUCTION**

Over 58 species of pests have been reported damaging lychee trees in China. Of these the major pests are lychee stink bug (*Tessaratoma papillosa*), lychee barking miner (*Conopomorpha sinensis*), lychee longhorn beetle (*Aristobia testudo*), lychee midge (*Dasineura* sp.) and Erinose mite (*Eriophyes litchi*) (Ren and Tian, 2000). Erinose mite is the most serious pest of lychee in India, Thailand and Viet Nam. The macadamia nut borer (*Cryptophlebia ombrodelta*) is the most serious pest of lychee in Australia. However, the most devastating damage is caused by flying foxes amounting up to 50 percent of the crop loss in Australia. Fortunately, the lychee growers in other countries of the Asia-Pacific are not facing the problems of flying foxes. Protocols exist for control of most of the other pests in different countries. There are about 25 species of natural enemies of lychee pests. Of these egg parasitoid, *Anastatus* spp. for controlling stink bug, nematode *Steinernema carpocapsae* for controlling longhorn beetle and predaceous mite *Agistemus exsertus* for controlling erinose mite have been used successfully.

There are no serious diseases of lychee. The 'sudden death' phenomenon is, however, observed in Australia, China and Viet Nam. Initial findings suggest that sudden wilt is a soil-borne disease, associated with *Fusarium solani*, *Phytophthora* sp. and *Phythium* sp. Poor drainage, deep planting and inadequate nutrition favour the disease (Ha Minh Trung, 2000). A number of diseases affect lychee after harvest, which are generally not apparent during harvest and packing. They develop as the fruit reach the end of their post-harvest life. Several fungi have been associated with disease symptoms affecting the sides of fruit or around the stem end. Among the post-harvest diseases, anthracnose (*Colletotrichum gloeosporioides*) is mainly responsible for such loss in China, Australia, Taiwan Province of China, Thailand and India.

## **11. HARVESTING OF FRUITS AND YIELD**

Only few fruits can be compared with the taste of a fully mature lychee fresh from the tree. If growers take care to harvest their fruit only when it is fully mature and then grade, treat and pack it properly, consumers can enjoy that same delicious flavour, and the market for the fruit will develop quickly. Maturity standards based on TSS/acid ratio, fruit weight, peel colour etc., have been standardized for most of the commercial cultivars of India,

Australia, China, Taiwan Province of China and Thailand. Lychees are harvested manually in bunches along with a portion of the branch and few leaves. The panicles are cut from the tree with secateurs or harvester meant for the purpose. In most countries, ladders, cherry pickers and picking bags are used.

Average lychee yields range from 1 to 15 tonnes per hectare in different countries of the world. In Taiwan Province of China, the productivity is about 9.4 tonnes/ha compared with 7.63 tonnes/ha in India, 3.83 tonnes/ha in Thailand, 2 tonnes/ha in Viet Nam, 1.8 tonnes/ha in China and 1.66 tonnes/ha in Australia.

## **12. POST-HARVEST MANAGEMENT**

Once lychees are picked, they start to dry out and brown. The mechanisms of pericarp browning, colour retention, and pulp quality maintenance have been the worldwide focus of lychee post-harvest biology research. Progress has been made in lychee pericarp browning and colour maintenance. Fruits should be kept in high humidity and cooled to 5°C as quickly as possible. Hydro-coolers or cool rooms are frequently used for this purpose. Sulphur fumigation has so far been the main post-harvest handling technology in prevention of lychee browning and maintenance of fruit quality. However, it has recently been questioned by both scientists and customers due to the chemical S residues and off-putting taste.

At the moment the cool-chain system can provide satisfying resolution to lychee transportation, storage and marketing problems in developed countries. However, the cool-chain system is still at the very early stage of establishment in developing countries such as China, India, Thailand, Viet Nam, Bangladesh and some other Asian countries.

## **13. INTERNATIONAL TRADE**

Among the major international markets Hong Kong and Singapore receive approximately 12 to 15 thousand tonnes of lychee from China and Taiwan Province of China during June-July. Taiwan Province of China exported about 5,900 tonnes of lychee in 1999, and the main destinations were Philippines (1,735 tonnes), USA (1,191 tonnes), Japan (933 tonnes), Canada (930 tonnes), Thailand (489 tonnes) and Singapore (408 tonnes).

The European markets absorb about 20,000 tonnes of fresh lychee of which nearly 50 percent was imported by France alone and the rest mainly by Germany and the United Kingdom. The market is especially lively between Christmas and New Year's Day. The main suppliers are Madagascar (80 percent), and South Africa (12.6 percent) during this period. The same markets also receive a small quantity from Australia during Christmas and from Thailand between July and August (400 tonnes), India (about 25 tonnes), China and Taiwan Province of China. The lychee market in the United Arab Emirates, Saudi Arabia, Yemen, Lebanon, Dubai and Canada are expanding and can absorb a few hundred tonnes more fresh lychee. Except for Australia (exporting about 25-30 percent of the total production), the other lychee producing countries in this Region are exporting very little (0.2-5.5 percent) of their total production. The reasons are mainly that all the producing countries have a good domestic market and lack proper cool-chain and other exporting facilities. Small quantities of lychees are, however, frozen and canned (about 2,500 tonnes in China, and 500 tonnes in

Taiwan Province of China) and exported to Japan, USA, Canada, Malaysia, Republic of Korea and Australia. About one third of the total production of China (300,000 tonnes) was dried in 1999 as lychee nut, which were marketed domestically and also exported to Southeast Asia.

#### 14. DEVELOPMENT STRATEGY

The expansion of the fresh lychee market will depend mainly on: (a) availability of high quality fruits in abundance, (b) availability for a longer period by lengthening of fruiting seasons, and (c) emergence of new supplier countries capable of transporting fruits by sea.

China is rich in lychee germplasm of lychee and some high yielding, good quality lychee cultivars/clonal lines have already been identified. Further breeding efforts, including molecular breeding, offer good scope for developing promising cultivars of lychee for greater adaptation and higher yield. Already, the major production zones in this Region are distributed in such a way that good quality fruits are available both in November-December (Australia) and May-August (India, China, Taiwan Province of China, Thailand). The experience of Israel, Taiwan Province of China and Mauritius has shown that further lengthening of the fruiting season is possible. Technologies to enhance shelf life through temperature management during storage and transportation are available. Consequently, the supply of good quality lychee for fresh fruit markets all the year round should receive a major development thrust.

Market restructuring for lychee is essential. Presently Europe is the main destination and fresh fruit is the major commodity market. New markets and product diversification, new products, new packaging, organic lychee and others are new options.

#### REFERENCES

- Anonymous 2000. Taiwan Agricultural Yearbook. Department of Agriculture and Forestry, Taiwan Provincial Council.
- Batten, D.J. and C.A. McConchie. 1995. Floral induction in growing buds of lychee (*Litchi chinensis*) and mango (*Mangifera indica*). Australian J. Pl. Physiol., 22 : 783-91.
- Chen, H. and H. Huang. 2000. China litchi industry : Development, achievements and problems. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 18.
- Ghosh, B., Mitra, S.K. and D. Sanyal. 2000. Litchi cultivars of West Bengal, India. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 25.
- Ghosh, S.P. 2000 World trade in litchi : Past, present and future. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 16.
- Ha Minh Trung. 2000. Lychee Production in Viet Nam – prospects and problems. Proc. 5<sup>th</sup> National Lychee Conf., Twin Waters, Australia, pp. 83-87.
- Li, J., Huang, H., Gao, F., Huang, X. and H. Wang. 2000. An overview of the research in litchi fruit cracking. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 46.
- Menzel, C. 2000. The physiology of growth and cropping in lychee. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 37.



- Menzel, C. and D.R. Simpson. 1989. The lychee nutrition story. Proc. Second Nat. Lychee Seminar, Cairns, Australia, pp. 49-58.
- Menzel, C. and D.R. Simpson 1994. Lychee. In The Handbook of Environmental Physiology of Fruit Crops. Vol. II. Subtropical and Tropical. (B. Schaffer and P.C. Anderson, Eds.). CRC Press, Boca Raton, Florida, USA, pp. 123-41.
- Menzel, C., Olesen, T. and C.A. McConchie. 2000 Marketing profit from lychees in Australia. Proc. 5<sup>th</sup> National Lychee Conf., Twin Waters, Australia, pp. 5-15.
- Mitra, S.K. and B. Ghosh. 1991. Description and performance of some lychee cultivars in West Bengal, India. Australian Lychee Yearbook, 1 : 64-70.
- Mitra, S.K. and D. Sanyal. 2000. Effect of cincturing and some chemicals on flowering of litchi cv. Bombai. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 40.
- Olesen, T., Menzel, C., Wiltshire, N. and C.A. McConchie. 2000. Manipulating flushing cycles and flowering in lychee. Proc. 5<sup>th</sup> National Lychee Conf., Twin Waters, Australia, pp. 47-52.
- Ren, S. and M. Tiang. 2000. Litchi pests and their natural enemies. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 74.
- Subhadrabandhu, S. and A. Koo-Duang. 1987. Effect of ethephon on flowering of two lychee (*Litchi chinensis* Sonn.) cultivars. Acta Horticulturae, 201 : 181-86.
- Wu, S.X. 1998. Encyclopaedia of China Fruits : Litchi. China Forestry Press, Beijing.
- Yapwattanaphun, C. and S. Subhadrabandhu. 2000. Litchi cultivars in Thailand. Abst. 1st Int. Symposium on litchi and longan. Guangzhou, China, p. 24.
- Yen, Chung – Ruey. 2001. Personal communication.
- Yuan, R.C. and H.B. Huang. 1993 Regulation of root and shoot growth and fruit drop of young litchi trees by trunk girdling in view of source-sink relationship. J. Fruit Sci., 10 : 195-98.
- Zhou, X.J., Wu, D.Y., Huang, H.B., Lai, J. and D.F. Huang. 1996. Manipulating growth and fruiting of young litchi trees by spiral girdling. Acta Hort. Sinica, 23 : 13-18.

# LYCHEE PRODUCTION IN AUSTRALIA

Christopher Menzel \*

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## 1. INTRODUCTION

Although lychee was introduced to Australia more than 60 years ago, major commercial plantings only commenced in the 1970s. The crop can be difficult to grow and yield consistently. The major problem is irregular flowering and poor fruit retention, while alternate bearing and small fruit size reduce grower returns in some districts. Trees take three to five years to come into production, and will not produce substantial crops until year six or eight. They require regular chemical control measures for pests and suffer heavy losses to birds and fruit bats if not netted. The fruit only ripen on the tree and have a very short shelf-life without refrigeration.

Successful production requires an experienced horticultural manager able deal with irrigation, tree nutrition and considerable pest load. You also need to have efficient packing and cool room facilities as the crop deteriorates very quickly after harvest.

Australia has an advantage in the international market with production during the Northern Hemisphere “off season” including the lucrative Christmas and Chinese New Year festivities. Demand for high quality product far exceeds Australia’s ability to supply. There are also opportunities in the domestic market, although some promotion and retail/consumer education are required.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION

Currently, there are about 320 growers with production of 3,500 tonnes from 1,500 hectares worth A\$ 15M. Production has steadily increased over the past decade (see Figure 1)

About 50 percent of production is in northern Queensland (Cairns, Ingham, and the Atherton Tablelands), 40 percent in central and southern Queensland (Rockhampton, Bundaberg, Gympie, Nambour and Caboolture) and only 10 percent in northern New South Wales (see map). The season lasts from about October in northern Queensland to March in northern New South Wales. Longan trees are often grown in the same orchards. Production of longan, however, is much smaller, with less than 1,000 tonnes.

Trees perform best on well-drained clay loam soils of medium to high fertility, with a minimum of one metre of well-drained topsoil. Trees may die on heavy clay soils, which become waterlogged. There can also be problems on very sandy soils during hot weather in

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northern Queensland. Slopes greater than 15 percent are best avoided as they will not allow safe use of machinery for pest control, tree management, harvesting and may lead to erosion.

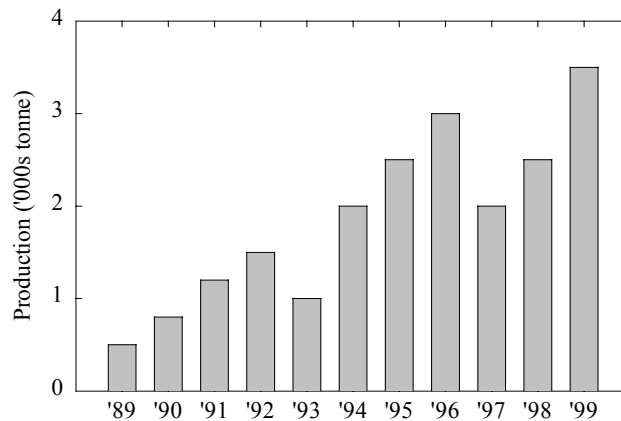
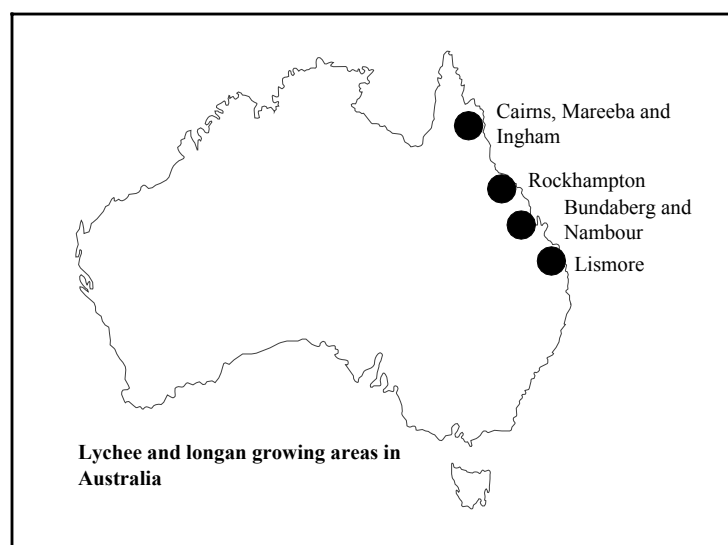


Figure 1. Lychee production in Australia.

Lychees require a period of cool weather (15° to 20°C) for successful flower initiation, but may be killed by frosts. Hot dry weather after fruit set has also been implicated in fruit drop, fruit browning and splitting. Fruit under these conditions do not develop full red colour. Trees are also susceptible to wind damage, and should be protected by windbreaks.

Irrigation is normally required to produce commercial crops, but care must be taken with water quality. Water with an electrical conductivity of more than 600 to 1,000  $\mu\text{S}$  per cm or dissolved salts of more than 500 ppm may reduce productivity. It is generally considered that about two to four ML of stored water is required for each hectare of trees.



One person should be able to handle about 5 to 7 hectares of mature trees without the need for other staff, except during harvesting and packing. Depending on the yield and spread of cultivars, up to five to ten staff would be required for harvesting over summer. Basic equipment required would include: an under-tree sprinkler irrigation system, tractor, sprayer, slasher or mower, trailer, harvesting equipment, netting and a packing shed and cold room.

There are over forty cultivars in Australia. However, the development of the industry has been hindered by lack of performance data for the major production regions. This has been accentuated by difficulties in identifying cultivars. Highest prices are paid for early and late fruit with strong skin colour, firm flesh, aromatic flavour, high proportion of edible flesh and small seed.

Cultivars currently being planted in northern Queensland on the Atherton Tablelands and coast include Kwai May Pink (Bosworth Number Three), Fay Zee Siu and Souey Tung, the later two being quite early. Kwai Mai Pink is also popular in central and southern Queensland and in northern New South Wales along with Salathiel, and the late cultivar Wai Chee.

### **3. PRODUCTION OF PLANTING MATERIAL**

New orchards are usually established with marcots or air-layers. These sell for about A\$ 10 each and are supplied by private nurseries. Many growers propagate their own material. Trees can also be propagated by grafting and cutting, but typically these have only been used for research experiments. Lychee cuttings are slow to establish in the field, while there can be incompatibility between some cultivars and rootstocks.

### **4. ESTABLISHMENT OF ORCHARDS**

A well-managed orchard should have a long commercial life. Hence, close attention to orchard layout and land preparation will have their rewards for many years. Growers need to make decisions on row direction, spacings, placement of waterways and drains, mounding, wind protection and all weather access to the block. Local horticulturists can help with the layout of the orchard and care of young trees. Details are also available in the Queensland Department of Primary Industries Lychee Information Kit.

Plantings generally range from 100 to 300 trees per hectare. Recommended spacings are 12 m x 6 m for spreading cultivars such as Fay Zee Siu and Souey Tung (equivalent to 140 trees per hectare), and 6 m x 6 m for upright or low vigour cultivars such as Kwai May Pink, Salathiel and Wai Chee (equivalent to 280 trees per hectare). Internationally, higher density plantings have given greater returns, but these types of orchards are only experimental in Australia.

Tree rows are usually considered to best run north-south, but erosion and operator safety should be considered. Strong winds can seriously affect tree growth and production, so windbreaks need to be considered in most localities.

A soil analysis (including soil pH) before planting will indicate any potential nutrient deficiencies or imbalances, which can be corrected. These results can be discussed with local horticulturists. Some soils need an application of lime, phosphorus, nitrogen and some organic matter into the planting site. Many growers plant a manure or cover crop before planting and incorporate this organic matter into the soil to improve soil texture, fertility and orchard establishment.

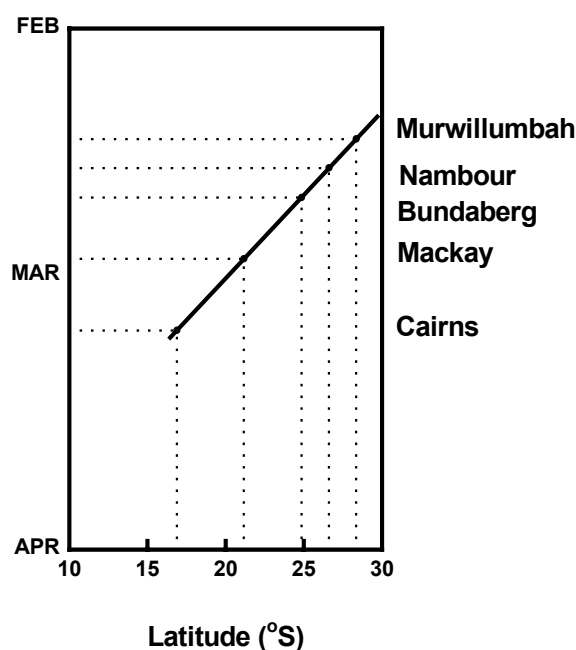
Irrigation is generally considered essential for regular production in most of the commercial growing areas of eastern Australia, and is normally provided by under-tree sprinklers. These systems can also be used to fertigate trees. In dry areas, the young plants will generally require watering at least weekly until they are well established.

## **5. CARE AND MANAGEMENT OF ORCHARDS**

### **Canopy management**

Horticulturists demonstrated that it is possible to prune lychee orchards in Australia to maintain tree size and promote flowering and cropping. This was a collaborative project between the Queensland Department of Primary Industries and CSIRO Plant Industry with funding from the Rural Industries Research and Development Corporation (RIRDC) and the Queensland Fruit and Vegetable Growers (QFVG). This work followed on from research in Israel.

These workers developed a model of flushing against radiation and temperature that was used to predict the optimum time of pruning along the eastern coastline of Australia. This model was then validated in commercial orchards. The model showed that flushing is slower in the southern, cooler, cloudier areas (e.g. Ballina in northern New South Wales) and that pruning must be carried out much earlier than in the northern, warmer, sunnier locations (e.g. Mareeba in northern Queensland); (see Figure 2). Should a tree fail to flower in autumn, a second opportunity can be provided using ethephon as a selective desiccant to remove young growth and promote the initiation of a new flush. Trees pruned at the optimum time were shown to have similar yields on a canopy surface area basis as productive non-pruned control trees.



**Figure 2. Latitudinal variation in the estimated optimum date of pruning for lychee in eastern Australia.**

## **Irrigation**

Work in South Africa with Australian horticulturists showed that a severe drought from just after panicle emergence through to harvest reduced both yield and fruit size in Tai So, such that the gross return per tree dropped from A\$ 250 to A\$ 35. However, in Australia, a mild drought after flowering actually increased yield, although this was at the expense of fruit size. These two studies showed that lychee trees are capable of extracting soil water at considerable depths in most soils, and can produce acceptable yields with fairly long intervals between waterings. Many orchards in Australia are watered two to three times per week, but this may be excessive. Indeed, in wet growing areas, such as those around Ballina and Nambour, irrigation might be ineffective in many years. In somewhat drier areas, however, such as those around Mareeba and Bundaberg, irrigation is likely to be far more important, especially for successful panicle growth, flowering and fruit development.

Irrigation is preferably related to actual water use by monitoring soil water levels with a neutron probe or an Enviroscan system. Tensiometers are less reliable. An acceptable cycle in a sandy loam soil would be two to three weeks, and considerably longer in a clay soil with greater water holding capacity. Irrigation in a sandy loam soil before 50 percent of the available soil water is used would maintain tree water levels in the acceptable range. The soil profile should be brought back to field capacity with every irrigation.

## **Nutrition**

Suggested amounts for well-grown trees at year ten are 1,000 g N, 450 g P and 1,200 g K. Results indicate that lychees are not likely to respond to fertilizers in the season of application. Nor is it likely that the timing of fertilizer applications will affect yield. For most nutrients, there is little impact on production over a fairly wide range of leaf nutrient

concentrations. Badly run-down trees, however, may take many years to recover. The cost of soil and leaf tests is small compared with the savings to production, fertilizer costs and the environment.

Nutrition is based on leaf and soil standards developed from surveys of high-yielding trees in the late 1980s, with samples collected after panicle emergence in winter. Leaf standards are: 1.5-1.8 percent for N; 0.14-0.22 percent for P; 0.70-1.10 percent for K; 0.60-1.00 percent for Ca; 0.30-0.50 percent for Mg; 50-100 µg per g for Fe, 100-250 µg per g Mn; 15-30 µg per g for Zn; 10-25 µg per g for Cu; 25-60 µg per g for B; <500 µg per g for Na; and <0.25 percent for Cl.

Soil standards are: 5.5-6.0 for pH; 1.0-3.0 percent for organic carbon; <200 µS per cm for electrical conductivity; <250 mg per kg for Cl; <1.0 meq per 100 g for Na; <10 mg per kg for NO<sub>3</sub>-N; 100-300 mg per kg for P; 0.5-1.0 meq per 100 g for K; 3.0-5.0 meq per 100 g for Ca; 2.0-4.0 meq per 100 g for Mg; 1.0-3.0 mg per kg for Cu; 2-15 mg per kg for Zn; 10-50 mg per kg for Mn; and 1.0-2.0 mg per kg for B.

Trees can take a very long time to respond to applied fertilizers, and a good example is shown for the response of lychee to nitrogen (N). This work followed on from the nutrient surveys. It took four years without N fertilizer to show significant reductions in yield of cultivar Bengal in southern Queensland compared with fertilized trees. Yield increased from 20 to 60 kg per tree as leaf N in August increased from 0.95 to 1.56 percent. In the same study, timing of fertilizer application (summer vs. winter or split between summer and winter) had no effect on yield. These results compare with maximum shoot growth in lychee seedlings in sand culture experiments with leaf N concentrations of 1.4 percent, the maximum N level obtained. The impact of higher N concentrations, up to 2.0 percent on production needs to be investigated, but at this stage, a value of 1.5-1.8 percent is recommended.

In contrast to the results obtained for N, similar experiments over three years with P and K on Tai So and Kwai May Pink, gave no symptoms of deficiency or excess with 0 to 2.4 t P per hectare or 0 to 3.2 t K per hectare, which are about ten times industry recommendations. Leaf P and K fell only slightly over time in trees given no fertilizer. Generally, fruit production was similar over the range in leaf P of 0.18-0.44 percent, and leaf K of 0.75-1.37 percent, compared with the industry standards of 0.14-22 percent for P and 0.70-1.10 percent for K. These results suggest that annual applications of P and K may not be required in lychee orchards with large amounts of extractable P and K in the soil, with savings for growers. No further nutrient experiments have been initiated in the past seven years. There have been no data collected to suggest that the rate or timing of fertilizer applications have any influence on flowering.

## **Girdling**

Girdling (cincturing) can be used to control the timing of flushes so that they occur when temperatures are ideal for flowering. Girdling is performed on the lower part of the tree or major branches and involves removing a ring of bark and the conducting tissue below it, down to the hard wood. The ring is cut with a hacksaw, 3 mm wide and deep. Girdling stops shoot growth for two to three months. Once the cut has started to heal, shoot growth is resumed. If temperatures are suitable for floral induction, the new shoots will flower and crop.

Experiments have also been conducted to examine the potential of girdling after flowering as a means of increasing fruit retention. Branches were girdled either 0.5 or 1.0 m from the fruit cluster about a month after fruit set. In other experiments, trees were girdled on the trunk just above the soil line. There was a 3-fold increase in the number of fruit at harvest in Tai So branches girdled at 1.5 m from the fruit cluster compared with controls, and a 35 percent increase in yield in Kwai May Pink and Wai Chee trees girdled in the lower trunk.

These experiments have shown that girdling can be used to increase production, but further research is required to assess the long-term effects on tree health, before these techniques are widely adopted by industry.

## Major pests

Up to 50 percent of the crop can be lost to birds and bats in some orchards. Various forms of netting are effective, but can be expensive, at A\$ 8,000 to A\$ 20,000 per hectares. However, some of these nets will also exclude fruit piercing moths and, possibly, macadamia nut-borer. Orchards must be profitable for the costs of netting to be viable. In some circumstances, other options are more practical.

Lychee is also prone to a great range of invertebrate pests, some of which can seriously reduce yields if not controlled. Protocols exist for determining when to spray for a few of these pests, but for the most part, growers tend to spray according to the calendar and weather. The cost of pesticides is small compared with the higher yields and quality obtained.

Erinose mite (*Aceria litchi*) is a major pest and causes a brown felt-like growth on the developing leaves, flowers and fruit. It can be very difficult to eradicate once established in an orchard. Recommended control is with three sprays of dimethoate or wettable sulphur at two to three week intervals to coincide with the elongation and expansion of new leaf flushes. New marcots should be treated before they are planted.

Macadamia nut-borer attacks every season, and can devastate the crop. Larvae mainly develop in green fruit with significant seed development, but before there is a large amount of flesh. Sprays of azinphos-methyl need to be applied to coincide with the hatching of the oldest 10 percent of the eggs so that the newly emerged larvae will be killed before they enter the skin of the fruit. Effective control generally requires a minimum of two to three sprays. Flower caterpillars (*Lobesia* spp., *Isotenes miserana*, *Prosotas* spp. and *Phycita leucomiltra*) are major but occasional pests, which can be readily controlled with endosulfan or carbaryl. Trees should be sprayed before the flowers open.

The fruit spotting bug (*Amblypelta nitida*) and the banana spotting bug (*A. lutescens*) are common in southern districts, while the banana spotting bug is limited to central and northern Queensland. These bugs cause the developing green fruit to drop. Generally, lychees are less susceptible once the fruit have started to colour. Two sprays of endosulfan starting two weeks after fruit set will generally provide adequate control.

Adult fruit piercing moths (*Othreis fullonia* and *Eudocima salamina*) cause much damage by piercing the skin of ripening fruit and sucking out the juice. No chemical control is available for these large nocturnal moths, although nets with a mesh of 15 to 20 mm will



effectively exclude them. These nets will also exclude birds and flying foxes. A smaller mesh with a cross hair would also keep out some macadamia nut-borer and elephant beetles. These cost from A\$ 15,000 to A\$ 25,000 per hectare.

## **6. HARVESTING OF FRUITS AND YIELDS**

The season commences with cultivars Fay Zee Siu in northern Queensland in October and finishes with cultivar Wai Chee in northern New South Wales in March. At any one location, harvesting normally lasts about six weeks with a spread of cultivars. Fruit do not ripen off the tree, so must be picked mature as indicated by a minimum brix:acid ratio of 35:1 (ripe fruit generally have a much higher ratio). Maturity can be judged by the shape, size, colour and flavour of the fruit, which varies greatly with cultivar. Fruit become bland if picked over-mature.

Fruit should be harvested early in the morning before they warm up. Some growers pick early season fruit individually off the panicle (spot picking). Generally, however, the bulk of the crop is picked in clusters. Once lychees are picked, they start to dry out and brown. Fruit should be kept in a high humidity and cooled to 5°C as quickly as possible. Hydro-coolers or cool rooms are frequently used for this purpose. After picking, fruit are destalked and sorted visually on mechanical conveyors to remove small, poorly coloured or damaged specimens.

Industry quality standards have been developed. Extra class must be practically free of defects, and typically comprises no more than 10 percent of the crop. First class fruit can have moderate defects with skin blemishes not exceeding 60 mm<sup>2</sup> in total on any one fruit. Other standards operate for other segments of the industry that have a commitment to quality assurance and are members of the United Lychee Marketing Association (ULMA).

To reduce water loss and browning, fruit are marketed in bulk packages in 9 L cartons that hold 5 kg of fruit and packed in two 2.5 kg low-density crispywrap bags (with small pores) or polybags. Fruit can also be packed in 250 g punnets, with a cling wrap film. Fruit should be free of surface moisture before being packed to reduce the potential for disease development. Fruit are normally shipping by refrigerated road transport. This system retains the red skin colour and greatly prolongs shelf-life. However, once the retailers open the bulk packs, fruit begin to deteriorate under air conditioning in the stores.

Research into extending shelf-life was active in the mid-1980s and again in the early 1990s. Lychees deteriorate rapidly after harvest. Several strategies have been developed to extend the shelf-life of fruit, and thereby 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. Experiments have also been conducted with sulfur, acid dips, hydro-cooling and other techniques to maintain the red skin, but none of this research has improved eating quality. CSIRO Plant Industry in Brisbane and Sydney is examining new approaches.

## **7. MARKETING**

Fruit are sold at the farm gate, consigned to the wholesale markets in Brisbane, Sydney or Melbourne or exported. Growers can handle marketing individually or join one of the lychee marketing groups. If sending fruit to some of the southern markets, quarantine restrictions must be adhered to. These restrictions vary from season to season.

The bulk of production is sold locally either at the farm gate or through the central markets, with about 30 percent exported. Exports have risen sharply in the past few years with improvements in post harvest handling and the development of cooperative marketing groups and quality assurance programmes. These groups export about 60 percent of their crop.

The main markets are Hong Kong, Singapore, French Polynesia, United Arab Emirates and the United Kingdom. Average net returns to the growers are about A\$ 5.50 per kg. This is after taking into account the costs of freight, commissions and agent's fees etc. At this stage the lucrative markets of Japan and the United States are not available due to quarantine restrictions associated with lychee being considered a host of fruit fly.

Marketing groups were established in the early 1990s, and are now the largest exporters. Groups are based in northern, central and southern Queensland. 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. The groups generally achieve a premium of A\$ 1 to A\$ 2 per kg above the average market price. Average prices have increased over the past few years despite an increase in production.

## **8. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT**

The Industry has the objective of producing 1 percent of the world's lychees by 2010. With total world production of about 1 million tonnes, this represents a crop of about 10,000 tonnes, nearly three times present production. Australia has many advantages in growing and marketing lychees. Production and post-harvest technology is reasonably advanced. Many growers have a business background bringing with them new skills, innovation and off-farm income. The production season is long, stretching from October in northern districts to March in southern areas, while the main cultivar, Kwai May Pink is well respected in domestic and export markets.

The industry also has a long history of grade standards, quality assurance and cooperative marketing. There has also been a strong commitment to exporting. Australia has a number of real advantages when competing with Madagascar, South Africa and Reunion. Whereas most fruit exported from these Southern Hemisphere competitors is chemically treated, Australian fruit do not receive any post-harvest sprays or dips. Australia also has close proximity to the expanding Asian market where it can supply fruit out-of-season. The close association between industry and research providers also offers a competitive advantage to Australian growers.

## **9. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

The industry is based in Queensland, with a few growers in northern New South Wales. Farms are scattered along the eastern coastline across a range of climates, soil types, pest pressures, availabilities and costs of labour, and distances to markets. There are few farms given entirely over to lychee production. Income from lychee is commonly supplemented with income from other crops or from off-farm sources. Most orchards are relatively small, with fewer than 1,000 trees.

While the returns for lychee can be very lucrative, there are risks associated with its production and marketing. Many orchards are inherently low yielding due to the cultivar selected or the location of the planting. Even in an ideal location, there can be problems with flowering or fruit set. The crop is also susceptible to a broad range of pests, while harvesting and packing are very labour intensive and costly. The fruit are susceptible to browning and rotting, and thus have a relatively short shelf-life when stored and transported under existing technology. This creates problems in both the domestic and export markets, even for growers committed to grade and quality standards.

The industry has come a long way since the First National Conference on the Sunshine Coast in 1986. Production has expanded and markets grown, but probably not at the rate suggested some fifteen years ago. There were several resolutions passed at the Nambour Conference that have impacted on the lychee industry. Grade and maturity standards have been developed, and the peak industry body, the Australian Lychee Growers' Association was formed in the late 1980s. There was also a call at the Conference to investigate irregular bearing, and to develop post-harvest technology. There can be no doubt that problems with flowering and fruit set still affect lychee trees in Australia. However, there have been significant improvements in our understanding of the effects of cultivar and weather on performance, and better recommendations for canopy management, watering, nutrition and pest control. Average yields in many districts have increased over the past decade, with prices generally well above the predicted figure of A\$ 2.50 to A\$ 3.00 suggested in 1986. We also have a better understanding of post-harvest and marketing issues. However, a significant improvement in shelf-life is still a few years away.

### **New cultivars**

It will be some time before better cultivars are developed for tropical coastal areas. Production is only consistent when early bud growth in winter coincides with several days of low temperatures. This is more likely on the Atherton Tableland in northern Queensland, and in southern Queensland and northern New South Wales. It is difficult to manage the trees for consistent cropping in tropical environments such as coastal far north Queensland.

The local industry needs to consider developing new cultivars so as not to be completely dependent on a single cultivar that could become susceptible to a new pest or disease in the future. A single cultivar has a short harvesting season in individual orchards. There has been limited breeding of lychees in China, Thailand, Israel and South Africa, and virtually none in Australia.

At the moment, the Australian industry does not have the resources to support a well-developed breeding programme, that would cost A\$ 50,000 per annum or more. The cost of maintaining seedling blocks is at least A\$ 5,000 to A\$ 10,000 per hectare. At this stage, the

emphasis would probably be on conventional breeding and selection, but there could be a role for biotechnology later. The main objectives would be improvements in production (regular and heavy yields), tree shape and fruit quality (seed size), along with earlier or later harvesting. In the short-term, it might be advantageous to link into existing programmes overseas, or at least import some of the better cultivars. It would also be useful to evaluate the performance of existing overseas cultivars in a systematic way.

### **Canopy management**

Guidelines are available on the optimum time to prune the trees after harvest to control tree size, but the optimum tree shape and canopy size have not been established. Studies in this area have led to increased efficiency in temperate deciduous fruit orchards, but are rare in tropical trees. This research could possibly include related crops such as longan and rambutan, and would build on earlier canopy experiments.

### **Irrigation and nutrition**

Guidelines are available for water and nutrient management. Irrigation is essential in northern Queensland, especially on the Atherton Tableland, but may not always be required in certain areas in southern Queensland and northern New South Wales. Droughting trees could be used to control flushing patterns and improve flowering in localities with dry winters, but has not been exploited apart from some areas in Israel and South Africa. The timing and duration of the water deficit for success in Australia are not known. There is also some indication that a light drought could direct resources to the fruit rather than new shoots under some circumstances, 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 a long irrigation once a week is more than adequate in most areas. This would be excessive in all but the driest orchards. Maximum water use would be about 60 mm per week. Soil water can be monitored with the use of EnviroScans or similar devices, but these are expensive and impractical when there are several soil types in an orchard. They also need to be calibrated. New systems are now available, with one instrument measuring several sites. It is possible that the increased cost of irrigation water will make these more widely used in the future.

Most growers base their fertilizer applications on the results of soil and leaf tests. 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 (N) status above 1.8 percent in the leaves, whereas there is probably no benefit in increasing the application of other nutrients. Future nutrition recommendations will probably be more concerned with limiting the cost to the environment. Slow release fertilizers and fertigation

will become more common. At this stage, there is no evidence that the rate or timing of nutrient applications have any effect on flowering.

## **Pest control**

The main insect pests are erinose mite, fruit spotting bug and macadamia nut-borer. There can also be problems with flower caterpillars and fruit piercing moths in some seasons. Current strategies generally employ calendar sprays with little monitoring. In the future, there will probably be a shift to monitoring and strategic applications, with possible biological control for mite and nut-borer. There also needs to be a change in pesticide label directions for tree crops that are currently based on application rates rather than on dose per tree. Exclusion nets currently appear to be the most effective control for birds and flying foxes, but orchards must be productive for the system to be economically viable. With a small aperture, the netting can control piercing moth and possibly even nut-borer. Insecticides could even be applied to the nets. Various options are being considered by the Flying Fox Consultative Committee. It is quite feasible that future orchards will use very few chemicals to control pests. This can only enhance the 'green' image of lychee in the market place.

## **Post-harvest and marketing**

The bulk of the crop produced in Australia is refrigerated after harvest, sometimes with hydro-cooling, and marketed in 2.5 kg crispywrap bags. The newer bags allow for some moisture loss, so there is less of a problem with rots, unless the fruit are very wet or are stored for long periods. The main problem is that the fruit dry out within a day or so of opening the bags in the shops, and turn brown, although occasionally there may also be browning within the bags. The industry is hoping to move to punnets before too long, but this technology will require some pre-harvest/post-harvest treatment to reduce breakdown. Ideally, these treatments will be based on biological products. The role of temperature during the marketing of punnetted fruit is yet to be determined. These treatments will be more attractive than those based on sulphur, acids and heating and cooling. Research is continuing. There have been some recent developments in Israel based on a heating/cooling cycle, but there were some problems with this technology in Australia.

The price in the domestic market has been about A\$ 5 to A\$ 6 per kg for the past five seasons, despite the prediction that it would fall to A\$ 3 with increasing production. There can be no doubt that the development of marketing groups, such as *Sun Lychee*, and their commitment to grade standards, quality assurance, and the development of export markets have contributed to the success in recent years. Exports have been mainly to Singapore, Hong Kong, Europe, the Middle East and the Pacific Islands, but short shelf-life, small production and limited airfreight services are significant hurdles to the expansion of these markets. There is also a trade restriction on direct entry of fruit into China, and a quarantine restriction with respect to the USA market, because of the listing of lychee as a host for Queensland fruit fly. China has applied to export lychees, and the Australian Quarantine and Inspection Service (AQIS) is currently reviewing this application. If successful, Australian growers will apply for access to the Chinese market.

In the domestic market, the majority of lychees are consigned to Brisbane, Sydney and Melbourne. There is a requirement that Queensland lychees must have unbroken skin when sent to Victoria as a precaution against fruit fly, otherwise the fruit must be dipped in dimethoate. There are also restrictions for other southern markets. Across these markets, there are food-safety/preferred-supplier-certification issues that need to be addressed by the industry in the next few years. Domestic sales have occurred with little or no advertising in Australia. Whether the market will continue to grow without promotion is yet to be determined. A longer shelf-life would be a good starting point. There has been the suggestion that one of the major chains is prepared to move to fruit in punnets. This can only be a positive development for the industry.

## **10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE**

The Queensland Department of Primary Industries (QDPI), New South Wales Agriculture (NSW Ag) and the Commonwealth Scientific and Industrial Research Organization (CSIRO) have traditionally provided research, development and extension. The support of individual growers, nurseries and industry leaders has also been substantial. Queensland, New South Wales and the Commonwealth have funded most of this work. It has been estimated that from 1981 to 1999, the QDPI, NSW Ag and CSIRO contributed about A\$ 4 million and external agencies some A\$ 1.3 million towards research. Industry contributed about A\$ 200,000. The Queensland Fruit and Vegetable Growers (QFVG's) levy on lychee sales generates about A\$ 40,000 per year that is currently matched by the Rural Industries Research and Development Corporation (RIRDC). This levy can fund about one large research project.

Activities at the moment include a CSIRO Post-Harvest Project, and one by a private consultant on the fruit disease pepper spot. The QDPI does not have any current research projects. NSW Ag withdrew from lychee research and extension in the mid 1990s.

The lychee industry organizes a national conference every four years, and an industry newsletter, "Living Lychee" is produced every three months. The QDPI has produced "Growing Lychee in Queensland" and the "Lychee Information Kit (Agrilink)" that form the basis of industry extension. CSIRO is not active in industry extension.

## **11. CONCLUSIONS**

Lychee was introduced into Australia more than 60 years ago, but major commercial plantings commenced only in the 1970s. Currently, there are about 320 growers with an annual production of 3,500 tonnes worth A\$ 12-15 million. Production has steadily increased over the past few years. About 50 percent of commercial plantings are found in northern Queensland, 40 percent in southern Queensland, and the balance in northern New South Wales. Successful production requires experience and expertise in managing irrigation, tree nutrition and pest control. Efficient packing and cool room facilities are needed as the crop deteriorates very quickly after harvest.

The Australian industry has a vision to represent 1 percent of world production by 2010, currently about 1.0 million tonnes. Hence, the local industry needs to grow by three-fold in the next decade or so. There is also the expectation that the industry will be well regarded in both the domestic and international markets, as a reliable supplier of quality clean fruit. These objectives will only be realized with considerable effort from industry and research providers. Opportunities for increasing production include new cultivars and better methods of orchard management and pest control. There will also need to be improvements in the post-harvest treatment and marketing of the crop. These developments are more likely to succeed if industry remains united in its vision for the future. Growers also need to consider options for research and development, information transfer and industry organization.

Initial research, development and extension in the late 1970s and early 1980s involved the introduction of cultivars from overseas, and their evaluation for commercial production along with local selections. Efforts were then directed towards understanding the basic physiology of flowering and fruit development, and the impact of tree management on production. There have also been efforts to improve the post-harvest life and marketing of the crop and to coordinate the development of the industry across Australia. Research was most active in the mid- to late 1980s, and accounted for about 30 percent of world scientific output (publications) on the crop during this period. Most of this activity was at Maroochy Research Station, the Hamilton Post-Harvest Laboratory (QDPI) and CSIRO. Current R&D is only a fraction of that during the initial development of the industry, although it could be argued that the need is just as great, especially as demand for fruit in export markets rises.

## **ACKNOWLEDGEMENTS**

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# LYCHEE PRODUCTION IN BANGLADESH

S. B. M. Abu Baker Siddiqui \*

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## 1. INTRODUCTION

The lychee (*Litchi chinensis* Sonn.) belongs to the family Sapindaceae and sub-family Nephelieae. It is one of the most important sub-tropical evergreen fruit trees which grow well in Bangladesh. Another member of the sub-family 'Anshphal' (*Euphoria longana* Lam.) also grows in Bangladesh, mostly in backyards. It bears longan type but small sized fruits of little commercial value.

Lychee is a highly priced, popular and major table fruit in Bangladesh. It comes to market in the months of May-June when the market is full of other fresh fruits, particularly mango and jackfruit. But in spite of the availability of different types of fruit in the market the demand for fresh lychee is always very high due to its unique taste, flavour and colour. The supply of lychee is insufficient and its availability is only for about 60 days. High quality fruits of elite cultivars like 'Bedana' and 'China-3' are in short supply due to their very limited area coverage. The average per hectare yield of lychee is about 2.5 MT, which is also low in comparison to other countries.

No authentic documentation on the history of cultivation of lychee in Bangladesh is available. However, it is believed that lychee came from Burma to Bangladesh sometime in the early 19<sup>th</sup> century. Chinese varieties along with Indian cultivars like Mujaffarpuri and Bombai were introduced in the early 20<sup>th</sup> century from West Bengal through the efforts of nurserymen and plant lovers. Lychee is mainly cultivated in the backyard (2-3 plants), or in very small orchards (15-20 plants) adjacent to the homesteads.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION

Lychee grows almost all over Bangladesh but the main areas of cultivation are Jessore, Rajshahi, Rangpur, Dinajpur, Khulna, Dhaka, Kushtia, Sylhet and Chittagong districts. Lychee was found to grow well in the Government horticulture centres of three hill districts namely: Rangamati, Khagrachari and Bandarban and also in Jamalpur, Rajbari, Meherpur, Chapainawabgonj and Comilla. The expansion of the lychee area in these districts is relatively slow due to high mortality rate of young lychee plants. Most of the growers as well as extension agents do not have the required knowledge and skill in lychee cultivation as a result of which interested farmers very often fail to establish new orchards.

At present the total area under lychee cultivation is about 4,800 hectares and total annual production is about 12,800 MT.

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**Table 1. Area and Production of Lychee in Bangladesh (1993/94 to 1997/98)**

Region	1993-94		1994-95		1995-96		1996-97		1997-98	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Bandarban	130	115	140	135	150	145	155	150	155	145
Chittagong	630	950	640	905	665	965	660	1015	635	985
Comilla	250	180	265	195	285	200	295	215	300	220
Khagrachari	200	130	210	140	235	165	245	170	245	160
Noakhali	255	210	285	220	285	230	315	255	320	260
Rangamati	265	145	285	150	295	155	295	135	295	130
Sylhet	630	795	645	800	650	795	615	715	630	735
Dhaka	640	615	660	620	700	630	720	645	745	680
Faridpur	440	285	415	285	365	246	345	235	320	210
Jamalpur	270	300	275	295	270	290	275	295	280	300
Kishoreganj	460	480	420	420	455	440	480	435	500	440
Mymensingh	390	480	420	525	450	580	480	605	500	625
Tangail	295	305	340	350	365	365	390	395	410	410
Barisal	720	485	725	480	740	490	770	525	775	515
Jessore	910	1395	920	1420	925	1415	955	1500	975	1520
Khulna	965	530	990	570	1050	590	1080	600	1115	625
Kushtia	405	545	415	545	415	540	415	550	430	656
Patuakhali	120	35	125	50	100	40	110	45	100	35
Bogra	330	415	345	435	345	430	330	410	350	440
Dinajpur	695	795	700	770	695	730	700	780	705	785
Pabna	370	400	395	405	415	450	450	490	465	490
Rajshahi	690	1055	705	1115	760	1245	780	1320	805	1380
Rangpur	795	955	780	1025	780	1040	805	1065	820	1100
<b>Grand Total</b>	<b>10855</b>	<b>11600</b>	<b>11100</b>	<b>11855</b>	<b>11395</b>	<b>12176</b>	<b>11665</b>	<b>12550</b>	<b>11875</b>	<b>12846</b>

**Source: Bangladesh Bureau of Statistic, 1999**

### 3. VARIETIES

Bombai is the oldest high yielding variety in the country, although there are a number of cultivars growing in different areas of Bangladesh. These are Rajshahi, Madrajie, Mongalbari, Kadmi, and Kalipuri. Muzaffarpuri, Bedana and China-3. Bedana and China-3, introduced in the 1950s, are now cultivated successfully in different parts of Bangladesh. Also there are many unnamed land races, most of which are sour in taste with low pulp:stone ratio. The fruits of cultivars like Bedana, China-3, and Rajshahi local contain more edible portion, with high quality pulp. The fruit size in these varieties is bigger with attractive skin colour. Bedana is considered the best variety but gives the poorest yield. Average yield per plant is about 3,000 fruits. The variety is confined to the Dinajpur district, northwest Bangladesh, which falls in agro-ecological zone-1. Recently three varieties, namely: BARI Lichu-1, BARI Lichu-2 and BARI lichu-3 were released by the Bangladesh Agricultural Research Institute (BARI) for farmers adoption. Among the released varieties BARI Lichu-3 is considered the best in respect of fruit size, pulp, colour and yield. The variety closely resembles China-3 variety.

The chief characteristics of important lychee cultivars are given in the following table.

**Table 2. Salient features of important lychee cultivars of Bangladesh.**

Variety	Salient features
Bombai	Most widely cultivated and good yielding variety of Bangladesh. The trees attain an average height of 6 m and bear fruits regularly. It is an early variety, fruits generally mature in the 2 <sup>nd</sup> week of May. Fruits are mostly heart shaped, carmine red in colour and each fruit has another tiny underdeveloped fruit attached to the fruit stalk. Average weight of the fruit is 18-20 g. Pulp is soft, juicy and sweet. TSS 17-18 percent, seed big, pulp:seed ratio 5:1.
Muzaffarpuri	The variety was brought from India and mainly grown in the northwestern districts of Bangladesh. The trees are medium in vigour and attain an average height of 5 m. The fruits are pink in colour, oval shaped and mature in the 2 <sup>nd</sup> week of May. Average weight of fruit is 20 g, pulp is long and sweet. TSS 17-18 percent, seed big, pulp:seed ratio 4.75:1.
Bedana	This variety is considered the best variety in Bangladesh. The trees of this variety are medium in height (about 5 m) and spread of 6 m and regular bearer. The fruits are mostly globose in shape, bright red in colour and mature in the 2 <sup>nd</sup> week of June. Average weight of fruit is 25-28 g., pulp is creamy white and soft, juicy, TSS 18-19 percent, seed small and shrunken, pulp:seed ratio 28:1
China-3	One of the best varieties grown in Bangladesh. The trees attain an average height of 5 to 6 m with relatively smaller leaves. Bearing is regular if proper management and care is taken, otherwise they show an irregular bearing habit. This is a late variety and fruits ripen in the last week of June. Fruits are globose, with a mixture of red, orange and patches of green colour. Average weight of fruit is 25 g. Pulp is creamy white, soft and juicy. TSS 18 percent, seed small, pulp:seed ratio 15:1.

#### **4. PRODUCTION OF PLANTING MATERIAL**

Lychee may be propagated both by seed and by vegetative means. In Bangladesh air layering is the most common and popular method for propagation of lychee. In this method a ring of bark about 2.5 cm to 3 cm in length is removed from one year old twigs. Generally the terminal branch which is selected for air layering is 60 cm to 75 cm in length. In some areas farmers prefer 2-3 year old and 1 m long branches for propagation. After removing the bark the exposed wood and the cut surface is covered with a rooting media consisting of clayey soil mixed with sand and organic manure (rotten cowdung). A piece of polythene or jute cloth of convenient size is wrapped around the rooting media and tied at both ends with fine twine. In about 2 months sufficient roots are formed at the upper end of the ring. The rooted layer is then detached from the mother plant by giving it a sharp cut below the lower end of the ring, preferably in 2-3 stages. A single cut operation sometimes results in high

mortality of the layers. Excess branches and leaves should be removed to bring a proper balance between the top and root system. This helps in quick establishment of roots and low mortality rate of the layers. The rooted layers are then kept in a shady place in the nursery in a slanting position for about a week and then potted. The potted plants are also kept in partial shade, preferably under a shade net. Success in air layering mainly depends on factors like time of operation, availability of moisture at the rooting area, growth stage of the terminal branch and age of the twig. Vigorous twigs or branches in active growth phase should be selected. The best time for air layering is July after the harvest of lychee when the available moisture in the soil and humidity are high. The rooting medium consisting of clay loam soil and well rotted cowdung (1:1) has been found to be best.

At present lychee marcottages are produced in about 70 Government own nurseries having mother orchards of China-3, Bombai, Rajshahi, Mongolbari and Mujaffarpuri varieties. Most of the mother orchards were established in the 1960s. Since the private nursery seldom owns any mother trees, Government nurseries are the main supplier of lychee planting materials.

Production of vegetatively propagated lychee planting materials in the public sector is about 90,000 per annum. No data regarding the production of lychee marcottage in the private nursery or farmers level is available, but is undoubtedly insignificant.

## **5. ESTABLISHMENT OF ORCHARDS**

Orchard establishment of lychee is not an easy task for the farmers, since in Bangladesh the mortality rate of lychee after planting is high. This is due to the supply of non-hardened planting material and lack of proper care at the time of planting and afterwards.

### **Land Preparation**

For lychee cultivation deep well-drained loamy soil having a pH 6.5–6.8 is suitable, although lychee is not fastidious about its soil requirements and in Bangladesh it grows in all types of soil. However, it performs better in deep sandy loam soil. The selected land should be flood free, open and under direct sunshine. After selection the land should be ploughed 2-3 times and a green manure crop cultivated to add to the soil to increase its organic content. *Sesbania rostrata* and *Crotalaria juncea* are the common green manure crops used in Bangladesh to improve the physical condition of the soil and soil fertility. In hilly areas lychees are planted in small hills with gentle slopes on terraces along the contours. When planted on terraces the soil is not ploughed, and only small half moon pits are made to keep the soil undisturbed. Bushes and other wild vegetation are cleared above the ground before plantation is made.

### **Planting season**

The planting of lychee is generally done during June-July, i.e. during the rainy season, but the best planting time is May-June when the weather is humid but not too wet or too dry. Planting may also be done after the rainy season, i.e. August-September, but regular irrigation is required for better establishment of the orchard.

### **Spacing and planting system adopted**

In old orchards lychee trees were planted 10-12 m apart both ways, i.e. in rows and between plants in rows. The spacing of 10 m is found to be adequate in areas where the soil is deep loam and fertile and when necessary care is taken during the initial stage of cultivation. In other areas 7-8 m distance was found to be sufficient. At present high density plantation has also started. In the case of high density planting the spacing is 4 m x 4 m.

The general planting system practiced in Bangladesh is the square system in the plains and the contour system in the hills. The square system of plantation allows the farmers to perform all the cultural operations conveniently and also to cultivate some vegetables as intercrops during the first few years.

### **Opening of pits and planting**

Before planting the recommended pits of 0.75 x 0.75 x 0.75 m dimension should be dug at the desired place two weeks before the actual planting. These are allowed to remain open for 10-12 days and then filled with topsoil mixed with manure and fertilizer at the rate of 30 kg well decomposed cowdung, 10 kg ash, 0.15 kg N, 0.30 kg P<sub>2</sub>O<sub>5</sub> and 0.20 kg K<sub>2</sub>O. The pits are then watered so that the soil settles down. At the planting time a small hole is made at the centre of the refilled pit and the desired air-layer is planted. Water should be applied immediately after planting. It is also suggested to add a basket full of soil per pit collected from an established lychee orchard.

### **Intercrops**

Common intercrops during the early years are vegetables and as soon as the canopy becomes larger, i.e. after 6-7 years and onward up to 15 to 20 years, turmeric and ginger are cultivated. During the pre-bearing stage leguminous crops like cowpea and beans are recommended for cultivation, which enrich soil nitrogen.

## **6. CARE AND MANAGEMENT OF ORCHARDS**

### **Training and pruning of plants :**

Training of lychee trees during the early years is necessary for building a good framework, but farmers seldom practice training. Branches developing from the main trunk should be allowed in all the four directions. Once the desirable shape and good framework is achieved, light annual pruning of old branches is only required to induce new growth. Since lychee flowers are borne mostly on the current year's growth regular light pruning is essential for good yield. Pruning of old branches will promote new growth, resulting in more flowering and fruiting. In Bangladesh farmers never prune bearing trees but the objective of pruning is achieved during harvesting, when a portion of branch bearing fruits is removed. Heavy pruning is to be avoided, except in the case of too much vegetative growth, when heavy shoot pruning is recommended. Root pruning to a depth of 5 cm is also helpful for floral initiation.

## Application of manure and fertilizer

Manuring and fertilization are important considerations in the upkeep of a lychee orchard. In Bangladesh manuring and fertilization are generally neglected, even though in lychee the nutrient requirement is high including high doses of organic matter. Application of cowdung or farmyard manure in sufficient quantity helps the young lychee plant to grow quickly.

Nitrogen is the major nutrient required by lychee. The deficiency of nitrogen results in stunted tree growth and small and pale green leaves. It was reported that nitrogen has a profound influence on fruit set, fruit retention, length, diameter and weight of fruit. Lychee also needs a substantial quantity of potassium and phosphorous for its proper growth and yield along with micronutrients like zinc, boron and copper.

Considering the nutrient requirements the following fertilizer doses are recommended for lychee.

### *Fertilizer recommendation before planting:*

- Cowdung 30.00 Kg/pit
  - Ash 10.00 Kg/pit
  - N 0.15 Kg/pit (or Urea – 326.00 g/pit)
  - $P_2O_5$  0.30 Kg/pit (or TSP – 667.00 g/pit)
  - $K_2O$  0.20 Kg/pit (or MP – 333.00 g/pit)
- a. All cowdung, ash, phosphorus and potassium should be thoroughly mixed with the soil and placed in the pit.
  - b. Ten to twelve days later the trees can be transplanted.
  - c. Five to six months after transplanting nitrogen should be applied.
  - d. Fertilizers should be applied annually in split applications-one half in the month of March and the remainder in September until the tree is fruiting. Rates of application should be increased each year by 0.05, 0.20, and 0.125 kg of N,  $P_2O_5$  and  $K_2O$ , respectively, over the previous year.

### *Fertilizer recommendation for fruiting tree:*

- Cowdung 7.00 Kg/tree
  - Ash 8.00 Kg/tree
  - N 0.70 Kg/tree (or Urea – 1.50 g/plant)
  - $P_2O_5$  0.30 Kg/tree (or TSP – 3.30 g/plant)
  - $K_2O$  0.20 Kg/tree (or MP – 1.15 g/plant)
- a. Trees should be fertilized annually in a split application. One half of all fertilizer should be broadcast around the tree and lightly incorporated in March.
  - b. Remaining half of the fertilizer should be similarly applied in September.

## Weeding

Weeds are generally controlled manually through hand weeding or hoeing during early years of plantation. At later stages, weeds seldom grow under the big overlapping canopy and are controlled during application of fertilizer and irrigation. Chemical weedicides are not used in lychee plantation.

## **Mulching**

In lychee orchards mulching is generally practised once/twice in a year in association with the application of fertilizer, weeding and irrigation. However, in young plantations mulching is a common practice for conserving soil moisture and control of weed growth. Dried leaves, compost/cowdung or straw are generally used as mulch. The use of mulch in young lychee plantations was found to be helpful for better growth of the young trees and quick establishment of the orchard.

## **Supplementary irrigation**

In Bangladesh supplementary irrigation is considered necessary during flowering, fruit setting and development since during these periods the soil moisture and atmospheric humidity remains very low. At the time of flowering the temperature in most of the regions of Bangladesh remains within 27° – 28°, but it increases afterwards and transpiration rises considerably.

Generally no supplementary irrigation is given to bearing trees as a result of which moisture stress due to prolonged periods of drought causes yield reduction through fruit drop. Very few farmers can afford to irrigate during the fruiting period, due to high demand and priority of irrigation for the Boro (Summer) rice crops. In most of the lychee growing area surface water for irrigation is seldom available. In addition ground water level goes down due to the prolonged dry period making shallow tubewells inoperative, which also restricts irrigation to the orchards. Young plants also suffer during this period due to shortage of water resulting in poor growth, and sometimes death.

In better managed Government orchards irrigation is given twice during flowering and after fruit set, utilizing either basin or flood systems. The common practice is single irrigation after the application of fertilizers, immediately after fruit set. Supplementary irrigation at fortnightly intervals after fruit set gives good harvest.

## **Control of pests and diseases**

Lychee does not suffer from any serious pests or diseases in Bangladesh, but bats and birds cause serious damage at the ripening stage of fruit.

Lychee mite and fruit borer are the two major insect pests of lychee.

### **Lychee mite**

In Bangladesh eriophid (*Aceria litchi*) is the most destructive pest of the lychee tree. Both adults and nymphs infest the leaves.

New leaves of the lychee trees are infested by the lychee mite and such infested leaves, at later stages of their growth, show leaf galls (known as erinose), which are thickened and wrinkled with abnormal hairs that are velvety brown in appearance. Infested leaves later dry up and fall from the trees. Inflorescences, flower buds and young fruits are also infested by the lychee mite. Twigs with severe infestation of leaves bear few inflorescences and fruits. The loss of large number of leaves due to severe mite infestations may affect yield in the following year because of the reduction in photosynthetic activities,

though general loss of green leaves due to the mite infestation is mostly compensated by frequent flushes of new leaves in the affected twigs. All varieties of lychee are susceptible to infestation by the lychee mite and trees having dense foliage show more severe infestations.

There may be 10 to 12 overlapping generations of the lychee mite in a year. Lychee mites are found in both the adult and nymphal stages in the infested leaves at varying ratios throughout the year. Their populations remain very low from November to the middle of February. The population reaches its peak in April – May. Adults are mostly seen in infested leaves during February-March and June to August. The lychee mites spread from one tree to another by movement through the soil and touching leaves of adjacent trees. The infestation starts in February, becomes maximum in May-June and continues up to October.

Controls are:

- Pruning and burning of affected twigs in June and August each year in severely infested trees and pruning and burning of affected twigs in August in less infested trees repeatedly for 2 to 3 years was found to be very effective in controlling the lychee mite.
- Spraying of lychee leaves during April and May with Kelthane 40 MF or Neoron 500 EC or Torque 50 EC or wettable sulphur at the rate of 2.0 ml/litre of water will be helpful for the control of the lychee mite.
- Three species of predaceous spider mites (*Tetranychus* spp.) have been reported to predate on different stages of the lychee mite in Bangladesh, but their role as effective natural enemies in the control of the lychee mite has not been established.

### **Lychee fruit borer**

The lychee fruit borer is a common insect pest of lychee in Bangladesh. Only one larva of the fruit borer moth bores into a developing fruit from the stem end and feeds on the seed. A portion of the fruit pulp at the stem end is also spoiled due to the larva feeding on the seed. Varietal resistance to the insect pest may be helpful for its control. Insecticides can also be used for the control of this insect pest. Cypermethrin (Ripcord/Cymbush/Basathrin/Arrivo/other) 10 EC at the rate of 1.0 ml/litre of water can be sprayed on fruits 15-20 days before ripening of the fruits for the control of the lychee fruit borer.

### **Caterpillar**

The next important insect pest of lychee is the bark eating caterpillar (*Indarbela tetraonis*). The adult moth of this pest lays eggs during May and June in groups of 15-25, which hatch after 8-11 days. The larvae feed on the surface of the bark until September. Afterwards they bore into bark and underlying tissues in the branches. These become fully grown in December and pupate in April. Plugging the holes with fumigants such as carbon bisulphide, petroleum or formalin and then plastering with mud checks the caterpillars effectively.

## 7. HARVESTING OF FRUITS AND YIELDS

The quality of fruit, particularly the characteristic taste and flavour, TSS, acid, etc. of a variety depends on the stage of harvest. Lychee should be harvested when the fruits ripen properly, because, unlike mango, lychee does not improve in quality after harvest. Maturity of fruit is judged by colour development, flatness of tubercles and comparative smoothness of the epicarp. The fruit colour changes from greenish to pinkish red. The development of red pigmentation was found to be associated with anthocyanin pigment. Generally fruit are harvested at about 55 – 60 days after the fruit set but it varies with the variety and environment. In Bangladesh harvesting is done in May-June. Fruits are harvested in bunches with few leaves. Since all the fruits on a tree do not ripen at the same time, the fruit clusters are spot picked several times. In Bangladesh fruiting lychee trees are generally sold to the middlemen before maturity, in order to get rid of the problem of bats and birds. The middlemen normally harvest all the lychees at a time and do not take care of the plants during harvesting. The indiscriminate breakage of branches injures the trees.

The lychee tree starts giving yield from the age of 5 years and the yield increases until they are 20 to 30 years old. In Bangladesh 60-70 years old lychee trees were found to give satisfactory yield. The variety wise average yields of 15-20 years old good lychee trees are given below.

Sl. No.	Variety	Yield/plant
1.	Bombai	7000 - 8000 nos.
2.	Madrajie	6000 - 7000 nos.
3.	China-3	4000 - 5000 nos.
4.	Bedana	2000 - 3000 nos.

Fruit quality of Bombai, China-3 and Bedana varieties is the best among the available land races. The recently released BARI Lichu-3 resembles China-3 in size, shape, quality and taste, but is yet to be distributed to the farmers. The yield of good variety lychee in Bangladesh is as good as in India, but the national average yield of lychee is far less.

## 8. MARKETING

Lychee is a highly perishable fruit and as a result without proper post harvest practices marketing of lychee is very difficult. In Bangladesh lychee is mainly sold at local or nearby markets in fresh form, except for high quality lychee, which fetch good prices in big cities and are brought from the distant lychee growing areas in bamboo baskets lined with lychee leaves. Lychee fruits remain fresh in such baskets packed loosely for about 48 hours. For distant city markets the fruits are harvested in the afternoon at the stage when they have just started to turn red. The harvested fruits are then packed in the field in a small basket and reach the wholesale market during night from where the fruits are distributed to the retailer.

Lychee is neither exported nor imported. Although the local production can barely meet the need, unlike other fruits lychee is not imported. Perhaps this is because of the fact that lychee fruits are still a commodity sold mostly in street side markets where adequate storage facilities for keeping fresh lychee are not available.



## **9. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT**

Good quality lychee is produced in the northwest region of Bangladesh covering 16 districts, hill tracts consisting of three districts and in Jessore, Tangail and Dhaka. At present production of quality lychee is mainly concentrated in certain areas from where marketing is done with comparative ease. Infrastructure facilities for post-harvest handling can be easily created in these areas. The lychee area can easily be expanded with good varieties in the flood free areas of the northwest, hill tracts and in Dhaka and Tangail districts.

### **Northwest region**

Lychee covers about 3,500 acres of land in the northwest region, which can easily be expended to at least 14,000 acres. Currently, the maximum concentrations of lychee orchards are in the districts of Rangpur, Dinajpur, Rajshahi, Pabna and Bogra. There is ample scope for expansion of area in Dinajpur, Thakurgaon, Panchagarh and Rangpur, where quality lychee covers only 1-3 percent of the present lychee area. The present yield of average quality lychee in this area is about 4.5 to 5.5 MT/ha. If proper management practices like fertilizer and irrigation management are adopted, the yield of good quality lychee like Bedana and China-3 can be increased substantially.

### **Hill Tracts**

Very good quality lychee grows in the Chittagong hill tracts area but the rate of expansion is extremely slow, which may be due to prevailing social unrest and difficulty in establishing new orchards. The present area under lychee is 295 acres in Rangamati, 245 acres in Khagrachari and 155 acres in Bandarban. This area can easily be expanded to a few thousand acres. The only limitation for the expansion of lychee in the area is inadequate irrigation facilities, which may be overcome by carefully choosing the expansion area and better management of residual soil moisture.

### **Dhaka and Tangail**

At present the area under lychee in these two districts are 720 and 390 acres, respectively. There is a good scope for expansion of area and replacement of inferior quality orchards with the best available varieties. The lychee area in these two districts can be expanded to more than 1,500 acres. The climate is quite congenial for growth and fruiting of lychee and in certain areas farmers are growing lychee on a commercial basis.

## **10. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

### **Improved varieties**

It has already been mentioned that Bedana and China-3 are the two good varieties available in Bangladesh. The area under Bedana is only a few acres and that of China-3 is not more than 100 acres. Bedana grows only in Dinajpur district. China-3 was found to perform satisfactorily in other areas, except where rain starts earlier. Consequently, introduction of more good quality varieties suitable for the potential areas will be helpful in increasing lychee production.

### **Short production season**

Lychee reaches the market during May-June. Sour and inferior lychee comes early followed by Bombai. Bedana comes in the last week of June followed by China-3. This short production season of good quality lychee may be extended by introducing early and late maturing varieties.

### **Quality planting material**

Lychee marcottage are mostly produced in the Government horticulture centres where the quality control system is far from standard. In the private sector the situation is worse. As a result farmers very often do not get high quality planting material of the expected variety. On the other hand Bedana lychee growers do not produce planting material from their mother orchard for sale. They only produce propagules for themselves, which is restricting the expansion of Bedana variety.

### **Inappropriate pruning**

Pruning is seldom practised in Bangladesh, except in young plants. In fruit bearing trees pruning is achieved at the time of harvesting, when a portion of the branch is removed from the plant along with the fruit. Generally, harvesting is done by the labourers of the middlemen (marketing agent) who climb on the fruiting plant for harvesting, remove a sizeable portion of a branch along with the fruits they find suitable for quick harvest rather than taking care of the fruiting plant. Due to such type of indirect and inappropriate pruning the lychee plants suffer, resulting in poor yield thereafter.

### **Lack of technical know-how**

Usually lychee farmers do not pay attention to modern cultural management practices like irrigation and fertilization and are not aware of application of hormones, good propagation techniques and post harvest handling. Some of the growers who are slightly conscious add cowdung or farmyard manure and provide irrigation once in a while. Due to inadequate care and management lychee plants show alternate bearing habit and after a good harvest yield is reduced to half or even less in the following years. Extension personnel also do not have adequate technical knowledge and skill to help the farmers. Their lack of knowledge on the establishment of orchards, propagation techniques, cultural management, etc. is also contributing to the low yield and slow expansion of the lychee area in Bangladesh. In fact the present extension personnel are mostly trained in cereal production technology and management. As a result the horticulture crops gets less attention. Block supervisors who are the grass root level extension agents do not get training on the propagation techniques, establishment of new orchards, pest management, management of lychee orchard and post-harvest handling. In order to give priority to the development of lychee and the fruit industry as a whole either a separate development organisation needs to be formed or separate horticulture based extension services within the present extension department should be developed. In this way human resource development as well as an adequate extension service in the field of horticulture will be ensured.

## 11. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE

Bangladesh Agriculture Research Institute (BARI) has released two lychee varieties through selection from their collection of lychee in Akbarpur regional research centre, Sylhet and one from Rajshahi station. The Characteristics of the varieties are described in Table 3.

**Table 3. Characteristics of Lychee varieties released from BARI**

Variety	Name of Station with time of release	Salient Features	Remarks
BARI Lichu-1	Binodpur (Rajshahi) Sept/96	High yielding, regular bearer, exceptionally early, edible portion 67-73%. TSS 18.4 to 20.5% and borer infestation minimum. Yield 85-97 kg/tree/year. Individual fruit weight 19.5 g.	Rajshahi region
BARI Lichu-2	Akbarpur	High yielding, late maturing, regular and heavy bearer, fruit pink red, pleasant flavour and tolerant to nut-borer and mites. Yield 32-44 kg/tree/year. Edible portion 68.4%. TSS 16.1% to 20.5% Individual fruit weight 15.2 g.	Eastern regions of Bangladesh
BARI Lichu-3	Akbarpur Sept/96	High yielding, mid season variety, small seed, edible portion 75-77% and tolerant to rust and other diseases. Yield 30-42 kg/tree/year, TSS 18.9% and individual fruit weight 18.4 g.	Eastern regions of Bangladesh

The performance of the released varieties in other lychee growing areas of the country has yet to be evaluated. BARI conducted some experiments on the fertilizer requirements of the existing varieties.

Under the Integrated Horticulture and Nutrition Development Project a demonstration on the improved management of lychee orchards including the control of fruit dropping by application of NAA in the Government horticulture centres is underway. Farmers from the lychee growing areas will be invited to a field day to see the results of the demonstration. In the next year demonstrations will be conducted in the farmers existing lychee orchards and participating farmers will be given training on lychee orchard management. It is expected that this will help in the development of lychee in Bangladesh. Also, it is planned to multiply a large number of promising varieties like China-3 for planting in the homesteads in certain lychee growing areas of Bangladesh.

## **12. CONCLUSIONS**

Lychee is one of the most popular fruits of Bangladesh and good quality lychee fetches a fancy price. Local demand for fresh lychee is very high, which can hardly be met by the present production. The agro-climatic condition of the country is conducive for successful production of good quality lychee and the present area can easily be doubled. However, expansion of lychee is very slow, mainly due to unavailability of high quality planting material and poor establishment of air layered plants. The knowledge and skill of the farmers as well the extension agents regarding improved production technologies are inadequate for the establishment of a lychee industry. The varietal base of is also too narrow. In some areas early rain during flowering reduces fruit formation.

Considering the present constraints and opportunities the following actions may be undertaken immediately.

- Introduction/selection of high quality lychee varieties of early mid and late maturity.
- Intensive training of the farmers and extension agent on the modern methods of lychee cultivation, management and orchard management.
- Production and distribution of quality planting materials.
- Proper pre- and post-harvest operations.

# LYCHEE PRODUCTION IN CHINA

Xuming Huang \*

## 1. INTRODUCTION

Lychee (*Litchi chinensis* Sonn.) originated in the northern tropical and southern subtropical regions of South China. Wild lychee trees can be found as one of the dominant tree species of tropical rainforests in southern provinces such as Hainan, Guangdong, Guangxi and Yunnan.

As the original home of lychee, China was the first country to cultivate the fruit. The recorded history of lychee cultivation in the country is more than 2,100 years. In 111 BC, during the Han Dynasty, the royal record described a trial of planting lychee trees in the palace on the order of Emperor Hanwu. However, the trial ended in failure as lychee could not survive the northern climate. The delicious but rare lychee fruit was also highly appreciated by the later emperors who sent express horsemen to the south in order to carry lychee to the palace. The earliest description of lychee cultivars appeared in The Lychee Register written by Cai Xiang during the Song Dynasty in 1059 AD, which described lychee cultivation and 32 cultivars in Fujian Province. Another version of The Lychee Register by Chen Ding in 1780 mentioned 43 cultivars grown in Fujian, Sichuan, Guangdong and Guangxi. The figure increased to 74 in Guangdong according to Wu Yingkui in his book “The Lychee Register in Linnan”. The most popular cultivars like ‘Nuomici’, ‘Feizixiao’, ‘Guiwei’, ‘Sanyuehong’, ‘Huaizhi’ and ‘Heiye’ were described in this book.

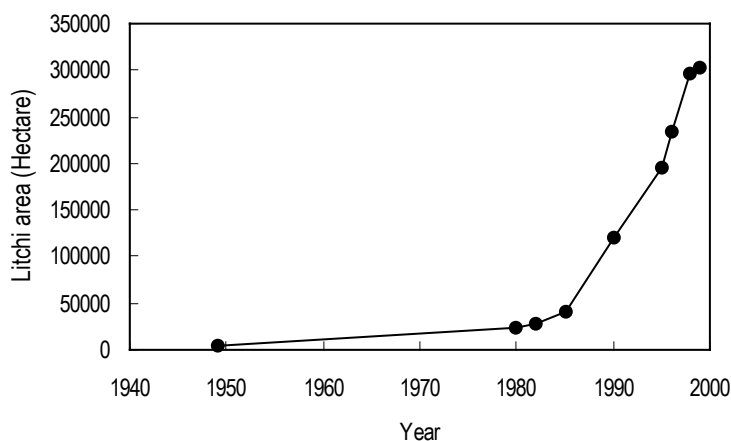


Figure 1. Lychee cultivation area in Guangdong Province

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Lychee used to be cultivated by individual farmer households as a sideline for self-consumption and the local market before the 1980s, and the fruit rarely reached the markets of the northern provinces of China. From 1949 to 1982, the lychee cultivation area in Guangdong, the largest lychee producing province, increased very slowly from 4,800 to 26,933 hectares. The average annual production during these 34 years was only 40,000 tons. A sharp increase in lychee area and production occurred in the 1980s and 1990s (Figure 1). The trend of lychee production in the whole country followed the same pattern. The sharp increase in the 1980s and 1990s was due to rural reform and the implementation of market economy in the country. The rural reform involved a household contract system that allows farmer households to manage a piece of land for certain crops. The farmers then found that planting lychee brought them better economic benefit than planting most other crops. This resulted in a surge in lychee production in South China. Meanwhile, the market demand has also greatly stimulated the development of the lychee industry in China. As in the case of Guangdong province, the sharp increase in lychee cultivation area did not slow down until the end of the 1990s.

Most of the lychee orchards established before 1990 in China were managed by smallholders. They managed lychee orchards on a small scale ranging from several trees to several hectares. However, since 1990, corporations with financial strength have been investing in the lychee industry. Larger orchards of several dozen to several hundred hectares have emerged.

## **2. PRESENT SITUATION OF LYCHEE CULTIVATION IN CHINA**

In 1999, the total lychee cultivation area in over-all China exceeded 580,000 hectares with a production exceeding 1.26 million tons. Lychee production regions in China are distributed between 19°-24° N latitude covering the provinces of Guangdong, Guangxi, Fujian, Hainan, Yunnan and Guizhou, although there is some lychee grown further north (28-29° N latitude) in Yibin and Dukou counties of Sichuan Province. This is because of the special local geographical circumstances and micro-climate which is suitable for lychee. The lychee acreage and production of the major lychee producing provinces in 1998 and 1999 are shown in Table 1. Since a considerable acreage (35 percent in Guangdong) of lychee orchards has been added within the past five years, the production of lychee is expected to increase considerably as the trees in these newly established orchards enter bearing stage. Lychee production has become an important industry in South China. In Guangdong, lychee is now the biggest fruit industry in terms of cultivated area accounting for 32 percent of the total fruit cultivation area (946,527 hectares) in the province.

**Table 1. The acreage and production of lychee in the mainland provinces of China in 1998 and 1999**

Province	Acreage at year end (ha)		Total production (tons)		Harvested area in 1998 (ha)	Unit yield in 1998 (tons/ha)
	1998	1999	1998	1999		
Hainan	15640	18600	4300	15000	1350	3.185
Guangdong	297180	303080	327000	793200	110700	2.953
Guangxi	202740	210000	106700	310000	80260	1.329
Fujian	39490	40220	91900	148700	17210	5.339
Yunnan	2700		2700		1200	2.25
Sichuan	8621		1955		3810	0.513
Guizhou	430		500		430	1.163
<b>Total</b>	<b>566801</b>	<b>&gt;580000</b>	<b>535055</b>	<b>&gt;1266900</b>	<b>214960</b>	<b>2.489</b>

The dominant commercial cultivars in China are listed in Table 2 in order of maturation season. In Guangdong and Guangxi, the major early-season cultivars include ‘Sanyuehong’, ‘Baila’, ‘Shuidong’, ‘Dazao’, ‘Heiye’ and ‘Feizixiao’, while ‘Guiwei’, ‘Nuomici’ and ‘Huazhi’ are among the major mid- to late-season cultivars. In Fujian, late maturing cultivars such as ‘Chenzhi’, ‘Lanzhu’ and ‘Yuanhong’ are widely planted. The cultivars in Hainan are mostly early maturing ones whose flower induction does not need a very chilly winter. ‘Nanmuye’ is a local late-season cultivar in Sichuan. Apart from the cultivars listed, some less dominant cultivars are also well-known and populous. These include ‘Qipitian’ (Guangdong), ‘Gualu’ (Guangdong), ‘Edanli’ (Guangdong, Hainan), ‘Jinfeng’ (Guangdong), ‘Shangshuhuai’ (Guangdong), and ‘Zhuangyuanhong’ (Guangxi). Some new elite cultivars have recently been bred. Examples are ‘Dongguan Seedless’ and ‘Hexiachuan’, which produce parthenocarpic or highly chicken-tongued fruit, and ‘Maguili’, which is extremely late maturing (late August) in Guangdong.

A lychee-related organization, “Guangdong Lychee Technical Association (GLTA)” composed of researchers, extension officials, growers and dealers, is functioning as an important source of information about lychee production. The Lychee Technical Communication released by GLTA enjoys wide popularity among lychee researchers, growers and dealers all over the lychee production regions in China.

### **3. PRODUCTION OF PLANTING MATERIALS**

Planting materials of lychee are propagated either by air-layering or by grafting (budding). For producing air-layered planting materials, 2-3 year old healthy branches about 2 cm in diameter are preferable. A strip of bark 2-3 cm in width is removed from the branch 15 cm from the fork and all the cambium tissue within the barking zone is cinctured. Root promoting growth regulators such as Indole-3-butyric acid (0.5 percent) are often used to treat the bark above the cincture before wrapping with root growth medium. Mud from fertile paddy field mixed with straw or with sawdust or coconut shell dust is the most common root growth medium. Air-layers are removed from the tree after 3-5 months, when 2-3 growths of new roots have occurred. The plants are trimmed to a good structure, most of the leaves are removed, the mud head is unwrapped and soaked in water and the plants kept under shade and high humidity to allow new root growth before nursery planting or field planting. Although air-layering can be done all year round in Guangdong, it is preferable to do it in

spring and summer.

Table 2. Dominant lychee cultivars in China

Cultivar	Other names	Cultivation Region	Maturation season
Sanyuehong	Sum Yee Hong Sun Yueh Hong	Guangdong, Guangxi	Mid-May
Baitangying		Guangdong	Late-May
Baila	Bah Lup	Guangdong, Hainan	Late-May to early-June
Shuidong	Souey Tung Yuan Zhi	Guangdong, Guangxi,	Late-May to early-June
Feizixiao	Fay Zee Siu Yu Her Pau	Guangdong, Guangxi, Hainan	Early- to mid-June
Dazao	Tai So	Guangdong, Guangxi, Fujian, Sichuan	Early- to mid-June
Heiye	Haak Yip Hak Ip	Guangdong, Guangxi, Fujian, Taiwan	Early- to mid-June in Guangdong and Guangxi Late-June in Fujian
Tianyan	Tim Naan	Guangdong	Early- to mid-June
Chenzi	Brewster	Fujian	Early- to mid-June in Guangdong, mid- to late- July in Fujian
Xinxingxiangli	Heong Lai	Guangdong	Late-June to early-July
Lingshanxiangli		Guangxi	Mid- June to early-July
Bobaitangbo		Guangxi	Early-July
Guiwei	Kwai May Red Kwai Mi	Guangdong, Guangxi, Fujian, Sichuan, Taiwan	Late-June to early-July
Nuomici	No Mai Chee No Mai Tsz	Guangdong	Late-June to early-July
Huaizhi	Wai Chee Kwai Li Kim Cheng	Guangdong, Guangxi, Fujian, Taiwan, Sichuan	Early-July
Xuehuaizi	Soot Wai Zee	Guangdong, Guangxi	Early- to mid-July
Lanzhu		Fujian	Late-June to early-July
Yuanhong	Zhuangyuanhong	Fujian	Mid-July to early-August
Xiafanzhi		Fujian	Late-July to early-August
Nanmuye		Sichuan	Early- to mid-August

For grafting and budding, seedlings are planted in advance. Seedlings of ‘Huaizhi’ are good rootstock for ‘Nuomici’, ‘Guiwei’, ‘Baila’ and ‘Baitangying’; while those of ‘Heiye’ and ‘Dazao’ are commonly used as the rootstocks of ‘Feizixiao’. The seeds should be collected from fully mature fruit. They are sowed in rows at a space of 20 cm x 10-13 cm and then covered with a 1.5-2 cm thick layer of soil. Scion budwoods are taken from 1 year old healthy twigs with strong buds of the required cultivars. It is preferable to do grafting or budding in late spring or early autumn, avoiding hot, chilly or rainy weather. The grafted trees will be ready for field planting 6 months after successful grafting, when their second flushes have matured.



#### **4. ESTABLISHMENT OF ORCHARDS**

For lychee orchards to be established on lowlands with high water table, the planting rows are built into high ridges (1 m in width and 30-40 cm in height), between which draining ditches are dug about 0.8-1.0 m in depth. This is important to prevent waterlogging.

Most lychee orchards in China are built on hillsides. Although it is recommended to build lychee orchards on land with slopes of less than 10°, orchards on slopes higher than 20° are frequently seen. Vegetation is cleared when preparing the sloping land. Precautionary measures are critically important to prevent soil erosion in South China where there is a lot of rainfall. The common anti-soil erosion measures include terrace construction and a drainage ditch system. An anti-flood ditch is dug across the hillside above the terraces and connected to a number of vertical rain-collecting ditches leading to the foot of the hill. Usually these are dug along the edge of the walkway. The terrace surfaces are built inclining slightly inwards with a ridge at the outer side and a drainage ditch at the inner side, which joins the vertical ditches.

Lychee can be planted in spring, summer and autumn. Most farmers in China prefer to plant in the warm and humid spring (March to May). Planting pits 80-100 cm in depth and width are usually dug 3-5 months before planting during the winter. They are filled with green manure, soil, animal manure, compost, and lime and/or lime super phosphate (0.5 kg/pit) after several weeks of sun-exposure.

There is no standard planting space for lychee orchards in China. Most lychee farmers prefer to plant at a closer space (2.5-3 m x 3.5-4 m) initially and thin the plants as their crowns expand and overlap to a permanent spacing of 6m m x 6 m or 300 trees/hectare. Intercrops such as beans, peanut, sweet potato, vegetables, pineapple and papaya are highly recommended and widely adopted in young orchards. There are some farmers who have successfully adopted a dwarf and dense planting system for cultivars like 'Feizixiao', with a density of about 1,500 trees/hectare. The success depends much upon intensive orchard management including heavy pruning each year, frequent fertilization and sufficient irrigation.

#### **5. CARE AND MANAGEMENT OF ORCHARDS**

##### **Tree training and pruning**

The young trees are usually topped at a height of 50-60 cm in order to allow 3-4 lateral shoots to develop into the main branches so that the canopy will form a semi-dome shape. The management of young trees aims at promoting tree growth and expanding the tree canopy. Shoot growth of young non-bearing lychee trees is fast and the shoot growth cycle is frequent (5-6 shoot growths per year). The principle of fertilization for young trees is correspondingly 'light but frequent', either as soil application or foliage spray. A combination of 25-30 g of compound fertilizer, 20-26 g of urea, 15-20 g of potassium chloride and 50-70 g lime super phosphate is recommended for each tree in each application. Foliage spray with 0.3-0.5 percent urea + 0.3-0.6 percent  $\text{KH}_2\text{PO}_4$  + 0.05-0.1 percent boric acid + 0.1-0.6 percent  $\text{ZnSO}_4$  is also effective in supplying relevant elements to the young trees. Organic liquid fertilizers such as manure maceration extract, peanut meal maceration

extract and molasses from sugar cane refineries, have been widely used by lychee growers in China. In dry seasons, irrigation is needed to ensure shoot growth.

The bearing trees are pruned during autumn and winter. Autumn pruning is done after harvest and before autumn shoot growth to encourage vigorous shoot growth. The trees are pruned to allow good light penetration and good ventilation in the orchard. Winter pruning should be slight and is done before spring shoots or panicle emergence, removing the diseased or pest damaged and weak twigs and thinning out overlapping ones. Bearing trees are managed to acquire a balance between vegetative growth and reproductive growth. After harvesting, two autumn flushes are fostered to form strong fruiting shoots for the coming year.

## **Fertilization**

Fertilizer is usually applied at three crucial stages.

- Fertilizer application prior to flowering facilitates flower development and improves setting. For production of 100 kg fruit, 1.5 kg urea, 0.5 kg KCl and 0.4 kg lime super phosphate are recommended at this stage.
- Fertilizer application after full bloom is to compensate the nutrient consumed during flowering and to improve setting and encourage fruit development. K is the major element supplied in this application. A recommended fertilization at this stage for production of 100 kg fruit is 0.5 kg urea + 0.5 kg lime super phosphate + 1.4 kg KCl. An alternative is foliage spraying of 0.4 percent urea + 0.3 percent  $\text{KH}_2\text{PO}_4$  prior to or after anthesis.
- Fertilizer application prior to harvest is for the promotion of autumn shoot growth and tree vigour recovery. For production of 100 kg of fruit, a combination of 1.5 kg urea + 0.5 kg KCl + 0.4 kg lime super phosphate is recommended for this stage. However, more and more farmers prefer mix these chemical fertilizers with organic fertilizer, such as chicken manure and fermented peanut meal.

Fertilizer is applied directly to the root zone of large trees in ditches dug 30-40 cm deep and 20-30 cm wide at two sides of the tree below the edge of the tree crown.

## **Weeding**

Weeding is done either manually or with herbicides. Forage culture and mulching in lychee orchards are nowadays highly recommended by researchers to keep biodiversity and soil moisture, increase organic matter and reduce extremes of soil temperature in dry seasons.

## **Flower promotion**

In order to prevent the growth of winter shoots, which is negative to flower induction, irrigation is withheld after the second autumn shoots mature. Girdling for vegetative control is also done on vigorous trees at this stage. Growth retardants such as paclobutrazole, ethephon and daminozide are used to suppress or kill winter flush.

## Facilitating pollination and improving setting

Bee colonies are placed in the orchards during the flowering period in order to facilitate pollination and setting. Cultivars like ‘Feizixiao’ produce excessively large panicles that consume excessive nutrient. Therefore, panicle pruning or flower thinning is necessary to increase fruit set in these cultivars. Growth regulators like auxins and gibberellins are often used by farmers to reduce fruit drop. Girdling, either closed or spiral, is also widely applied prior to setting for fruit retention.

## Pest and disease management

Considerable production loss is caused by problems such as diseases, pests and physiological disorders. The most serious ones are as follows.

- Downy mildew: A fungal disease (*Peronophythora litchii*) that damages fruit, panicles and new shoots, causing panicle rot and withering and watery brown spots on fruit which later produce snowy mildew. The disease is severe after successive rainy and overcast days.
- Anthracnose: A fungal disease which causes brown spots and quality loss on fruit, browning on the leaf tip and edge and tree vigour decline.
- Fruit cracking: A physiological disorder. ‘Nuomici’ and ‘Guiwei’ fruits crack most severely among all the lychee cultivars. Lychee fruit cracking is caused by multiple factors including heavy rain after long term drought, dry and hot wind, pests and diseases. Deficiency of Ca intensifies cracking. Anti-cracking measures include balanced water supply, application of Ca fertilizer and control of pests and diseases.
- Lychee stink bugs: The insects attack new shoots, inflorescence and fruits by sucking the sap, causing withering of shoots and flower and fruit drop.
- Lychee stem-end borer: Lava of the insect bore into the fruits or new shoots, causing fruit drop, inflorescence and new shoot withering.
- Lychee gall mite: The insect attacks new shoots, panicles and young fruit. Curling of the leaves and dense fuzz on the surface of infested organs are the characteristic symptoms of its damage. Gall mite infested trees produce low yield and poor quality fruit.

Chemicals commonly used in controlling pests and diseases are listed in Table 3. In order to lessen the dependence upon chemical control, lychee farmers in China take every possible agricultural means to bring pests and diseases under control. A good example is orchard cleaning, which is usually done in the dry late autumn or winter season. It includes weeding the orchard, loosening and sun drying the soil, winter pruning, burning the weeds and pruned twigs, and soil application of lime. These can reduce the incidence of diseases and pests remarkably, especially the soil-borne ones. Another good example is bagging the fruit clusters, which effectively protects the fruit from most of the pests and diseases. Bagging also improves the skin colouration, increases fruit size and facilitates maturation.

**Table 3. Chemicals commonly used to control diseases and pests in lychee in China**

<b>Chemical</b>	<b>Effective on</b>	<b>Dosage</b>
Cypermethrin	Stink bug, stem-end borer, loopers leaf roller, and leaf-eaters	10% emulsion 1:1500-1:2000
Alphacypermethrin	Stink bug, stem-end borer, loopers leaf roller, and leaf-eaters	5% emulsion or wettable powder 1:2000-1:3000
Trichlorphon	Stink bug, moths, loopers, beetles and longicorns	90% crystal 1:800-1:1000
Isocarbophs	Stem borer, scales, loopers, leaf rollers, red spider and thrips (Forbidden to be used from 20 days prior to harvest)	40% emulsion 1:1000-1:1500
Dimethoate	Loopers, leaf-eaters, leaf-rollers, scales, mites, aphids and thrips	40% emulsion 1:800-1:1000
Omethoate	Mites, loopers, leaf-eaters, leaf-rollers, scales, aphids and thrips (Forbidden to be used from a month prior to harvest)	40% emulsion 1:1500
Bisultap	Moths and caterpillars	25% solution 1:500
Isofenphos-methyl	Underground pests	3% pellet 75 kg per hectare, well mixed with fine sand before soil application
Dicofol	Mites	20% emulsion 1:800-1:1000
Bromopropylate	Mites	50% emulsion 1:1000-1:1500
Metalaxyl+mancozeb	Downy mildew and leaf spot fungal diseases	58% wettable powder 1:600-1:800
Oxadixyl+mancozeb	Downy mildew and leaf spot fungal diseases	64% wettable powder 1:400-1:500
Alitte	Downy mildew	40% wettable powder 1:250-1:300 90% soluble powder 1:600
Thiophanate-methyl	Anthrachnose	70% wettable powder 1:1000
Carbendazim	Anthrachnose and leaf spot fungal diseases	40% emulsion 1:500-1:800
Chlorothalonil	Anthrachnose	75% wettable powder
Bordeaux mixture	Powder mildew, anthracnose and leaf spot fungal diseases	1% solution (spray or soil application )
Copper oxychloride	Powder mildew, anthracnose and leaf spot fungal diseases	30% emulsion 1:600

## **6. HARVESTING OF FRUITS AND YIELDS**

Fruit colour is an important indicator of fruit maturity. During maturation, the peel undergoes colour changes from green to yellowish green and to bright red 7-10 days later. When the peel colour changes into dark red from bright red, the fruit is over-matured with reduced storability as well as sugar content. It is recommended to harvest the fruit when their peel is 80 percent fully red. At this stage of maturity, the fruit is of good quality. In China, lychee harvesting is done entirely by hand, preferably in fine or overcast days. Rainy days and mid-day blazing sun are undesirable for harvesting. Sorting and packing is also mostly done by hand under shade within the orchard immediately after harvest.

Lychee yields differs greatly among cultivars, tree ages and years. A 10-year-old tree of large-seeded cultivars can produce as high as 100 kg of fruit, while the figure is usually much smaller for shrivel-seeded cultivars. 1999 saw a record high lychee production of 793,200 tons from a harvested area of 155,300 hectares in Guangdong, with a unit production of 5.1 tons per hectare. However, in the off-year of 1998, 327,000 tons of lychee fruit were harvested from 110,670 hectares, unit production being only 2.953 tons per hectare.

## **7. MARKETING**

More than 60 percent of lychee produced is consumed fresh, about 30 percent is used for producing lychee nuts (dried lychee), and a small portion (2,500 tons in 1999) are frozen, canned or fermented.

Although different lychee cultivars differ considerably in maturation season, the peak period of harvest of the dominant cultivars lasts for only about one and half months from late May to early July (Figure 3). Most of the fruit produced has to be marketed immediately after picking, with a small portion cold-stored for later marketing.

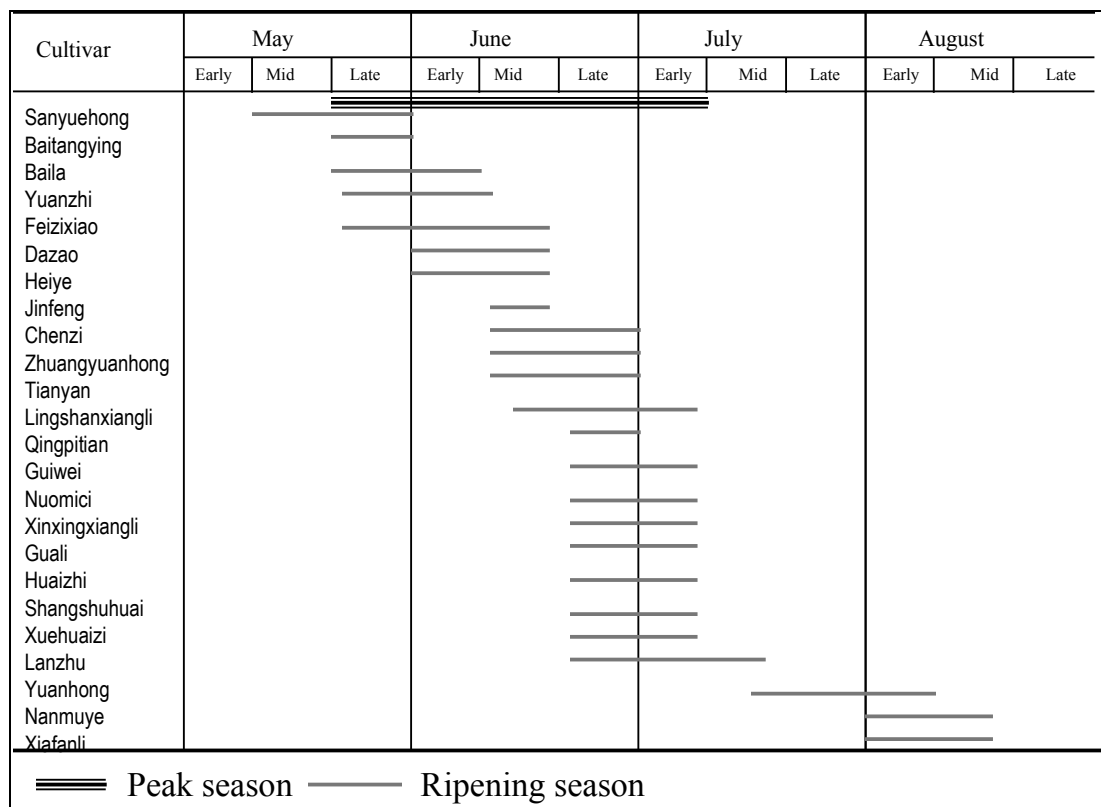
Post-harvest treatment and packaging differs according to the distance and time the transportation of fruit takes. For local markets, where transportation takes only a few hours to reach, the fruits are given no treatment and are usually packed in bamboo baskets or cardboard boxes. For long distance markets, where transportation takes more a dozen hours without cold chain, the fruit are commonly packed in plastic bags and foam boxes with added ice (about 1/3 of the fruit in volume). Cold chain plus fast transportation means have enabled lychee produced in China to reach international markets in fresh condition. However, lychee fruit turn brown and rot rapidly after harvest especially when taken out from low temperature. Post-harvest treatments like SO<sub>2</sub> fumigation and acid dip are adopted to prevent fruit browning and preserve the fruit colour. However, the fruit thus treated have a sulphur dioxide residue problem and the market of such treated fruit is shrinking.

Lychee growers and consumers are mediated by a large number of fruit dealers in China. Smallholders sell their fruit at local markets by themselves or to lychee dealers who purchase lychee from individual growers and then sell the fruit to wholesale markets, retail dealers or supermarkets. Most of the corporations who run large lychee orchards have their own fixed channels of marketing. Some of them also run cold storage plants. They also purchase fruit from smallholders when their market demands more than they produce. Some

lychee orchard managers market their fruit by running orchard tours that attract city dwellers who prefer to buy fruit freshly picked from the trees.

Local government plays an important role in promoting the marketing of lychee fruit. A successful example is the local government of Gaozhou in western Guangdong, which boasts the title of “No.1 Municipality of Lychee in the World”. By improving local infrastructure, holding lychee news conferences, inviting fruit dealers to local lychee trade fairs, organizing lychee exhibitions in major cities, setting up a lychee website and making every effort to spread their lychee information, the Gaozhou government has made the municipality known nationwide for its lychee fruit. When lychee ripens, lychee dealers crowd to Gaozhou and distribute the fruit in thousands of lorries to every corner of the country. In 1999, 120,000 tons of lychee fruit was produced within the municipality and sold out, bringing a total income of 1.2 billion Yuan (US\$ 144.6 million) for local lychee growers.

**Figure 3. The maturation season of major lychee cultivars in China**



The lychee price in China varies greatly as a function of demand and supply in the market. The earliest cultivars, like ‘Sanyuehong’, are of low quality, but enjoy a fairly good price (around US\$ 2 per kg) as this cultivar has no rival in the market. The price drops down as the peak season comes. In the off-year of 1998, the best quality ‘Nuomici’ and ‘Guiwei’ fruit cost US\$ 10-15 per kg, while in the bumper year of 1999, their price dropped to only about US\$ 0.5 per kg during the peak season. 2000 was a fair year for the two cultivars, their price was US\$ 2-3 per kg. However, on international markets, lychee fruit enjoy good prices. In 1999, the lychee price was US\$ 6.2 per kg in Germany, US\$ 6.0 in Singapore, US\$ 6.4 in the UK, US\$ 14.4 in the USA, Holland and France, and US\$ 16.8 in Canada. The

amount of lychee exported via the port of Guangdong was about 7,000 tons in 1999 and dropped to about 1,370 tons in 2000 (calculated according to Yangcheng Evening, August 27, 2000).

## **8. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT IN CHINA**

Lychee production in China has undergone rapid development since the 1980s. In the past 3 years, the development has slowed down. However, as the recently established lychee orchards enter production, a further increase in lychee production is expected for the coming years. The present lychee production has saturated the lychee market in South China, but there is an unsaturated market in North China. Even in the bumper year of 1999, lychee only reached large and medium sized cities with convenient transportation in North China. To the majority of consumers remote from lychee production regions in China, lychee is still a rare and inaccessible fruit. Moreover, lychee is the most competitive fruit in China for the international market. As long as there is a great domestic potential and international market, there is great room for further development. In addition, China possesses the best climate for lychee, plenty of sloping land that can be constructed into lychee orchards, and an incomparable rich germplasm and labour resource. However, lychee production development in China is still strongly limited by several constraints.

## **9. CONSTRAINTS IN LYCHEE DEVELOPMENT**

The constraints limiting lychee development in China are:

### **Short shelf-life, poor storability and short production season**

The lychee production season is short, about one and half months from late May to early July. The large quantity of lychee produced within such a short time must be marketed immediately since the fruit turn brown and rot rapidly (within 3 days) after harvest under ambient temperature. Short shelf-life strongly limits the extension of the lychee market in terms of time and space and causes heavy loss when the produced fruit cannot be marketed immediately. Cold storage houses are thus constructed in some large lychee orchards in order to provide a temporary buffer between production and marketing. Although low temperature storage (3-5°C) plus fungicide treatment (500 ppm TBZ or 250-500 ppm Sportak) has been able to keep fruit in fresh condition for 30-40 days, the capacity of the presently available cold storage houses is far from enough for the large quantity of lychee fruit produced in such a short season. Moreover, the poor storability of lychee fruit casts a high risk for cold storage companies to store the fruit. Lychee fruit become even more vulnerable to browning and rotting when taken from low temperature to ambient temperature. Therefore, cold chain is important to market cold-stored fruit. Unfortunately, there is a serious shortage of cold chain for the huge domestic market in China. Part of the reason is the high cost of cold chain. A much cheaper alternative involving transportation of lychee fruit packed in heatproof foam boxes plus ice has recently been widely used. However, the fruit in this type of package experience gradual temperature rise and cannot endure for more than 2 days.

### **Absence of an efficient and nationwide marketing system**

Because of the short shelf-life and short production season of lychee, an efficient marketing system is urgently needed to enable lychee fruit produced in large quantity within a short period to be marketed before they turn brown. Presently, large number of small fruit dealers are playing the major role in fruit marketing system, which usually involves local dealers who purchase lychee fruit from the growers, transporters, wholesaler at the destination, and retail sellers. Most of the dealers do not have the financial strength to invest transportation means of large volume, cold storage and cold chain. Their business is therefore limited to a small volume and to a small region. They are functioning in an unorganized manner with a low handling capacity, far below the demand of the ever-increasing lychee production in the country. In some lychee production regions such as Gaozhou, the local government has set up an efficient information system to attract wholesalers from all parts of the country and a sound marketing system is running involving only growers, wholesalers, retail sellers and consumers. However, such a system awaits further development so as to cover all the lychee production regions as well as the nationwide market in China.

### **Unorganized production by individual farmers**

Most of the lychee orchards in China are managed by unorganized individual farmers or smallholders. This production system functioned well before the local market was saturated. With the rapid expansion of lychee production and the saturation of local markets, its disadvantages become apparent. Most of the farmer households are weak in financial strength and their limited investment is put into the management of their orchards, which are usually small in size. They lack enough technical support, market information and channels for marketing their fruit beyond local market. As a result, farmers and smallholders compete bitterly on the local market. In years with bumper harvest they produce more than the local market can digest, and most of them suffer big losses. The orchard management standard and cultivation techniques are different among orchards, and thus the yield and quality of fruit produced by different farmers differ. Such a production system can no longer produce high economic benefit.

### **Climatic constraints**

Although lychee cultivation techniques have improved a lot in the past 10 years, lychee production is still largely dependent upon climate. In general, the climate in the lychee production regions in China is favourable for lychee growth and development, but there are still unfavourable climatic conditions in South China that cause crop loss and/or irregular bearing. They are:

#### **Frost**

Lychee is susceptible to frost. Though it is rare in lychee production regions, its damage is severe once it occurs. In late December of 1999, a frost resulted in massive damage to lychee orchards, especially the new ones and those in low places. Lychee production loss caused by this frost damage in Guangdong alone was estimated to be 400,000 tons.



### **Humid autumn and warm winter**

In South China, autumn is usually dry and winter is dry and chilly. The long autumn and winter drought plus chilly winter (temperature below 15°C in the day and 10°C in the night) is essential for lychee flower induction. Humid autumn and warm winters are unfavourable for winter shoot growth. Such kind of weather occurred in 1998 and most mid- to late-season cultivars failed to flower resulting in an off-year for these cultivars.

### **Cold and rainy spring**

Most lychee cultivars flower in spring, when cold and rainy weather frequently occurs. Cold or rainy weather inhibits bee activity and causes diseases to the trees. This kind weather happening during the lychee bloom period is very harmful to pollination and subsequent fruit set and may cause severe crop loss.

### **Typhoons**

The typhoon season usually starts from June in China, when lychee fruit of mid- and late-season cultivars are maturing. The strong wind of typhoons causes heavy damage to the trees and severe fruit drop. The heavy rainfall brought by typhoons usually causes serious fruit cracking to some susceptible cultivars like ‘Nuomici’ and ‘Guiwei’.

The development of lychee fruit happens to be in the rainy and humid spring and summer in South China. Rainy and humid weather not only increases the incidence of fruit drop and cracking, but also brings diseases and pests as well as difficulties in their management. Rainy weather during the harvesting period reduces the storability of lychee fruit remarkably and brings difficulty in post-harvest handling and heavy post-harvest loss.

## **10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE**

Facing the entrance into WTO, the Government of China has attached great attention to improving the competitiveness of domestically produced fruits for the international market. Lychee is considered as one of the most competitive fruits in China for the international market. However, presently only a tiny portion of the fruit is exported.

The guiding principle of the Government in China for future fruit production is “to adjust regional distribution and species or cultivar structure, and improve the quality, unit yield and economic benefit based on the existing orchard area”. This policy aims to acquire a more sustainable fruit production and to increase the benefit by improving unit yield and quality instead of by expanding the area. As for lychee, this policy together with various constraints has remarkably reduced the boom of lychee orchards in the past few years. In order to acquire a rationalized cultivar structure that extends the production season of lychee, selection, breeding and propagation of high quality early lychee cultivars and extreme late-season ones is an important resolution, and relevant programmes have been given heavy financial support.

The poor storability and short shelf-life of lychee fruit are still the toughest problems that need urgent resolution in view of the rapid increase in lychee production. Research programmes on the mechanisms and control of lychee browning, cultivation measures to improve lychee storability, breeding and selection for more storage-endurable cultivars, and technology for safer and longer storage and transportation of lychee fruit have been strongly supported by all levels of government.

Irregular bearing of lychee caused by multiple factors is another aspect giving much concern. Research programmes have been conducted to clarify mechanisms of flower induction, fruit setting, cracking susceptibility and quality formation so as to formulate relevant technical strategies to ensure flower induction, improve fruit set and quality and prevent fruit cracking.

Integrated management of pests and diseases and environmentally friendly orchard management (e.g. green food fruit production and organic farming) are encouraged by the Government to bring about sustainable fruit production while protecting the biodiversity in orchards and improving fruit safety. Relevant research is underway in China. Techniques of green food lychee and other fruit production are being formulated.

In order to increase lychee export, the Government is encouraging large corporations with financial strength to join the lychee industry. These large corporations will be able to integrate large scaled fruit production, post-harvest handling, marketing and exporting into a whole business. Governmental support is also given to the establishment of so called “Dragon-head enterprises”, which are actually large fruit dealers who do not produce much fruit by themselves but are mainly involved in post-harvest handling (storage and transportation), marketing and exporting of fruits purchased from the farmers or smallholders. With these enterprises, the farmers will not worry about marketing their fruits but concentrate on orchard management. These enterprises, with technical support from lychee researchers, are to help farmers to formulate and implement upgraded and standardized orchard management in order to obtain stable and high yield and quality fruits. The cooperation between these enterprises and lychee farmers will bring mutual benefit to each other, improve the marketability of lychee fruit and promote the sound development of the lychee industry.

## **11. CONCLUSIONS**

Although lychee production has a long history in China, it did not become an important industry until the 1980s. The current output of lychee has saturated the local markets in South China. There is a very large potential domestic and international market for the future development of lychee production. However, major constraints of short shelf-life and the poor storability of the fruit, the short production season, the low efficiency marketing system, irregular bearing, and unorganized production by individual farmers or smallholders are blocking the sound development of the lychee industry in China. Government, researchers, extension services, corporations and growers have to make joint efforts to tackle these constraints.

# LYCHEE PRODUCTION IN INDIA

H.P. Singh <sup>1</sup> and S. Babita <sup>2</sup>

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## 1. INTRODUCTION

The lychee (*Litchi chinensis* Sonn) an important sub-tropical evergreen fruit crop belonging to family *Sapindaceae*, is believed to have originated in China, where it has been grown in Southern Guangdong state for thousand of years. It is highly specific to climatic requirements and probably due to this reason its cultivation is restricted to few countries in the world. In India, lychee was introduced in the 18<sup>th</sup> century through Burma, and from there, it spread to many countries. India and China account for 91 percent of the world lychee production but it is mainly marketed locally. In India, 428,900 metric tonnes of lychee is produced annually from 56,200 hectares. Lychee being exacting in climatic requirement is confined to a few states with 74 percent of production recorded in Bihar. In this state, lychee is the livelihood for millions of people as it provides both on-farm and off-farm employment. Small and marginal farmers get additional income from lychee plants in their homesteads. Thus, lychee cultivation is the livelihood security for a large population, especially in the state of Bihar.

The lychee tree is handsome, dense, round-topped and slow growing with evergreen leaves having 6-9 elliptic oblong and lanceolate abruptly pointed leaves. Colour of leaves varies from light green to dark green. Greenish white or yellowish flowers are borne in clusters. Fruits are round or heart shaped having thin, leathery skin. The colour of fruits varies with cultivar, and is red or rose or pinkish. The edible portion or fruit is the aril, which is immediately beneath the skin. Flavour of the aril varies with cultivar, which is distinctive. Seeds are bold but in some cultivars seeds are partially developed, due to failure of pollination, referred to as 'chicken-tongue' seed. The trees with small seeded fruits are prized because of the greater portion of pulp.

Considering the importance of this fruit crop in the region, efforts are made to provide technological support through research and promoting production, post-harvest management and marketing, including export, through development programmes. Lychee has also been identified as an important crop for export. Currently, Indian export of lychee remains quite small due to expanded domestic market. The product for export and distant domestic markets is typically packed in 2 kg cartons after pre-cooling and sulphuring. Domestic marketing generally receives lychee in 10 kg wooden cages or 15 to 18 kg baskets. The growing of lychee in different states under various climatic conditions has advantages in terms of earliness and extended harvest. With a narrow genetic base, under given climatic conditions, fruits are available only for 3-4 weeks. However, due to the spread of cultivation over a wide range of climate there is possibility for extending the cropping period from the first week of May to the first week of July. Evidently, with an expanding market, there is ample potential for increasing area and production with improved production technology and

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efficient post-harvest management and storage. This paper deals with the current status and identifies the constraints which are required to be addressed.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN THE COUNTRY

### Area and Production

In India, lychee ranks 7<sup>th</sup> in area and 9<sup>th</sup> in production among fruit crops (Table 1), but in value terms, it ranks sixth. At national level banana and mango are the most important fruit but in Bihar state, lychee is considered to be the most important fruit as it contributes significantly to its total fruit production.

**Table 1. Area and Production of Major Fruit Crops in India**

Crops	Area (000 ha)			Production (000 tonnes)		
	1991-92	1996-97	1998-99	1991-92	1996-97	1998-99
Apple	195.00	222.70	231.00	1148.00	1308.37	1380.00
Banana	384.00	424.66	464.00	7790.00	10014.14	15073.00
Citrus	387.00	474.73	488.00	2822.00	4456.16	4575.00
Grapes	32.00	429.39	43.00	668.00	1134.66	1083.00
Guava	94.00	150.89	151.00	1095.00	1601.24	1800.00
Lychee	49.00	51.22	56.00	244.00	377.65	429.00
Mango	1078.00	1344.87	1401.00	8751.00	9981.25	9785.00
Papaya	45.00	63.05	68.00	805.00	1299.29	1582.00
Pineapple	57.00	68.73	74.00	769.00	924.58	1006.00
Sapota	27.00	45.67	50.00	396.00	588.49	668.00
Others	522.00	304.09	694.00	4144.00	8774.17	6659.00
<b>Total</b>	<b>2870.00</b>	<b>3580.00</b>	<b>3720.00</b>	<b>28632.00</b>	<b>40460.00</b>	<b>44040.00</b>

There has been substantial increase in area and production of lychee in the last 50 years. Area has increased from 9,400 hectares in 1949-50 to 56,000 hectares in 1998-99. The contribution of lychee to total area under fruit has increased from 0.75 percent to 1.5 percent. Increase in area between 1991-92 and 1998-99 (7 years) has been 14.28 percent, while production increase during the same period is to the tune of 75 percent. Productivity also recorded an increase of 52.91 percent during the same period. Evidently, production and productivity of lychee is constantly increasing in the country.

Lychee being exacting in climatic and soil requirements has limited distribution. It is grown in the states of Bihar, Tripura, West Bengal, Uttar Pradesh, Punjab and Haryana. Of the total production of lychee in India, 74 percent is contributed by Bihar. The second largest lychee producing state is West Bengal followed by Tripura and Assam (Table 2). Productivity is highest in Bihar followed by West Bengal. An interesting feature of distribution of lychee in India is that maturity commences first in Tripura, followed by West Bengal then Bihar. The first and second week of May is the time for harvest in the eastern region, while lychee of Bihar matures in the 3<sup>rd</sup> –4<sup>th</sup> week of May and continues up to the first week of June. Lychee in Uttar Pradesh and Punjab is ready for harvest during the 2<sup>nd</sup> - 3<sup>rd</sup> week of June. In Himachal Pradesh, lychee of the same cultivar is harvested in the last

week of June. Interestingly, in most of the states the best lychee orchards are seen along the rivers, big or small.

**Table 2. Area and Production of Lychee in different States**

State	Area (000 ha)			Production (in 000 MT)		
	91-92	96-97	98-99	91-92	96-97	98-99
Assam	3.96	4.10	4.00	11.92	17.60	16.80
Bihar	19.14	23.50	25.80	191.15	282.40	309.60
Orissa	-	2.10	3.20	-	7.30	8.60
Punjab	1.52	2.20	2.30	9.13	13.00	13.20
Tripura	11.87	3.50	4.70	5.65	22.10	26.60
Uttar Pradesh	9.12	8.70	8.80	10.89	13.20	13.70
W. Bengal	3.25	3.40	3.70	14.49	17.90	36.00
Others	0.42	3.70	3.70	0.58	4.10	4.40
Total	49.28	51.20	56.20	243.81	377.60	428.90

## Varieties

Lychee varieties grown in India are highly variable under different climate and soil conditions. Singh (1954) described 33 varieties and classified them into 15 groups varieties of lychee grown in India have also been subsequently described (Singh, 1998). When distinguishing the cultivar, the shape of skin segments and protuberances are the reliable and stable genetic characteristics. Fruit size, shape and taste are also variables but are influenced by other than genetic factors. Indian cultivars vary greatly in vegetative flushing pattern, flush colour and flowering ability. Based on these characteristics, cultivars were classified in five groups (Singh, 1998). Group A, which has 7 cultivars is the early group, B and C groups are mid-season, and group D is the late group. Only one cultivar, which is very late, is under group E and its cultivation is confined to Muzaffarpur. Yield and physicochemical characteristics of important cultivars are given in Table 3. The cultivars also show variation in yield, cracking, and physico-chemical quality. Shahi among the early group and China among the mid-season groups appeared to be promising in Jharkhand state (Babita, Personal communication).

Leaf colour along with shape and size of the leaves is of importance in varietal identification. The leaf of Rose Scented is boat-shaped while China has a distinctive twist along the length curved upward from the midrib and down along its length. Small leaflets of Bedana are oval shaped. The fruit shape of the lychee is very distinguishing. The round shape of Bedana is distinguished from the oblong shape of China or Shahi. The fruit is smooth and pulp is even or uneven. The apex of the fruit can be round, obtuse, blunt as in Shahi, or pointed as in China. The varieties can also be distinguished depending upon the colour of the new flush and season of flushing. Shahi produces very light coloured flush while China has pinkish flush. Bedana has very dark pink flush. Emergence of the panicle and its shape also differs. Singh and Singh (1954) distinguished the cultivars based on panicle characteristics. Shahi has long panicles while Bedana produces short and compact panicles. The colour of the lychee fruit is pinkish brown or dark red depending on the cultivar. Colour of the skin varies and is also influenced by growing conditions.

**Table 3. Physicochemical characteristics of important cultivars**

Varieties	Cracking (%)	Estimated Fruit Yield (Kg/ plant)	Length (cm)	Shape Index	Fruit Weight (g)	Pulp (%)	TSS 00 Brix	Acidity (Citric Acid-100g)	Total Sugar (g/100g)
Ajghauli	27.58	72.42	3.48	1.15	15.29	63.13	20.22	0.3	12.53
Bedana	0.24	32.75	3.32	0.94	16.33	70.68	19.33	0.28	10.2
China	0.33	95.33	3.4	1.1	14.77	58.46	20.22	0.29	10.95
Dehra Dun	14.27	67	2.82	1.17	16.77	71.74	20.75	0.41	11.87
Dehra Rose	10.01	74.87	3.34	1.13	19.63	74.12	21.27	0.37	12.19
Deshi	13.63	83.03	3.5	1.18	15.94	66.65	22.82	0.37	13.48
Green	24.44	84.72	3.57	1.27	16.7	61.35	21.42	0.33	11.55
Kasba	0	37	3.78	1.12	25.93	72.23	20.23	0.4	11.24
Late Bedana	0	54.22	3.36	1.06	16.7	75.08	18.17	0.27	10.38
Longia	0	63.85	3.17	1.16	13.84	67.51	19.27	0.28	11.5
Purbi	0.95	80.65	3.31	1.07	20	71.73	20.1	0.29	11.04
Rose Scented	8.85	88.05	3.63	1.16	19.39	69.05	20.37	0.37	12.98
Shahi	12.25	100.3	3.4	1.21	19.47	74.78	22.3	0.38	12.97
Trikolia	12.03	42.37	3.37	1.14	17.35	70.83	22.43	0.36	12.7
CD (5%)	7.45	9.71	0.17	0.09	1.73	3.07	0.48	0.03	0.18

Skin thickness depends on the cultivars. Bedana and China have very thick skin. Rose Scented and Shahi have very thin skin. Skin surface at maturity also varies being smooth, swelling, sharp and pointed. Protuberances of the skin (pericarp) can be smooth and sharply pointed. Bedana has very smooth protuberances while Shahi has very distinct protuberances. The presence and absence of seed as well as structure and size of seeds also vary from cultivar to cultivar, although it is influenced by environmental conditions. In Rose Scented and Bedana, a high proportion of chicken-tongued, seeds (aborted seeds) are observed while China has bold seeds. In a recent selection cv. Swarna Rupa, a high proportion of fruits have small seeds (Singh and Yadav 1992). Although lychee has short duration not exceeding 30-40 days, cultivars can be distinguished based on season and maturity, provided they are grown at same location. Accordingly, cultivars can be grouped into three categories namely, early, medium and late season. Fruit maturity also varies slightly and relatively from year to year depending upon prevailing weather conditions. The maturity period of the fruit also varies depending upon agro-climatic regions. Some of the varieties in West Bengal come to maturity earlier, while the same varieties can be late in Uttar Pradesh. Due to the production of lychee in varying agro-climatic conditions, maturity, fruit colour, shape and size are reported to be varying. Thus, there has been much confusion in the names of varieties. As a result, the same variety is called by different names at different locations (Ray et al. 1984). Varieties grown in India are given in Table 4 and a few selected varieties are described.

**Table 4. Varietal Distributions of Lychee in Different States in India**

<b>States</b>	<b>Varieties</b>
<b>Bihar</b>	Deshi, Purbi, China, Kasba, Bedana, Early Bedana, Late Bedana, Dehra Rose, Shahi, Manragi, Maclean, Longia, Kaselia and Swarna Rupa
<b>Uttar Pradesh</b>	Early Large Red, Early Bedana, Late Large Red, Rose Scented, Late Bedana, Calcuttia, Extra Early, Gulabi, Pickling, Khatti, Dehra Dun, Piyazi
<b>West Bengal</b>	Bombai, Ellaichi Early, China, Deshi, Purbi and Kasba
<b>Haryana / Punjab</b>	Early Seedless, Late Seedless, Seedless-1, Seedless-2

### **Shahi**

This is the most popular cultivar grown in North Bihar, Jharkhand, Uttaranchal and Uttar Pradesh regions of India. Besides having high quality fruit it has a distinct rose aroma and hence is called ‘Rose Scented’. It is known as Shahi in Bihar, Rose Scented in Uttaranchal and Muzaffarpur in Western Uttar Pradesh. The vegetative flush of this cultivar is light, and fruit weight ranges from 20-25 g. This cultivar is earliest in maturity, and ripens during the second week of May to the first week of June at various locations. It matures on 12-15 May in Jharkhand, the 25th May in North Bihar and by the first week of June in the Terai region of Uttaranchal. Trees of this cultivar are very vigorous and produce fruits ranging from 100-150 kg per plant. Mature fruits are prone to cracking in zones with low humidity and poor moisture content in the soil. Fruits are globous-heart or obtuse in shape having rose madder and fuchsia purple background with red tubercles at ripening. Pulp is greyish-white, soft, moderately juicy and sweet, and TSS ranges from 19.00 to 22° brix. Seed size varies. On the same plant larger fruits have big seeds while seeds in small fruits are shrunken. The fruits are known for excellent aroma and quality. This cultivar occupies a major area under lychee in India.

### **China**

The origin of this cultivar is not known but the name indicates that it was selected for its superiority and named ‘China’. It is tolerant to hot waves and fluctuations in soil moisture, which cause fruit cracking. It is known as Purbi, Calcuttia, Bengalia, Bombaiya and Manragi in different regions. This is a medium-late season cultivar. Fruits ripen during the end of May in West Bengal, the first week of June in Jharkhand and North Bihar and the third week of June in Uttar Pradesh. Trees are comparatively dwarf and high yielders but it is prone to alternate bearing. Rains at the time of fruit bud differentiation cause emergence of vegetative flush resulting in loss of crop. It bears fruits in cluster of 12-18. In some cases more than 30 fruits per cluster are also recorded. The plants bear less fruit in eastern and southern directions. Fruits are large in size, medium-heavy in weight, oblong in shape, and tyrant rose in colour with dark tubercles at maturity. The aril is creamy-white, soft, juicy, sweet having 18 to 17° brix TSS, 11 percent total sugar and 0.43 percent titratable acidity. Seeds are glaucous, dark chocolate in colour, oblong to concave or planoconvex in shape, medium in size (2.9 cm length and 1.5 cm diameter), and average in weight (3.49 g/seed). The ratio of rind:pulp:seed by weight is 16.42 : 69.22 : 14.36 (Pandey and Sharma, 1989).

The flavour of the pulp is not pleasant like Shahi, but owing to its high yield and no cracking this cultivar is popular. This cultivar cannot be distinguished from Manraji and Purbi grown in the eastern part of Bihar state.

### **Early Bedana**

It is also known as Early Seedless in Punjab because of its early ripening and small seeds. This cultivar has distinguishing leaf and flower characters. The cultivar is very much popular in Uttar Pradesh and Punjab. Trees are medium, attaining an average height of 5.0 m and spread of 6.2 m. It is a medium yielding cultivar (50-60 kg/tree) but bears fruits regularly. Fruits are medium in size and weight ranges from 15 to 18 g having oval or heart shape, rough surface with uranium green skin covered with carmine red tubercles at maturity. Aril is creamy white, soft, juicy and sweet containing 17.2 to 19.8<sup>0</sup> brix TSS. Seed is very small, shrunken, glamorous, dirty chocolate in colour. The overall fruit quality of the cultivar is good.

### **Late Bedana**

This cultivar is also known as Late Seedless. This is a late maturing cultivar, which usually ripens, in the last week of June in Uttaranchal, the end of May in Jharkhand and in first the week of June in Muzaffarpur. The trees are vigorous having an average height of 5.5 m and spread of 7.0 m., with yield ranging from 60-80 kg/tree. Although the fruit size is medium the pulp content is high. The fruits are conical in shape and vermilion to carmine in colour having dark blackish brown tubercles at maturity. The pulp is creamy white, soft, juicy, sweet having 18 to 2<sup>0</sup> brix TSS, but acidity is low. Seeds are very small, shrunken, glamorous, and chocolate in colour with fusiform shape. The new flush is dark pink in colour and its leaf can be distinguished from other cultivars. The panicle is compact.

### **Ajhauli**

This is an early maturing variety selected from Ajhauli village. It yields about 80-100 kg fruit from a sixteen year old tree. Fruits are red in colour weighing 15 to 18 g and have big seeds. It cannot be distinguished from Shahi on vegetative characteristics as it has many similarities. This variety is highly prone to cracking but under irrigated condition cracking is minimized.

### **Bombai**

This is an important cultivar in West Bengal. It is a vigorous cultivar attaining a height of 6-7 m and spread of 7-8 m. The cultivar matures early (second week of May) and gives 80-90 kg fruit yield per tree. Fruits are large in size (3.5 cm long and 3.2 cm diameter), obliquely heart shaped, and weigh 15-20 g. The colour of ripe fruit is an attractive carmine red with uranium green skin background. Like the Chinese cultivar 'Nuomici', this cultivar also has a tiny under-developed fruit attached to the fruit stalk of each fully developed fruit. The pulp is greyish white, soft, juicy, sweet, containing 17<sup>0</sup> brix TSS, 11 percent total sugar and 0.45 percent acidity. The elongated, smooth and shining seed of light chocolate colour is 2.3 cm long, 1.6 cm in diameter and weighs 3.4 g. This cultivar is akin to China grown in other states.



### **Dehra Dun**

This is an important cultivar of Uttar Pradesh and Punjab where it is grown with the name of Dehra Rose. The fruits start ripening by the third week of June in Uttar Pradesh but in Jharkhand it matures with Shahi. It is a medium vigorous tree (5 m height and 7 m spread) which produces medium to high yield. Fruits are medium to large in size, measuring 3.7 cm in length, 3.5 cm in diameter, weighing 15.2 g and having oblique-heart to conical shape. Bright rose-pink coloured fruits of Dehra Dun look very attractive at ripening. The pulp of this cultivar is greyish-white, soft, moderately juicy with 18° brix TSS, 10.4 percent sugar and 0.44 percent acidity. Seeds remain small, light, shrunken, mostly oblong in shape and dark chocolate in colour. Under rainfed conditions this cultivar is highly prone to cracking. The name of the cultivar suggests that it is a selection made in Dehra Dun.

### **Gulabi**

This is another late maturing cultivar of North India in which ripening takes place by the fourth week of June. Early rain hampers the quality of fruits. The medium vigorous tree of cultivar Gulabi bears profusely and regularly with medium to large sized fruits. The shape of the fruit is variable from oblong-oval to heart shaped whereas the rind colour at ripening varies from shrimp red to carmine red with mandarin red tubercles. The pulp is firm, greyish white, sweet with 18.2° brix TSS, 10.7 percent total sugar and 0.49 percent titratable acidity. The seed is rather big, heavy, oblong-cylindrical in shape with a shining chocolate seed coat.

### **Ellaichi**

This is an important cultivar in West Bengal having brighter prospects for commercialization. The trees are moderately vigorous, attaining an average height of 5-6 m and spread of 6-7 m. It is a mid season cultivar which ripens in the first week of June. The cultivar yields 50-60 kg fruits annually. Fruits are conical, marigold-orange red in colour with an average weight of 12-15 g. The pulp is creamy white in colour, sweet, soft and juicy with agreeable flavour. The cultivar has 18° brix TSS, 11.5 percent total sugar and 0.45 percent acidity, and 6.91 :1 pulp:stone ratio at ripening. Seeds are relatively small, shining, and weigh 1.5 - 2.0 g. Fruits are less susceptible to sunburn and cracking. This cultivar has not assumed commercial success.

### **Longia**

This cultivar is well distributed in North Bihar, and is preferred for late maturity. The tree is medium in size, leaves are small and light in colour and it has compact panicles. Fruits are medium in size and the aril has an excellent aroma. Due to shy bearing habit, there is a declining preference for this cultivar.

### **Kasba**

This is a large fruited cultivar selected from Kasba village for its attractive fruit size and colour. The tree is large and compact having broad and elongated leaves. Fruit weighs between 23-27g, perhaps the heaviest fruit among the known varieties, but the number of fruit is less. Interestingly, the cultivar performs better in marginal soils as it has the capacity to absorb more nutrients (Personal Communication, S. Babita).

### **Kaselia**

This is later maturing cultivar found growing in isolation. The tree is medium in size and fruits mature very late. Fruit attain a pink red colour. The pulp content is comparatively low and the seed is big. This cultivar is also known as 'khatti' or 'pickling'. The cultivar has not assumed commercial success.

### **Swarna Roopa**

This is a late maturing, cracking resistant cultivar of lychee selected at the Central Horticultural Experiment Station (CHES), Ranchi. The fruits are a attractive red colour with small seed and high aril percentage. Leaves are similar to Bedana in shape and size. New flush is pink and mature leaves are dark in colour. The cultivar has 18.5-22.5 cm long, compact panicles. Fruits are medium in size weighing 12-15 g and have a high pulp content. The pulp contains high TSS and low acidity. Total sugar content in the fruit is 13 percent out of which 8.5 percent is reducing sugar. The cultivar is suitable for extended harvest as it matures after China and is prized for its attractive fruit colour. This cultivar is recommended for commercial production.

### **CHES-2**

This is a late maturing selection from the population of the China group. It bears fruits both at the outer and inner canopy, which helps in reducing the sunburn as well as fruit cracking. The fruits are deep red, conical shaped and appear in a cluster of about 15-20. The fruit has an average weight of 21.3 g containing 3.8 g seed and 16.1 g pulp. Vegetative characteristics are similar to China however flowering and fruiting is earlier.

The cultivars described above can be grouped based on the flush colour, shape of the leaf, panicle, fruit, pulp colour and flavour and maturity. Accordingly a key to important cultivars of lychee has been prepared and is presented in the Table 5. All the major cultivars fall into five groups.

**Table 5. Key to Important Cultivars of Lychee**

- |   |                           |
|---|---------------------------|
| 1. Flush pink, leaf boat-shaped, dark green, panicle long, fruits oblong with round apex.   |                           |
| -Colour of fruit deep pink  | <b>Shahi/Tirkolia</b>     |
| -Rose flavour   | <b>Rose scented</b>       |
| -Colour of fruit light and greenish   | <b>Green</b>              |
| -High cracking and big seed   | <b>Ajhauli</b>            |
| -Late in Maturity   | <b>Dehra Dun</b>          |
| 2. Deep pink flush, leaf with twist along the length, curved upward from the midrib and down along their length, panicle long, fruit oblong with pointed apex |                           |
| -Color of fruit pink  | <b>China</b>              |
| -Fruits deep pink   | <b>Purbi/Manraji</b>      |
| -Fruits in bunches  | <b>Bombaia/ Calcuttia</b> |
| -Early maturity   | <b>CHES-2</b>             |

3. Dark pink flush, oval shaped leaves, compact and small panicles, Fruit round, smooth, chicken tongue seed (aborted seed)
  - Early maturing **Early bedana or Early seedless**
  - Late maturing **Late seedless/Late Bedana**
  - Deep pink colour **Swarna Rupa**
  - Mid season maturity **Kasba**
4. Deep pink flush, boat-shaped and dark green long leaves, panicle long, largest size fruit, deep in colour **Longia.**
5. Small elongated leaves, light green in colour, panicle compact, fruit medium in size, very late maturity. **Kaselia/Khatti.**
  - Pulp sweet and excellent flavour
  - Pulp sour

### **Climate and Soil**

Since, flower bud differentiation, flowering, fruit set, fruit quality and flavour development in Lychee is influenced significantly by temperature and humidity, it has adapted well in the sub-tropics where summer months are hot and wet and winter months are dry and cool. Hot summers free from hot wind and winters free from frost are essential.

Lychee cultivation is highly successful in areas having minimum temperature of 10°C from December to February and 38°C from April to June. However, temperature of 32° C during these months is considered to be optimum. It is highly specific to climatic requirement for its establishment, plant growth and fruiting, and consequently spread of area. A moist atmosphere, occasional rainfall, cool dry winter free from frost and hot winds are ideal for its cultivation. In lychee growing areas in India the temperature varies from 21° C to 37.8°C during flowering and fruiting. It has been observed that flower initiation in lychee requires comparatively low temperature. Seasonal variation in temperature is favourable for proper fruiting. A dry climate, free from rains for about 2 months before flowering induces flower bud differentiation, blossom and consequently give high production. In Chotanagpur, the fog free dry winter, mild sub-tropical summer and intermittent pre-monsoon showers during April-May have been observed to be highly favourable for blossoming, better aril development and improvement in fruit quality. The sub-tropical to mild temperate climate in the foothills and valleys of the Himalayas are also suitable for lychee cultivation. Depending upon the temperature rise after winter the time of flowering and maturity is determined. No fruiting has been recorded when lychee has been grown in tropical conditions. However, on hills in southern states flowering is observed and harvesting commences in November-December.

In India, lychee is grown successfully on a wide range of soil types, which include sandy loams, laterite, alluvial sand, and calcareous soil, but the best lychee orchards are seen in alluvial sandy loam soils with good drainage and access to the water table. The performance of orchards is very poor on clay soil with poor drainage. Lychee grown in sandy soils have a root system network, while trees grown in clay soil have very poor root distribution. The pH of soils in North Bihar ranges from 7.5 to 8, while in Jharkhand lychee grows well at a pH of 6 to 6.5. It grows well even in calcareous soil with 30 percent free lime content. However, in acidic soil of Jharkhand mycorrhizal activity is minimal which affects fruit yield and quality (Pandey and Mishra, 1975). The taxonomy, morphology and mycotrophic habit of mycorrhiza association with lychee was described by Pandey and Misra (1975) and their work also confirmed that lychee requires mycorrhiza to grow and

produce better quality of fruits. Thus, it is often suggested that new orchards should be grown with the introduction of soil from old orchards.

### **3. PRODUCTION OF PLANTING MATERIAL**

Lychee is generally multiplied by vegetative methods of propagation as plants raised through sexual method (by seed) grow slowly, have a long juvenile period and do not produce fruit true to the type. However, earlier introduction in different parts of the country was perhaps through seeds, which enabled the selection of superior types and perpetuation the cultivar through vegetative means. The most commonly practiced method of vegetative propagation is air-layering, though cutting, grafting and budding have been found to be successful.

#### **Air-layering**

Air-layering, known as 'marcottage' in China and 'goottee' in India, is commercially practiced for large scale multiplication both in public sector and private sector nurseries. When and how this practice was adopted is not documented but the process of development and modification in the method of layering suggests that the method has gone through transformation. Earlier layering was done using clay soil having provision of watering, however, the air-layer practiced now uses growth hormone and nutrient mixed media of peat moss or coir pith, which is covered with polythene. For preparation of the air-layer a healthy terminal branch receiving good sunshine with a thickness of about 1.2-1.5 cm is selected and a 2.5 cm ring is made by removal of bark about 45-50 cm below the apical growth. The cambium layer is rubbed off and the woody portion is exposed. Rooting hormone (1000 ppm IBA) is used as paste or powder. A layer of moist sphagnum moss or coir pith is placed and wrapped with a piece (20 x 25 cm) of 400 gauge polythene sheet and tied properly at both ends to ensure supply of proper moisture which facilitates the development of roots. It is advised to enrich the rooting medium using organic nutrients. After about 50-60 days, the adequate root system develops from the upper end of the ring, which is visible through the polythene film. The layer is removed by making a sharp cut about 5 cm below the lower end of the ring, preferably in 2-3 stages. The detached layers are planted in partial shade. Success in rooting of the layer is determined by temperature and humidity. When night-time temperature falls to less than 20°C the root becomes brittle. Thus, June is considered to be best time for air-layering. In order to enhance the success of the detached layer, defoliation of leaves up to 50 percent is advocated. At the time of planting excess vegetative growth may be removed to maintain balance between the top and newly developed root system. Regular irrigation and weeding is done to facilitate better establishment and growth. Beds are kept weed free. Lychee layers become ready for field planting in 4-5 months. Growing of layers in the greenhouse has been found to enhance success.

#### **Pot layering**

Some nurseries practice, pot layering wherein a lower branch of mature wood is cinctured and the cut surface is buried in a pot or container filled with rooting medium. The pot is watered regularly. The roots develop in the cinctured portion of the branch in about 2 months. Then the branch is detached from the main plant by giving sharp cut, preferably in 2-3 stages. No repotting is required before transplanting in the field. Application of IBA (2000-5000 ppm) improves rooting and survival of the layers.

## **Stooling**

For large scale multiplication stooling is also recommended. In this method, planting is done closely at 1 x 2 m. Once the plant attains the required growth it is headed back to the stump during January-February which permits new shoot (stools) emergence from the stump within two months. A ring of 2 cm is made at the base of the newly emerged shoots and rooting hormone is applied. Then a mound of soil is raised around the shoots to encourage rooting and watering is done regularly. Profuse rooting occur in the stools within two months. These stools are detached and kept in the nursery for hardening and become ready for transplanting in July-August. In stooling, one must be careful not to allow the soil mound to dry, otherwise the rooting process is affected adversely. Therefore, the stool beds should be irrigated at weekly intervals from April-June.

## **Cuttings**

Although this method is advocated it has not been practiced by nurserymen on a commercial scale. The propagation of lychee has also been tried through cutting under mist conditions. A high percentage of rooting was also obtained from the cutting treated with IBA and planted in April-May under mist. But this has not been adopted commercially.

## **Grafting and budding**

Grafting in lychee is mainly practiced for changing scion cultivar or seedling tree or unproductive and old orchards by top working. The apical, side and approach grafting are mainly practiced. In apical grafting 10 cm long scion wood (non-terminal) with at least 2 slightly swollen buds gives better results. The technique of splice or tongue grafting is successful. Apical grafting has not been commercially used for large scale multiplication. Grafting appears to be promising provided seedling growth and percent germination improves. Yadav and Singh (1988) observed that the highest germination of lychee seeds could be obtained if fruits are harvested one week before maturity. A higher rate of growth in seedlings is possible under greenhouse conditions. Softwood grafting has been found to be successful in many nurseries. Budding of lychee has also been successful. However, much more work is required to be done before these methods become accepted practices.

Since, air-layering is a commercial practice, a large number of private nurseries have come forward for large scale multiplication of plants especially in lychee growing regions. It is estimated that about 300,000 lychee plants of different cultivars are produced annually. The regulatory framework to ensure the quality of plants is not in place, thus the creditability of public institutes or private nurseries determine the preference of growers. The cost of plants also becomes a factor in determining the preference of farmers.

## **4. ESTABLISHMENT OF ORCHARDS**

Orchard establishment is a highly specialized activity, which requires proper planning, selection of site, land preparation, layout, planting of saplings, as well as orchard protection and management.

## **Selection of site and soil**

Lychee can be cultivated in a wide range of soils, starting from sandy to clay loam with good drainage and rich in organic matter. However, well-drained deep sandy loam soils having good moisture holding capacity, rich in organic matter and calcium content have been found ideal for lychee cultivation. The well-drained soils of North Bihar rich in calcium content have been observed to be most suitable for better growth and quality fruits. The rolling uplands of Chotanagpur have also been found to be suitable. Soils with poor physical conditions, lacking in available nutrients can be improved for lychee cultivation by adding sufficient quantities of decomposed farmyard manure (FYM), compost and green manure. Lychee growth is restricted in clay soil, thus the site selected should have the above characteristics. When selecting the site climate is also given due consideration. Lychee should not be grown in excessively humid regions when winter temperature is not below 12°C. Also when selecting a site the source of water and transport facilities should be given due consideration.

## **Planting**

Before layout the land is cleared of bushes and other weedy vegetation and is leveled with a mild slope in the opposite direction of the water source. To improve the fertility of the soil organic matter is added. A green manure crop is grown and incorporated into the soil, which improves its fertility, moisture holding capacity and physical condition.

Pits 90 x 90 x 90 cm in dimension are dug at the spacing decided for the orchard. Pit opening is normally recommended in April-May to have a sterilization effect for about 3 days. Before the onset of monsoon pits are filled with topsoil mixed with about 40 kg decomposed compost, 2 kg neem/karanj cake, 1 kg bone meal/single super phosphate and 200-300 g muriate of potash. Incorporation of about 2 baskets of soil from the root zone of old lychee trees encourages the mycorrhiza growth. Then the soil is allowed to settle with the first few rains and leveled properly. Planting is done during June to July. At the time of planting a hole the size of ball of earth is made in the centre of the pit at the marked point where the plant is fixed and the soil is pressed to remove air. Watering is done immediately after planting for proper establishment. Subsequently the plant is regularly irrigated till it is properly established.

## **Spacing and planting system**

Lychee is an evergreen spreading tree, which attains the height of about 10-12 m at its full growth and development. Light penetration of its canopy is also desirable for proper fruiting, hence planting in square system at a distance of 9-10 m within and between the rows has been practiced. However, in an experiment conducted at the Central Horticultural Experiment Station, Ranchi, planting of lychee in a double hedgerow system at a distance of 4.5 x 4.5 x 9 m accommodating 329 plants/ha has been found to be the best and gave higher yield of equally good quality fruits up to 16 years of plantation. High density planting adopting a double row system has also been found to be superior at other locations in terms of yield and quantity of fruits. Through appropriate canopy management high density planting accommodating about 1,200 plants per hectare could also be done as has been found successful in mango. However, this would need further investigation.

## **Training and pruning**

Training of the plant in the initial stage is essential to provide the required framework. Unwanted branches should be pruned to provide definite shape and to promote growth of the trunk and crown of the tree. Three to four branches 60-75 cm from ground opposite to each other are allowed to form the proper frame of the tree. Further, crowded and crisscross branches are removed to facilitate better growth. The branches with narrow angles are also avoided as they are prone to breakage. Non-fruiting unproductive branches inside the canopy in growing and mature trees should also be pruned. Dried, diseased and scissors-shaped branches should also be periodically removed. Light pruning after harvest has been found congenial for better growth, fruiting and yield. While harvesting the fruit the panicle is plucked along with 8-10 cm of twig to promote new flush and better bearing for the succeeding year.

## **Manure and fertilizer**

Among the several factors associated with production of lychee, balanced nutrition is considered to be the most important which determines productivity and quality. Lychee responds to exogenously applied manure and fertilizers and response varies depending upon cultivar (Kotur and Singh, 1993), climatic conditions and soil types. A survey conducted in the Doon valley indicated that 80 percent of orchards are low in N and P and need N and P application (Kunwar and Singh, 1993). In West Bengal, NPK was reported to be below the optimum level (Rao *et al*, 1985). However in Punjab N, K, Mg, Zn and Mn are reported to be in deficit range. Recently, a survey conducted by Babita (Personal Communication) has clearly shown that low yield and poor quality fruits in lychee are associated with a sub-optimal range of nutrients. Variation in nutrient content was also observed among varieties.

Field experiments conducted on different cultivars at different locations have clearly demonstrated the effect of a graded dose of NPK on growth, yield and quantity of fruits. Application of 600-800 g N, 200-300 g P<sub>2</sub>O<sub>5</sub> and 400-600 g K<sub>2</sub>O per plant is recommended for 12-15 year old trees. Nitrogen and Potassium should be applied in 2-3 splits and P<sub>2</sub>O<sub>5</sub> in two splits. Excessive application of nitrogenous fertilizer before flowering should be avoided. Phosphorus application at the time of flower bud differentiation improves flowering and fruiting. Application of cakes and manure is generally practiced to get better quality fruits. In general, lychee orchards maintained with higher doses of organic manure have better yield and quality as compared to orchards maintained with chemical fertilizers.

Additional application of Ca, Zn, B, Cu and Mn is recommended. Application of 0.6 percent Ca as calcium chloride improves fruit weight and quality. Zn is applied in the form of 0.5 percent zinc sulphate hydrated with lime, which helps in reducing fruit drop and enhancing fruit yield and quality. Boron in the form of borax (600 ppm) enhances fruit setting and reduces fruit cracking.

In acidic soil application of 10-15 kg lime/tree once in 3 years has been found to increase the yield. In general, application of FYM, potassic and phosphoric fertilizers in major lychee growing areas of the country is done during June-July, just after harvesting of the crop. However, in heavy rainfall areas like West Bengal, Uttaranchal, and Uttar Pradesh, manure and fertilizers are applied in the month of September-October just before the end of monsoon. The nitrogen is applied in two equal split doses. The first dose is applied after fruit set, in the month of March-April while the remaining half dose is applied immediately after

harvesting of the crop. After application of fertilizer, irrigation of the tree is essential to maintain proper soil moisture. The total requirement of nitrogen, phosphorus and potash is applied through basal application. However 2 percent urea spray is practiced once or twice during the period of fruit growth as needed.

Foliar application of zinc sulphate (0.1 percent) is done twice, 10-15 days before flowering for improving sex ratio and to reduce fruit drop. If a deficiency of zinc and magnesium is observed, application of 150-200 g ZnSO<sub>4</sub> and 150-200 g MgSO<sub>4</sub>, respectively per plant during September has been found to be beneficial. Foliar application of 0.1 percent borax, 2-3 times during the period of fruit growth and development of the trees enhances fruit retention, minimizes cracking, improves fruit colour and sweetness, and advances maturity. Other micronutrients like Fe (Ferrous sulphate), Cu (Copper sulphate), Mg (Magnesium sulphate) are applied if deficiency symptoms are observed. Two to three spray in a year is sufficient to maintain the trees in good health.

Foliar application of the plant bio-regulator, NAA (20 ppm) at an interval of 10-15 days during the period of fruit growth and development, twice or thrice, has been found to be useful for minimizing the fruit drop. IAA may be substituted for NAA if the latter is not available. Spraying plain water four to six times in the early morning hours of the day during the advanced stage of fruit growth and development have been found to be highly effective for achieving better growth with minimized fruit cracking.

Monitoring of plant nutrients is done arbitrarily although some farmers get their soil analyzed for pH and nutrients content once in a while. However, it is advocated to use leaf nutrients as diagnostics for monitoring nutrient needs (Kotur and Singh, 1993). Application of fertilizer based on leaf analysis values, though holding promise, is not yet a reality. Babita (Personal Communication) observed that the critical value of nutrients could be used as a guide to determine the nutritional needs, and could economize on fertilizer and provide higher yields of quality fruits.

### **Irrigation, mulching and water conservation**

Lychee being an evergreen plant, the maintenance of optimum soil moisture is critical for growth, development and fruit production. If the rainfall is evenly distributed lychee is grown successfully and supplementary water requirement depends upon cultivar and evaporation demand. Water requirement ranges from 600-800 mm. Investigations carried out to determine the irrigation needs have clearly indicated that irrigation is critical at the fruit development stage to get better yield and quality of fruits. Interestingly, differential management of water in the vegetative phase and reproductive phase is also suggested. To achieve faster growth of the plant no water stress should be permitted, while in the reproductive phase water stress is beneficial at the time of fruit bud differentiation. Light irrigation during summer and winter months and cleaning of the basin is advocated. Irrigation at the intervals of 2-3 days during the initial stage of plant establishment is considered essential. Further, the young plants should be irrigated during dry periods and winter months at intervals of 3-5 days. For young plants mulching with dry leaves or residues in the basin help in better moisture conservation. Experiments conducted at Ranchi indicated that irrigation of plants at alternate day intervals, 6 weeks before harvesting improves fruit retention, encourages better fruit development, and minimizes the cracking, apart from the quality of fruits. Certain physiological disorders like poor sex ratio, poor fruit set, heavy fruit drop and high fruit cracking, besides sunburn of the fruits can be minimized



with proper water management. The basin or flood method of irrigation is normally practiced. However, adoption of drip irrigation has been found to be effective in the economic use of water and enhanced growth, especially in an area where water availability is not satisfactory.

Moisture conservation through mulching using dried weeds or black polythene sheet has been found useful. Trials have also been conducted to conserve moisture using farm residues and polythene sheets. Through adoption of mulching, frequency of irrigation is reduced. In a trial conducted at Ranchi mulching with 3 irrigations was effective in reducing cracking and enhancing yield and quality of fruits (Singh, 1986). To check fruit cracking mulching with 3-4 irrigations during fruit growth has been found to be satisfactory.

### **Filler plant and intercropping**

Lychee is a slow growing plant and takes about 15-16 years to develop canopy and cover the area. During the initial period of establishment, the space between the plants can be utilized for planting of filler plants/intercrops. The planting of guava, custard apple, lime/lemon in the centre, between and within the rows of lychee have been found to give additional income in the initial stage of planting without competing with the main crop. Papaya is also planted as filler plant at the spacing of 2.5 x 2.5 m. In between the plants in the initial stage, cowpea, french bean, okra, brinjal or other suitable crops of the regions are grown as intercrops. In the mature lychee orchards, cultivation of partial shade loving plants (ginger, turmeric, elephant foot yam) is practiced successfully, which provides additional income.

### **Control of pests, diseases and physiological disorders**

Lychee plants and fruits are affected by insect pests and diseases, which causes considerable losses, if not managed. Lychee plants as compared to many fruit bearing species are least affected by diseases. A few leaf spot diseases have come to light that are caused by fungal pathogens. No bacterial or viral infections have been reported so far. Powdery mildew (*Oidium* spp.), anthracnose or leaf spot (*Botryodiplodia theobormae* Pat, *Colletotrichum gloeosporioides* Penz) and red rust (*Cephalexros mycoides*) are some diseases which cause some damage to the lychee crop, but severity varies from season to season even in the same locality. Their control measures consist of 1-2 applications of proper fungicides, while for red rust sulphur washes in September-October and February-March is sufficient.

Although about 40 insect and mite pests are reported to affect lychee trees and fruits at different stages of growth, erinose mite, lychee bug and fruit borer are the insect pests of most concern.

#### **Lychee mite**

Lychee mite (*Aceria litchi*) is a serious pest in all the lychee growing regions in the country. The tiny nymph and adults stick to the under-surface of the leaf and suck the cell sap. Consequently, the young leaf turns yellow to greyish-yellow and a velvety growth develops on lower surfaces, which subsequently turn brown. The affected mature leaf develops continuous to scattered brown patches with curling, twisting and leathery structure, which ultimately result in blister-like gall formations. It spreads fast under favourable

conditions and reduces the photosynthesis activity and increases leaf drop. As a result the tree becomes weak, and yield and quality of the fruit is severely affected. The pest is well studied. It is suggested to prune the affected twigs/branches and burn to avoid spread. Two sprays of karathene 0.05 percent at 7-10 days interval during the attack of the insect has been found to effectively control the pest. Application of neem cake has also been found to reduce the incidence of this pest.

### **Shoot borer**

In lychee orchards incidence of shoot borer is reported. The caterpillar bore inside the newly growing shoot and feed on inner parts resulting in drying of the twigs. In the case of severe infestation the sap movement is interrupted and the tree ceases to flush. Pruning and burning of affected twigs minimize the infestation.

### **Bark eating caterpillar and trunk borer**

The caterpillar (*Inderbela* sp.) bore inside the trunk/main stem. During the night they come out and feed on the bark protected by the large silken webs usually during July-September. The branch ceases growth and the stem becomes weak and may ultimately fall to the ground. The presence of the insect can be known by seeing the excreta and silky web. This pest has become a very serious problem in Bihar state where yield and quality of fruits have been adversely affected. Cleaning of the infested area and plugging holes with petrol, nuvacron or formaline soaked material is advocated.

### **Fruit Borer**

This pest becomes serious especially in humid conditions at the time of ripening. The small caterpillars bore through the stalk end of the fruit, and feed on the seed and skin. As a result fruits become unfit for consumption. The excreta of the caterpillar is seen near the stalk end of the fruit. High humidity and intermittent rains favour the infestation.

Besides the important pests described above, lychee are often affected by leaf eating caterpillars, leaf miners, bugs and aphids. Birds, bats and squirrels also cause damage to lychee fruits.

### **Weeds**

Weeds Compete for water and nutrients during the initial year of growth. Depending upon location more than 25 species of weeds are reported to be present in lychee orchards. Inter-culture operation and mulching suppress the weeds. Herbicides, although found effective for the control, are rarely applied. In mature orchards the weed problem is not encountered due to heavy shade and natural mulching by falling leaves.

### **Fruit cracking**

Fruit cracking is one of the major limiting factors in the cultivation of lychee, especially early cultivars (Singh, 1986). The early varieties are more prone to the problem of fruit cracking in comparison to late cultivars. The low atmospheric humidity, high temperature and hot winds during fruit development and maturity stage favour fruit cracking. Light irrigation to maintain soil moisture and to improve humidity has been found to

minimize this problem through maintenance of a better micro-climate. Mulching with farm residues and 3 irrigations significantly reduced the cracking (Singh, 1986) in a trial conducted on the cultivar Shahi. In addition, spraying with either 100 ppm NAA or 0.2 percent borax during the developing stage of the fruits has been found to be highly effective in checking the cracking.

## **5. HARVESTING OF FRUITS AND YIELDS**

### **Maturity standard**

Lychee being a non-climacteric fruit requires to be harvested after attaining full maturity on the tree. Studies have been conducted to determine the maturity standard for different cultivars under different agro-climatic conditions. Fruits have a sigmoid pattern of growth. First the pericarp develops, then the seed and aril is formed and the seed turn from green to brown. During maturity acidity declines and TSS increases which corroborate the appearance and colour on the fruit. Thus, the colour of fruit is an important criteria to decide the harvesting stage (Singh and Yadav, 1988). The red pigmentation in lychee is associated with anthocyanin pigments (cyanindin-3-glucoside, cyanindin-3-galactoside, pelargonidin-3-glucoside and pelargonidin-3, 5-diglucoside), which develop better in the direction of good light penetration. Invariably pericarp colour and smoothness of pubicles are the best indicators (Singh and Yadav, 1988). Depending upon the cultivar, 65-80 days are taken for maturity from fruit set.

### **Harvesting**

The fruits are harvested in bunches along with a portion of the branch and a few leaves. At the time of harvesting care is taken to harvest the selected bunch, which has attained the desirable maturity as determined by colour development and taste of the pulp. For distant market fruits are harvested when TSS attains 19° Brix and acidity 0.3 to 0.4 percent. The fruits are harvested early in the morning when temperature and humidity are congenial, to have longer shelf-life of the fruit. At the time of harvest fruits are collected in a manner so that they do not fall on the ground. Use of mechanical tools for harvesting is practiced. The harvesting period is generally May-June, depending upon cultivar and location. However, in the hills of southern India lychee is harvested in November-December.

Changes in the physicochemical characteristics of lychee after anthesis were observed at two locations. Interestingly, the cultivar Rose Scented had similar patterns of growth at both locations, but the maturity date was one month later in comparison with Muzaffarpur. This phenomenon of maturity at two locations provides an opportunity for extended harvest of fruits. Maturity of fruits at Muzaffarpur was one month earlier than Dhaulakuan (H.P)

### **Yield**

The yield of lychee varies according to the age of the tree, agro-climatic condition and maintenance of the orchard. Usually about 80-150 kg fruit/tree is obtained from 14-16 year old trees. However, from a fully grown tree a yield of 160-200 kg/tree has also been recorded. Apart from a management practice, bee keeping in lychee orchards has been found

to increase the yield of quality fruits by 15-20 percent, since lychee needs cross-pollination. *Apis mellifera* is the commonly used bee in lychee orchards, which also provide additional income from honey.

### **Post-harvest management**

Lychee deteriorates very fast after harvest. Pericarp browning is a major post-harvest problem, which renders the fruit unmarketable. Browning is associated with desiccation. Peroxidase activity coupled with ascorbic acid oxidation enhances anthocyanin degradation. Techniques to reduce browning and maintain the red colour and prolonged storage life include sulphur treatment and packaging in perforated plastic bags and storage under cold conditions. Sulphur dioxide (SO<sub>2</sub>) fumigation is used as a post-harvest treatment to reduce browning. SO<sub>2</sub> treated fruits have a bleached pericarp which turns uniformly pink in colour after 2-3 days. Fumigated fruits absorb 30-65 percent of applied SO<sub>2</sub>. There is increasing concern about the residue of sulphur and the residual limit is only 10 ppm. For sea transportation 600-650g sulphur is recommended for the duration of 50-60 minutes, while for air transport 300-400 g sulphur for 30 minutes are advocated. The Agricultural Produce Export Development Authority (APEDA) has developed a procedure for production of quality lychee. The steps are: production > inspection of farm > harvesting > desolating and sorting > receipt at packhouse > acceptance of produce > sorting and grading > sulphur treatments > packing and cooling > palletization > storage > container loading and transportation.

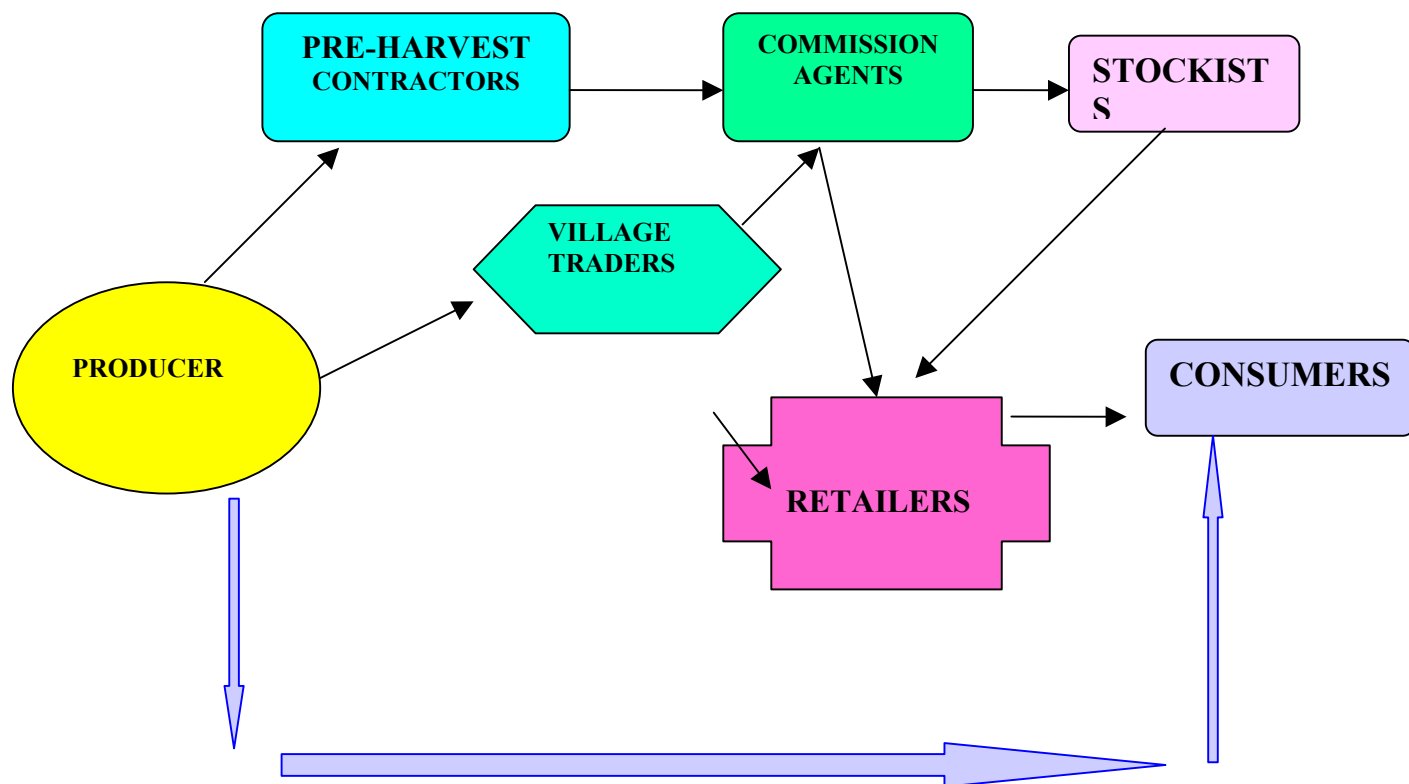
Aril breakdown or softening of the aril involves a loss of turgidity and translucency where fruits become blunt in taste. The disorder starts near the pericarp and is prevalent at the end of the stem. Post-harvest decay also occurs due to bacteria, yeast and fungi. Lychee browning and fungal contamination is prevented by dipping fruits in hot benomyl. Since this chemical is being restricted from use, alternative methods are desirable. Irradiation of fruit is considered to reduce browning and post-harvest losses. Storage temperature of 2-5°C is considered to extend the shelf-life. Use of perforated polythene bags and storage at 3°C have also been reported to increase shelf-life. Controlled atmosphere storage is considered better for maintenance of the freshness of the fruits. Thus, to have better post-harvest life of fruits, careful harvesting, pre-cooling, transportation in cool van, sulfuring and storing at 2-3°C would be essential.

### **Processing**

Processing of lychee is done in different forms. Canning of pulp, aseptic packing and ready to serve lychee juice are common. Dried lychee processing is not in practice. Pulp of lychee is aseptically packed and stored at 2-3°C for preparing lychee juice.

## **6. MARKETING**

A substantial amount of lychee produced in the country is consumed locally. Lychee, being highly perishable, is available for very short duration. Marketing of fruits is done in different forms. Growers rent their orchards to contractors, who in turn harvest and sell to local markets. Different market chains prevalent are given in Figure 1.



**Figure 1. Marketing chain in lychee production**

In chains of marketing increased numbers of middlemen reduces the share of growers in the price of produce paid by consumers. Generally, for the domestic market lychee is packed in 10 kg boxes or baskets having a lining of lychee leaves. There has been considerable importance given to the packing of lychee for niche domestic markets. Now lychee is packed in 2-2.5 kg boxes and transported in cool-chain.

In the last few years serious attempts have been made to export lychee from India. Test consignments were initially sent by air and the technology for sea transport has also been perfected. The exportable lychee is packed in 2 to 2.5 kg or 5 to 6 kg boxes after sulphur treatment. Quality standards are managed as per the standard developed by APEDA. The strong cooperative marketing and infrastructure facilities developed are expected to promote marketing of lychee.

## **7. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT**

With increased market base, there is an ample opportunity for increasing the area under lychee as prevailing agro-climatic conditions have not been fully exploited. Extended area under different situations could be exploited for extended harvest. Based on the fruiting behaviour, quality development and area under cultivation, the lychee growing districts could be grouped in a manner to take full advantage of climatic variability. However, to increase production and productivity, concerted efforts would be required for technological support and development of infrastructure. The foothills of the Himalayas free from frost offer good scope for plantation of lychee. Experience has indicated that lychee cultivation can be done up to an altitude of 1,000 m above mean sea level. In these foothills, fruits mature late and ensure the availability of fruits late in the season. Interestingly, the lychee crop in India matures early in comparison to other lychee growing countries and offers better domestic and export markets. Accordingly there is potential for an additional 100,000 hectares to be brought under lychee cultivation. However, to achieve targeted growth in production, strategic planning, including improved production systems and infrastructure for post-harvest management, is needed.

## **8. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

Despite the fact that the lychee is one of the finest fruits and has a growing demand in national and international markets, productivity continues to be low and a gap exists between potential and existing yield. The ratio in yield between the best managed orchards and national productivity ranges between 2 to 4 times at different locations. The probable reasons for low yield are the narrow genetic base of the crop, non-availability of suitable superior cultivars, traditional production systems, poor technological support and incidence of insect pests, coupled with poor post-harvest management. The shortage of genuine planting material coupled with the long juvenile period of lychee are also the constraints. The low female/male flower ratio, premature fruit drop, and fruit cracking due to non scientific water and nutrient management also add to low productivity and production of poor quality fruits.

The lychee tree has luxuriant vegetative growth, which causes problems in harvesting. Thus, canopy management to achieve the required plant architecture is essential. Lack of scientific information on critical stages for flower bud differentiation, and requirements of water and nutrients also significantly reduces the yield. The lychee has a short shelf-life. Practices that can enhance post-harvest life of fruits would be useful to achieve higher productivity.

## **9. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE**

The research support for varietal and production technology improvement is provided through the All India Coordinated Research Project on Sub-tropical Fruits, which has four centres located in lychee growing regions. The Central Horticultural Experimental Station (CHES), Ranchi, Jharkhand, RAU, Pusa, Samastipur, Bihar, G.B.Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttaranchal and BCKVV, Mohitnagar, Nadia, West Bengal are engaged in research. The main thrust of research is on augmentation of germplasm, varietal evaluation, orchard management, propagation studies

and development of fruit production technologies for higher yield and improved shelf-life. A network project for improving productivity of lychee has also been initiated. A National Research Centre on Lychee has been started for strategic and basic research on lychee.

The state Governments of Bihar, Jharkhand, Bengal, Tripura, Uttar Pradesh, Chattisgarh, and Uttaranchal also having programmes for the propagation of planting material to meet the requirements. Bihar has special focus on lychee development. The Government of India is implementing a programme on 'Integrated Development of Fruits' that includes lychee. Under this programme, support is provided for production of planting material, expansion of area under improved cultivars, rejuvenation of old orchards, transfer of technology, micro-irrigation etc. APEDA is making efforts for improving the export of lychee through the creation of infrastructure and enhancing capabilities.

## 10. CONCLUSIONS

Lychee, a climate specific, evergreen fruit plant, introduced in the country in the 18<sup>th</sup> Century has adapted well to the climate in Eastern India, i.e. Bihar, Jharkhand, West Bengal, Tripura, Uttar Pradesh, Uttaranchal, Chattisgarh, Punjab and Himachal Pradesh. Due to its increasing demand the area under cultivation has increased manifold. However, there is need for improving productivity and also widening the genetic base. Concerted research efforts and effective linkages are essential. Suitable cultivars are needed for various climatic conditions. It is also essential to develop promising lines/hybrids, which have larger fruit size, small/chicken-tongued seeds, tolerance to pericarp splitting, and having various maturity groupings. Suitable agro-techniques particularly for source and sink management, micronutrients, post-harvest technology and effective marketing need due attention. In this context exchange of information among countries would be beneficial. The following points need due consideration:

- Lychee has a very narrow genetic base, which needs to be widened through selection of genotypes from the existing population. Target oriented programmes must be launched so that germplasm is conserved and used.
- A systematic approach for the description of cultivars is needed. Thus, a lychee descriptor needs to be developed.
- Faster multiplication techniques for the production of quality planting material need attention.
- There is need to develop propagation technology for faster multiplication of quality plants.
- The development of nutrition management to maintain tree health and encourage successful flowering, fruiting and quality in sustainable manner, requires attention.
- Monitoring of nutrition in lychee through leaf analysis would be an approach for efficient fertilizer use.
- Integrated management of nutrient and water with efficient monitoring mechanisms would improve input use efficiency.
- Through effective recycling of residues coupled with organic manure, it is possible to improve soil health. Thus, there is an immense potential for organic production of lychee through effective management.
- Integrated management of insect pests and diseases is required to improve productivity and reduce the cost of production.
- Infrastructure for post-harvest management requires emphasis to reduce risk.

- The lychee product range has to be widened for effective utilization.
- Cooperation among lychee growing countries for the exchange of information and cultivars is vital. Starting of a network programme on lychee would boost the production and ensure livelihood security of the people.

## REFERENCES

- Chadha, K.L. 1968. Litchi cultivation in India. *Indian Hort.*, 12:13-16.
- Dass, C.S. and K.R. Choudhary. 1958. Floral biology of Litchi (*Litchi chinesis Sonn.*). *South Indian Hort.*, 6:17-22.
- Kotur, S.C. and H.P. Singh. 1993. Leaf Sampling technique in Litchi (*Litchi chinesis Sonn*) *Indian J. Agril. Sci.*, 63:632-8
- Kotur, S.C. and H.P. Singh. 1994. Varietal differences in leaf nutrient composition of litchi (*Litchi chinesis Sonn*). *Indian J. Hort.*, 51:59-62
- Kunwar, R. and R. Singh. 1993. Note on nutritional survey of litchi orchards in Doon Valley of Garhwal Hills of Uttar Pradesh. *Prog. Hort.*, 25:164-5.
- Mallik, P.C. and D.L. Singh. 1965. Hunger sign in litchi. *Indian Agriculturist*; 91:127-138
- Pandey, R.M. and H.C. Sharma. 1989. *The Litchi*. ICAR Publication, New Delhi.
- Pandey, S. and A.P. Misra. 1975. Mycorrhiza in relation to growth and fruiting of *Litchi chinesis Sonn.*, *J. Indian Bot. Soc.*, 54:280-293
- Rao D.P., S.K. Mukherjee and R.N. Ray. 1985. Nutritional Studies in litchi orchards in different districts of West Bengal. *Indian Hort.*, 42:1-7
- Ray, P.K. S.B. Sharma and K.A. Mishra. 1984. Important litchi cultivars of Bihar. *Indian Hort.*, 30(1):9-13.
- Roy. R.N., Rao, D.P. and S.K. Mukharjee. 1984. Orchard efficiency analysis of litchi. *Indian J. Hort.*, 41:16-21.
- Singh, H.P. 1986. Cracking of fruits a problem in litchi growing. *Chona Hort*; 3(2):8-9.
- Singh H.P. 1992. Physico-chemical evaluation of litchi cultivars in South Bihar. In *National Seminar on Recent Developments in Litchi Production*, 30-31 May, RAU, Pusa.
- Singh, H.P. 1998. Genetic Diversity, Breeding and Utilisation of the Genepool of Litchi. *Tropical Fruits in Asia* (Arora and Rao Eds) IPGRI. 171-184.
- Singh H.P. and I.S. Yadav. 1988. Physico-chemical changes during fruit development in litchi cultivar. *India J. Hort.*, 45:212-18.



- Singh H.P. and I.S. Yadav. 1992. CHES-1, a promising selection of litchi. In National Seminar on Recent Development in Litchi Production. 30-31 May, 1992, RAU, Pusa.
- Singh H.P. and I.S. Yadav. 1992. Studies on seed germination in litchi cultivars affected by physiological maturity. In National Seminar on Recent Developments in Litchi Production 30-31 May, RAU, Pusa; 16p.
- Singh, H.P. and K.K. Kumar. 1988. Litchi growing in India. *Chona Hort.*, 5(1):22-32.
- Singh L.B. and O.P. Singh. 1954. The Litchi. Superintendent Printing Press, Allahabad. 110p.
- Verma, S.K., Jain. B.P. and S.R. Das. 1980. Preliminary Studies on the evaluation of the effect of growth substances with minor elements in controlling fruit drop in litchi (*Litchi chinesis Sonn.*). *Haryana J. Hort.*, 10:4-10.
- Yadav, I.S. and H.P. Singh. 1988. Studies on germination of seeds in litchi as influenced by physiological maturity of fruits. In National Convention of Strategies of Horticultural Development for Tribal Region held at Ranchi, March 1988.
- Yadav, I.S. and H.P. Singh. 1992. Genetic Resources of Litchi in India. In National Seminar on Recent Developments in Litchi Production. 30-31 May 1992, RAU, Pusa.

# LYCHEE PRODUCTION IN INDONESIA

M. Winarno \*

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## 1. INTRODUCTION.

Lychee (*Litchi chinensis*) is one of the minor tropical fruits in Indonesia. It is less popular than the longan (*Dimocarpus longan* Lour), the related fruit in the Sapindaceae family, which is more commercially known in the country. Another related fruit in the same family, the rambutan (*Nephelium lappaceum*), is much more widely grown and sold commercially throughout the country.

The cultivated lychee in Indonesia could have originated from a single mother tree of lychee grown in the garden of the Tapaksiring Palace in Bali. However, there is no report on the origin of the tree. Besides the cultivated lychee in Bali, there was also a report of lychee as a forest tree in East Kalimantan (local name: ihau).

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN THE COUNTRY

At present, the lychee cultivated area is very limited. The only known province or island in the Indonesian archipelago where the crop has been cultivated for decades is Bali, in the districts of Gianyar, Tabanan, and Bangli, at elevations of 400-700 metres.

The area has 4-5 dry months and temperatures of 22°-31°C and 80 percent relative humidity. The annual rainfall is 2,500-3,000 mm.

The total number of cultivated trees is about a thousand most of which are over 50 years old, whereas the numbers of longan and rambutan in the country are around 30,000 and 4 million trees, respectively. The lychee is mostly grown in the home garden lots and also as roadside trees. The yield is reported to be about 200-300 kg per tree. In the last harvest season, the price of lychee in the market reached 7-10 thousand rupiah per kg (1 US\$ per kg).

## 3. PRODUCTION OF PLANTING MATERIAL

There is no private nursery that produces commercial lychee planting materials, since little attention has been given to the development of lychee production. The long-term investment required may be one of the reasons for little interest in production development programmes either by the Government or the private sectors.

The only report was a single-year development programme of lychee production carried out in 1999 by the local government of Bali. This development programme distributed 50

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vegetatively propagated plants to each of the three districts. The planting materials were raised by air-layering, the propagation method adopted by the local growers.

The future production management of more lychee planting materials could be included in the National scheme for the production of superior planting materials of tropical fruits crops. The National scheme covers the development of a Foundation Block and a Multiplication Block. Mother trees of selected clones are grown and well-managed in a Foundation Block. The number of mother trees kept in the Foundation Block is limited. Therefore, a Multiplication Block is designed for providing large quantities of propagation materials to nurseries. The Multiplication Block can be a densely planted with lychee or other fruits.

#### **4. MANAGEMENT OF ORCHARDS**

As mentioned earlier, lychee is a home garden or road side tree as are other minor fruits crops. Therefore, there has generally been no specific crop management as applied in an orchard. Tree spacing is irregular and there is practically no water management, no fertilizer application, no pruning, and no disease/pest control treatments.

Several of the trees have even been cut down for specific reasons such as for the development of infrastructure and housing.

#### **5. HARVESTING AND MARKETING**

The marcotted tree starts bearing in the fifth year after planting. Growers harvest lychees when they are mature. Maturity is judged especially by the fruit's skin colour. The fruit is picked when 80 percent of the skin is red in colour. The whole panicle is then cut with a knife or scissors. The period of November to December is the harvest season for lychee in Bali. The lychee is sold on the local markets or to hotels in bunched panicles of fruit in bamboo baskets without any grade specifications.

#### **6. PRODUCTION DEVELOPMENT**

Lychee has been traded internationally as fresh fruit, dried, and canned products. The main producing countries are Taiwan Province of China, India, and China.

Provided there are growing regional and international markets, there may be interest in production development, especially in the regions where the agro-climatic requirements can be met and other production constraints can be overcome. The production development may then also lead to the development of the processing industry.

Orchard and agro-industry development can at least provide jobs opportunities for the people and accelerate rural economic growth. In this respect and especially considering the agro-climatic requirements for the growth and development of lychee, the eastern part of Indonesia could be a possible area for lychee development.

## **7. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

The only areas of cultivated lychee trees at present are the three districts in the province of Bali. Since the trees could have originated from the single mother tree and propagated vegetatively, there is no opportunity for further breeding work such as clonal selection.

The weaknesses of the existing cultivar are short harvest season, year-to-year variation in yield, low quality and small size of the fruits. Growers also have problems in growing lychee, especially the large tree-size and root-system. Growers have experience that the root system may damage the foundations of houses. Therefore, growers are reluctant to increase the planting area in their home gardens.

Lack of technology is another problem of production development, including the technology for the mass production of planting materials.

## **8. RESEARCH AND DEVELOPMENT PROGRAMME**

The research institutes of the Department of Agriculture and the universities usually carry out research work in Indonesia. Due to limited resources, lychee has not been included as a research work priority.

However, a short-cut R & D programme, which could be developed first would be the introduction of improved varieties from other countries. The improved varieties must possess the market preference characteristics. A variety trial in several regions could then be conducted. Observed characteristics of the tested varieties must include flowering, harvest season and yield consistency. The next step would be planting material production of the selected varieties. Orchards could then be established in the grower's dryland areas. The orchard management would be arranged through grower groups. The Government could facilitate the development of infrastructure and provide financial assistance.

## **9. CONCLUSIONS**

At present, lychee is a minor fruit crop in Indonesia. The cultivated area is found in the districts of Gianyar, Tabanan, and Bangli, on the island of Bali.

Constraints in production development have been identified. Growing regional and international markets will drive the interest on lychee development through improved technology in the appropriate areas. The eastern part of Indonesia could be a possible expansion area for lychee development.

# LYCHEE PRODUCTION IN NEPAL

Kedar Budathoki \*

## 1. INTRODUCTION

Lychee is one of the important sub-tropical fruit crops of Nepal after mango, banana and guava. It was introduced by the Rana who ruled the country for 104 years. It is reported that the Rana were very fond of fruit farming and gardening and introduced lychee from India and Burma and planted them in the Terai (Plain), low hills and mid-hills at altitudes ranging from 61 m in the Terai to 950 m in the mid-hills. Although lychee plants were planted and tried at Kathmandu (1,344) by the Rana in their palaces, the plants died due to cold weather and frost.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION

Geographically, Nepal is divided into three physical parts. These are the Terai, Hills and Mountains, the altitude of which ranges from 60 m above mean sea level in the Terai to 8,845 m in the Mountains. Because of these variations in the, Nepal enjoys a sub-tropical climate in the Terai and a cool temperate climate in the Mountains, which are suitable for farming various kinds of fruits. Farming is limited within 3,000 m altitude. Nepal has 75 districts and it has been recorded that lychee is cultivated in 62 out of these and they are distributed as follows:

• Mountain Districts	= 6
• Hill Districts	= 36
• Terai Districts	= 20
<hr/>	
Total	= 62

### Major lychee growing areas

Lychee is a sub-tropical crop and needs sub-tropical frost free areas during winter and favours well-drained moist soil rather than dry soil. It is, therefore, the Terai districts of the Central Developmental Region that have the highest areas under lychee followed by Terai districts of the Eastern Development Region. The lowest areas under lychee are in the Western, Mid-Western and Far Western regions of the country (Table 1 and 2).

- The Terai districts under the Central Development region where the area under lychee is highest are: Sharlahi, Bara, Parsa, Chitwan, Dharusa, Mahotari and Rautahat with a total area of 817 hectares.
- The Terai districts of the Eastern Development Region where lychee is commercially grown are: Jhapa, Morang, Sunsari, Saptari and Siraha with a total area of 309.7 hectares.

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- The Terai districts under the Western Development Region where lychee is slowly reaching commercial scale are: Nawalparasi, Rupendehi and Kapilbastu with a total area of 206.7 hectares.
- Banke, Bardia and Dang are the Terai districts of the Mid-Western Region.
- Kailali and Kanchapur districts of the Far Western Development Region are also emerging as the commercial lychee growing areas in recent years.

The following hill districts are commercially utilized for lychee production:

- Western Development Region - Gorkha, Lamjung, Tanahu, Kaski, Parbat, Syanja, Palpa, Myagdi, Baglung, Gulmi and Aoghakhachi districts
- Central Development Region - Ramechhap, Sindhuli, Kavre, Nuwakot, Dhading and Makawanpur districts.
- Eastern Development Region - Panchthar, Ilam, Terahatum, Dhankuta, Bhojpur, Khotang, Okhaldhunga, and Udaipur districts.
- Mid-Western Development Region - Surkhet, Puthan and Dailekh hill districts.
- Far-Western Development Region - Dadeldhura and Doti districts.

### **Area and production**

The total area under lychee in Nepal is about 2,830 hectares (Table 1) and most of the commercial areas lie in the Terai (Plain), which falls in the Southern part of the country and runs from east to west. Out of 2,830 hectares, there are 214,800 bearing trees grown on 1,791 hectares, which produced about 13,875 MT of fruit during 1998/99 (Table 2). It is believed that production will increase year by year due to the increased number of new bearing trees and also the increase in the age of bearing trees up to 20 years of age. Similarly, the area under the lychee is also increasing every year as it is found to be a more profitable crop than mango and banana in the Terai.

**Table 1. Total area (hectares) under Lychee in Nepal**

<b>Region</b>	<b>Terai</b>	<b>Hill</b>	<b>Mountain</b>	<b>Total</b>
Eastern	309.7	218.3	27.6	533.6
Central	817.6	246.5	19.8	1083.9
Western	206.7	511.3	0.0	718.0
Mid-Western	181.1	96.5	0.0	277.6
Far-Western	149.5	44.7	1.0	195.3
<b>Total</b>	<b>1664.6</b>	<b>1117.3</b>	<b>48.4</b>	<b>2830.4</b>

**Table 2. Productive area (hectares) and production (MT) of lychee in Nepal**

Region	Terai		Hill		Mountain		Total	
	Area	Prod. <sup>n</sup>	Area	Prod. <sup>n</sup>	Area	Prod. <sup>n</sup>	Area	Prod. <sup>n</sup>
Eastern	202.0	1555.0	138.0	994.0	2.0	14.0	342.0	2563.0
Central	531.0	4354.0	153.0	1194.0	3.0	23.0	687.0	5571.0
Western	134.0	1072.0	326.0	2447.0	0.0	0.0	460.0	3519.0
Mid-Western	117.0	878.0	62.0	434.0	0.0	0.0	179.0	1312.0
Far-Western	97.0	728.0	26.0	182.0	0.0	0.0	123.0	910.0
Total	1081.0	8587.0	705.0	5251.0	5.0	37.0	1791.0	13875.0

Source: Agriculture Statistics of Nepal. Ministry of Agriculture, His Majesty's Government of Nepal (1998/1999).

### **Cultivars**

Broadly, there are two types of lychee cultivar in Nepal, namely the Terai and the Hill cultivars

#### **Terai cultivars**

These are introduced cultivars mostly from India. They are being grown in the Terai and low hills. Fruits mature from mid-May to mid-June. The common varieties grown under commercial scale are as follows:

- Mujafpuri
- Raja Saheb
- Deharaduni
- China
- Calcuttia

#### **Hill cultivars**

The hill cultivars are late in maturity and fruits are harvested from the end of May to the end of June. The fruits are larger than the Terai cultivars and seeds are also a little bit larger. Some of the important cultivars are as follows:

- Pokhara local
- Udaipur local
- Tanahu local
- Chitwan local
- Kalika local
- Gorkha local

Farmers at Pokhara, Palpa and Gorkha reported that those trees which are as old as 40-50 years and are still productive might have been introduced from the Terai area by some amateur fruit growers in past and are now adapted to the hill environment and are multiplied and distributed among the farmers and between the villages.

### **3. PRODUCTION OF PLANTING MATERIAL**

In Nepal lychee plants are propagated by the following methods:

#### **Seed**

In the past 15-20 years lychee plants were produced from seed in the hills. This practice was common among the farmers who had no lychee plants for using other methods of propagation. It was also common that those seedlings were also sold for cash or exchanged between the farmers for other material. It is, therefore, in the hills where there is big variation in height, canopy, leaf size, fruit size, seed size and fruit shape. It was also observed that some plants were found superior in bearing capacity, fruit size, colour and shape.

Farmers reported that they know that lychee seed loses viability very soon after harvest. Hence, they sow the seed as quick as possible. Usually, farmers sow the seeds directly in situ rather than raising seedlings separately in a bed or in polypots. They reported that plants raised from this system have low mortality and establish well compared to the plants raised and transplanted from air-layering. With the available of plants raised from vegetative propagation, the raising and production of plants from seed has been gradually decreasing.

#### **Air-layering**

In the Terai from the very beginning of lychee cultivation and in recent years in the hills, the lychee plants are propagated commercially by air-layering. The air-layering is done from spring to early summer (mid-March to mid-May). Success rate is as high as 90 percent in spring to summer and decreases gradually when the air-layering practice is carried out too late.

#### **Planting material producing agencies**

In the early days from 1960 to 1980, the lychee plants used to be produced by the Government horticulture farms/stations located in different parts of the country. The method of propagation applied was air-layering. After one year of propagation, these plants would be distributed direct to the farmers and also to the farmers through district based agriculture extension offices. The following horticulture farms were responsible for the production of fruit plants including lychee:

- Horticulture unit, Agriculture Station, Tarahara, Biratnagar
- Horticulture unit, Agriculture Station, Parwanipur, Birgunj
- Horticulture farm, Nawalpur, Sharlahi
- Horticulture farm, Yagyapuri farm, Chitwan
- Horticulture farm, Malepatan, Pokhara
- Horticulture unit, Agriculture Station, Khajura, Nepalgunj
- Horticulture farm, Dhunbesi, Dhading
- Horticulture farm Trisuli, Nuwakot
- Horticulture farm, Panchakhal, Kavre.



The total numbers of plants produced annually by these station ranges from 20,000 to 40,000 plants. Today, only the horticulture farm at Nawalpur, Sharlahi produces lychee plants as other farms ceased to produce the plants due to the establishment of private nurseries which commercially produce planting material of all the fruit plants.

There are 81 registered private fruit nurseries, which produce various kinds of fruit plants and flowering plant saplings. However, only 7 private nurseries are involved in lychee sapling production.

In borders villages, lychee and other fruit plants are sometimes imported either by Indian nurserymen or middlemen during the season (June to August) and sold to Nepalese farmers.

#### **4. ESTABLISHMENT OF ORCHARD**

##### **Land preparation**

Lychee plants are planted on uplands. The selected piece of land for the lychee orchard is ploughed and made weed-free. These operations are done from March to April.

##### **Pit digging**

With the help of district based horticulturists/agriculturists, all the technical assistance needed for establishment of the orchard is provided. The layout of the orchard is made at least one month before planting by marking and pegging planting points at appropriate spacing.

The pits measuring 1 x 1 x 1 m are dug and following manure and fertilizers are applied:

- |   |                   |                           |
|---|-------------------|---------------------------|
| • | FYM               | = At least 2.5 kg per pit |
| • | DAP Granule       | = 100 g per pit           |
| • | Muriate of Potash | = 100 g per pit           |
| • | Urea              | = 25 g per pit            |
| • | Bone meal         | = 100 g per pit           |
| • | Lime              | = 50 g per pit            |
| • | Micronutrients    | = 25 g per pit            |

These materials are well mixed with topsoil in the pits and kept at least one month for settlement of these inputs in the pits before planting the saplings.

##### **Planting season**

Wherever watering is possible after planting, lychee plants are planted from April to May. Where there are no irrigation facilities and lychee is cultivated under rainfed condition, the saplings are transplanted from 15 June to August. However, early planting (April-May) has given good results in terms of plant growth.

## **Planting system and spacing**

In the Terai flat land, a square system is widely used and in the hills, depending upon the land position, a contour, rectangular or sometimes even a square system of planting is practiced. In the early days of planting neither planting systems nor recommended spacing were followed. However, in recent years the recommended spacing between the plants or rows is maintained at 10-12 m. In the hills, this distance is reduced to 8-10 m due to the terraced type of land.

## **Inter cropping**

In Nepal none of the orchard field is initially kept free from crops. When the trees are large and producing fruits, usually after 5-6 years of planting in the Terai and 7-8 years after planting in the hills, the intercropping of arable crops is avoided.

## **5. CARE AND MANAGEMENT OF ORCHARD**

### **Training and pruning of plants**

Usually, training and pruning are not done in lychee due to its evergreen nature. However, some farmers remove the branches or twigs from the soil surface to 45 cm height of the plants while others remove up to 60 to 75 cm height of the plant. These days nurserymen do these operations at the nursery. In some areas like in East and Central Terai districts the central parts of the lychee plants are removed so that side branches are encouraged to develop and central parts are open. Removing the central branches/parts of the plants, which do not receive sunlight and produce very little fruit, is also common even with large trees. These operations are done during December-January both in the Terai and the hills.

Unlike temperate fruit crops, annual pruning practices are not common in lychee orchards. Many farmers believe that removing long twigs along with fruit at harvest is a useful pruning method, but other commercial growers reported that removing fruit clusters, i.e. panicles only, at harvest without removing the twigs or branches and leaves produce more fruit than removing fruit with twigs in the coming season.

### **Manure and fertilizer**

Annual application of the following manure and fertilizers after a year of planting are recommend for young trees before fruiting up to 5-6 years after planting

- FYM or Compost = 30 kg per plant
- DAP = 100 g per plant
- Muriate of Potash = 100 g per plant
- Urea = 100 g per plant

Lychee starts producing fruits from 5-6 years after planting in the Terai and 6-8 years after planting in the hills. The manure and fertilizer recommendations for bearing trees are as

follows. These recommendations are followed or even exceeded by commercial lychee growers.

- Organic Manure = 50 kg per plant
- DAP = 150 g per plant at 6 years of age and increased by 100 g each year up to 15 years and as a constant dose from 15 years onwards.
- Urea = 100 g per plant at 6 years of age and increased by 100 g each year up to 15 years and as a constant dose from 15 years onwards.
- Muriate of Potash = 100 g per plant per at 6 years of age and increased by 100 g each year up to 15 years and as a constant dose from 15 years onwards.

The manure and fertilizers are applied in the winter months of December and January.

### **Weeding**

Weeds in well developed trees are not a problem. They are a problem in the early stages of plant growth. Farmers keep the young plants and the orchard clean by hand weeding and use mulches of dry grass like rice-straw to keep down the growth of weeds around the young lychee plants and conserve moisture.

### **Mulching**

Mulching of young plants around the root and stem zone by using local materials like dry grass, dry weeds, dry straw etc., immediately after planting is a common practice followed by lychee growers due to the advantages of weed control, soil moisture conservation and addition of organic matter to the soil.

This mulching practice is commonly done from the end of the monsoon to conserve residual soil moisture. In rainfed conditions, farmers reported that mulched plants growth is faster and fruit production better than those of non-mulched plants.

### **Supplementary irrigation**

Lychee is cultivated under non-irrigated/rainfed conditions in both the hills and Terai except in a few isolated cases. However, growers who were able to provide water just before blooming to the fruit maturing stage (mid-February to early-May) reported that fruit quality and production increased significantly. Hence, in recent years the introduction of drip irrigation has become very popular among the resource rich farmers where water is scarce. However, in all cases, regular watering is applied to the seedlings after planting until the plants are well established so that root zones are kept moist.

### **Diseases**

In Nepal, no serious diseases limiting production and productivity of lychee have been observed or recorded.

## **Pests**

### **Lychee mite (*Eriophyes litchi*)**

Lychee mite is one of the biggest problems in both the Terai and hills. The pest attacks new shoots at the beginning of spring and if the attacks continue, the terminal growth is checked and tree vigour reduced due to reduction in photosynthesis. Fruit produced from affected plants are poor in quality and marketability and yield is also drastically reduced. Use of wettable sulphur at the rate of 2 g per litre of water before bud break is found to be very effective. Spraying two times at 10 days intervals further improved crop vigour and fruit yield.

### **Lychee bug**

This pest attacks the young leaves by sucking the sap from the leaves and tender twigs and branches. In uncontrolled conditions leaves curl, wrinkle and die. In heavy infection new stem twigs also died. In Nepal, this pest is controlled by the application of chloropyrifos + Cypermethion at the rate of 2 ml per litre of water before flowering and two times after the fruits are set.

### **Fruit worm**

The fruit worm is not a serious problem and growers reported that damage caused by this pest is small. However, this pest is also kept under control by above operation.

### **Fruit cracking**

This problem is more serious in Terai orchards and is most common in dry than in relatively moist orchard soils. Cracked fruits are commonly seen in the mid-western Terai districts because the soils of this area are drier than those of central and eastern parts of the country.

Farmers in Sarlahi district reported that thick mulching of lychee plants with local materials while there is a rain in mid-September reduces the cracking.

## **6. HARVESTING FRUITS AND YIELDS**

### **Harvesting time**

Fruits in the Terai are harvested from the third week of May to mid-June, though this varies from cultivar to cultivar. In the hills, the fruits are ready to harvest from the end of May to the end of June.

Since lychee fruits are non-climatic, the fruits should be harvested when the fruit skins change to bright red, orange red, pink red etc., depending upon the variety, but before they are fully red and soft. For fruit transported over long distances 80-90 percent of the fruit skin should have the original colour so that its quality becomes marketable.

Generally, all fruits in the lychee trees do not mature at the same time and hence, multiple pickings are necessary. It is necessary that regular inspection of the tree is carried out and the fruit clusters that are well mature should be harvested. When picking the fruits, fruit clusters along with twigs, branches and leaves are removed. This is the common practice followed by lychee farmers in Nepal. However, removing fruit clusters with only the panicle is more beneficial than removing fruit clusters with twigs and leaves. A few farmers in the hills have been doing this practice and reported that it has increased fruit yield in the following year.

### **Fruit yield**

The yield per plant depends on the age of the plant, tree or orchard management, variety and location. In both the hills and Terai even 60 years old but healthy and productive trees were observed and the number of fruit from such a plant was recorded as high as 10,000 and total yield per plant obtained was 380 kg and income from the tree was more than Rs.10,000.

The fruit yield of a well-managed orchard in the Sarlahi district is as follows:

Age of trees	Yield per tree (kg)		
	Average of 3 trees	Highest	Poor yield
5 years	Few kg	4 0	Few
6 years	13.0	22.0	4.4
7 years	18.0	31.0	7.0
8 years	30.0	50.0	16.0
9 years	46.0	67.0	26.0
10 years	95.0	120.0	39.0
15 years	105.0	120.0	40.0
20 years	130.0	150.0	-
60 years	380.0	-	-

### **Causes of high and poor yields**

#### **Causes of poor yields**

- Use of poor yielding cultivar
- Poor nutrient application
- Lychee mite problems
- Lack of mulching
- Poor fruit set
- Small fruit size

#### **Cause of high yields**

- Use of good high yielding cultivar
- Winter, pre-blooming and fruiting stage application of organic manure, nitrogen, phosphorous and potash as per recommendation.

- Spray of micronutrient (Multiplex), 3 times from pre-blooming to fruiting stage.
- Liming every year at the rate 100 g lime per plant.
- Use of growth regulator (Miraculan, Atonic and Pencibao) before blooming and after blooming.
- Mulching and small water application over mulching 3 times during blooming to fruit set.
- Use of drip irrigation
- Well managed spray schedule for controlling pests and diseases.
- Use of Mycorrhiza in soil from an old orchard at the time of planting.
- Excellent harvest method i.e. removing only the fruit cluster with panicle.
- All central and thick unproductive branches are removed annually during winter months and hence all the branches easily receive the sunlight.

## **7. MARKETING**

At present domestic production of lychee is inadequate and 60 percent of the consumed fruits are imported from India. It is also reported that some quantities are also exported to India from the Eastern Terai districts of Nepal.

In some cases, contractors go to the orchards, negotiate with owners and buy the fruits when they are still on the trees. The owners know roughly how many lychee fruits there are in each tree. Once agreement is reached farmers receive an advance ranging from 10-25 percent of the total cost of the fruits from the orchard. Thereafter the contractors hire watchmen to look after the fruits, which means that the whole responsibility for the orchard is shifted from the farmers to the contractors. Once the fruits are harvested, they are graded, packed and sold to the fruit wholesaler who sells them to retailers and finally retailers sell them to the consumers.

In some cases groups of lychee farmers harvest their fruit individually and bring them to a collection center. After grading, packing, and weighing the fruit is brought directly to the wholesalers and sold at wholesale price. Some percentage of the income of each farmer goes to the group. The total cost of transport etc. is shared by all the members based on the quantity of lychee sold and income received.

Sometimes some individual farmers also sell their fruit directly to the wholesalers or retailers or even to the consumers.

## **8. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT**

In view of the availability of suitable climate and soils, adequate land area for further expansion, road accessibility, and farmer's interest and enthusiasm in lychee farming, the area under lychee can be increased significantly.

Looking into the huge domestic and even export markets, the markets for fresh lychee are unlimited, especially as lychee produced in Nepal are superior in quality due to absence of sunburn in the fruits. Also, as hill lychee fruits are harvested after the Terai fruits are finished the continued supply of fruit over a longer period for various markets is ensured.

Income from lychee farming is higher and more regular than that of mango where alternate and shy bearing is common. Consequently, many farmers in the Terai are now shifting from mango to lychee farming.

## **9. CONSTRAINTS OF LYCHEE PRODUCTION DEVELOPMENT**

### **Lack of a research programme**

Although lychee is one of the very important cash generating fruit crops for both small and large farmers, the research on this crop is absolutely lacking. As a result, the generation of technologies leading to increasing productivity, quality and marketability have not been developed.

### **Large seed varieties**

Most of the varieties used in Nepal contain large seeds and hence, these fruits are not attractive in the markets and also among the consumers. The introduction or selection of small seeded varieties from existing cultivars is therefore urgently needed.

### **Shortage of high quality planting materials**

Today lychee is propagated by air-layering from any available mother plant variety without considering fruit quality, plant vigour and maturity. Propagation from a well identified variety by nurserymen and the Government farm is necessary. Production of large numbers of healthy plants from top quality mother plants through tissue culture or micro-propagation is urgently needed. It has been observed that those plants produced by Government farms or private nurseries are weak, lean and thin, while roots and minimum height and twigs and branches are not well developed. They usually sell small one-year-old plants. When such seedlings are planted by the farmers, many plants die and those that survive also have poor growth and poor establishment.

### **Lack of skill in extension agencies**

In Nepal extension agents transfer the technologies and these agents have very poor know-how and skills on lychee farming. Also there is no training programme for either farmers or extension agents.

### **Inappropriate pruning/harvesting methods**

Wrong harvesting methods of fruits is also one of the reasons for declining yields in succeeding years. Similarly, retaining central unproductive branches in the tree is another reason for low productivity and low quality.

### **Post-harvest technologies**

Lack of cultivars suitable for long distance travel and long storability without losing quality are problems faced during transportation to markets.

## **Tall and large trees**

The fruit produced by tall and large trees are very difficult to harvest and the harvested fruits have poor quality and increased labour cost for picking. Dwarf trees producing high quality fruits are necessary for increasing the area, production, and productivity of this crop.

## **10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT**

Although lychee is an important fruit crop suitable for cash income generation for small, poor, rich and large farmers of the hills and Terai, research activities addressing the problems faced by lychee growers are lacking. This is due to fact that the Government in the 9th five-year plan has given high priority to orange and apple and low priority for sub-tropical fruit crops like lychee. At the same time, trained, skilled, experienced and qualified manpower for research is lacking.

Similarly, development programmes like the pocket development programme, quality plant production, distribution, extension, training etc. are also almost lacking. However, it is felt by the Nepal Agricultural Research Council, Khumaltar that research activities addressing major problems limiting the production, productivity and quality of lychee fruit should be initiated in a well identified research station and farmers fields from the beginning of the 10th five year plan (2001 to 2006). Once the technologies are available the mechanism to involve private nurseries for the production of healthy sapling, lychee growers, NGOs, INGOs and Government extension agencies will be developed for launching a lychee programme in selected villages and districts during the 10th five year plan.

## **11. CONCLUSIONS**

It is very encouraging that in the absence of Government priority on a lychee development programme, the area under lychee has been increasing and farmers were found to be very enthusiastic over lychee farming. The lychee crop is becoming attractive among the farmers due to its regular and stable income generating capabilities compared to mango and banana in the Terai.

To enhance a lychee development programme in Nepal, research in following areas should be launched immediately.

- Small seeded but large red fruit producing productive variety selection. There are large numbers of such genotypes available in farmer's fields and the areas should be surveyed and potential genotypes collected, vegetatively propagated, and evaluated at the NARC station or in farmers fields.
- Productive dwarf tree selection. Large trees are a problem for harvesting. However, small or dwarf trees were also observed both in hill and Terai farmers fields. Collection and evaluation of such material is necessary.
- Lychee has the highest mortality rate and poor plant establishment in Nepal after planting up to 2 years of age. Research on this area is very essential for motivating farmers in lychee farming.



- Wrong harvest methods and practices are reducing the life of the plant and decreasing the yield. Investigations in this area are equally important.
- Incapability of producing healthy and standard plants by the private nurseries and the Government farms are another problem for research. Standard propagation techniques and raising healthy sapling means should also be investigated and the producers should be trained.
- A skilled manpower development programme both for researchers and development agency staff through training is necessary.
- Similarly, farmer's knowledge and skills must be enriched through running a field-based training and visit programme in lychee growing areas where modern but sustainable technologies are developed and used.
- Research and development on use of Mycorrhiza and Azotobacters should be initiated to improve soil fertility and crop productivity as sustainable soil fertility improvement measures.

# LYCHEE PRODUCTION IN THE PHILIPPINES

Rachel C. Sotto \*

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## 1. INTRODUCTION

The lychee, which is locally known as 'litsiyas', is considered a high value fruit crop in the Philippines. It is highly esteemed as a fresh fruit and has good consumer acceptance. However, it is costly and is considered a luxury fruit. This is due to the limited supply of the fruits since the crop is presently grown on a limited scale. No local statistics on production at the national level are available.

Prominent relatives of lychee that are grown in the country are rambutan (*Nephelium lappaceum*) and longan (*Dimocarpus longan*). A relatively unknown indigenous species belonging to the same genus and found growing wild in the Philippines from sea level to 500 m altitude is 'alupag' (*Litchi chinensis* subsp. *philippinensis*). Initial grafting trials indicated its good rootstock potential and compatibility with lychee.

There is no accurate date of introduction of lychee into the Philippines. The earliest recorded statement of its introduction was made by Wester (1916). He stated that lychee was first introduced from China into the Philippines several years earlier at low altitudes but has never fruited. The first recorded event of flowering was in 1931. It was of a 25-year-old tree planted in Rizal. Later, five other trees located in various places were reported to bear fruits. A marcotted tree planted in 1940 in the Mountain Province started fruiting six years later. The original tree from which this marcotted tree was acquired was of seedling origin from Amoy, China and started fruiting 12 years after planting. In 1951, a 4-year-old marcotted tree from Thailand was planted in Bataan, and bore fruits for the first time in 1953. In 1961, a 30-year-old fruiting tree of seedling origin was found in Benguet while a 23-year-old fruiting tree was discovered in Laguna. All these discoveries gave rise to possibilities of growing lychee in the Philippines.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN THE COUNTRY

### Area and Production

Lychee is one of the fruit crops that is very selective in its climatic requirements. In the Philippines, it is therefore grown in areas with a continuous cool (approximately 15 to 19°C) and dry period for almost a month and a warm and humid period after the trees have flowered. The cool period is needed for flower initiation while the warm and humid period is important for a successful fruit set and development. Lychee is therefore found growing predominantly in the highlands of the Cordillera Autonomous Region (CAR) in the northern part of the country, specifically in the provinces of Benguet and Mountain Province (municipality of Bauko), and in Ilocos Sur (municipality of Cervantes). Lychee is observed

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to thrive at elevations ranging from 1,000 to 1,380 meters above sea level. However, some trees could also be found growing in the lowlands particularly in the provinces of Batangas and Laguna, which are also in the northern part of the country, and Cagayan de Oro in the south, which also experience cool temperatures during the months of December and January.

Being a very minor fruit crop and owing to its limited area of cultivation, no secondary national production data is available. Partial data from the Department of Agriculture's 1995-1996 survey of the fruit growers in selected areas of CAR and Ilocos revealed small sizes of fruit farms. Lychee growers who were interviewed had at least 1,400 m<sup>2</sup> to 1 ha of land, which was also planted to a variety of other fruit trees. Interviewed growers in the Mountain Province had a total of 125 lychee trees while those in Benguet and Ilocos Sur had 36 and 31 trees, respectively.

The volume of lychee production from five fruit farms in the Cordillera highlands was estimated at 1.1 tons/annum. Of this, 0.42 ton (38 percent) was utilized for home use, 0.66 ton (60 percent) for the market and 0.20 ton (2 percent) for other uses. Each grower produced an average of 0.22 ton/annum.

The fruit tree growers of the Cordillera Provinces where most of the lychee trees are grown, may be classified into four groups. The first group is composed of established growers of traditional high value crops like pears and lychee (around 50 trees). This group consists of few growers who are mostly the old settlers in a community. They learned much from their old experiences and have generated their own planting materials. The second group also consists of established growers but their experience is less than 10 years and their crops are mostly citrus (more than 100 trees) with few quantities (10 to 20 trees) of lychee, longan and pear. They are continuously expanding production and are often experimenting on new production techniques. The third group consists of small household growers with less than 100 trees (with about 1 to 5 trees of lychee, longan and pear). This constitutes the majority of fruit tree growers in the Cordillera. The fourth group is composed of a few growers with less than 150 trees, which are predominantly citrus and they are rather pessimistic about their fruit venture due to crop failures.

## **Varieties**

There are two cultivars, which are predominantly grown in the highlands. These are 'Mauritius' and 'Sinco'. 'Mauritius' is an introduction from South Africa while 'Sinco' is a local seedling selection from China. 'Mauritius' has round to broadly ovate fruits with bright red skin and larger than those of 'Sinco'. Fruits of the latter are round to ovate and dull red.

In the lowlands, an outstanding cultivar from a seedling tree, which was introduced from Thailand in 1968, had been approved by the National Seed Industry Council for commercial planting. It was named 'UPLB Red'. Marcotted and grafted plants from this variety bear fruits in 3 to 4 years from field planting. The trees flower from December to January and the fruits are harvested from April to May. Fruits of 'UPLB Red' weigh 14 g, are ovate to almost round with a rough skin that turns dark red when fully ripe. The aril is 6 mm thick, is 61 percent of the whole fruit by weight and has a total soluble solids (TSS) of 20° Brix .

Recently, the Department of Agriculture (DA) in Lipa, Batangas identified two promising selections for planting in the lowland areas. One of these was named 'Olan' after

it's owner. It is a selection from a seed, which was brought from Thailand. The fruit is ovate and weighs 26 g. The aril is 6 mm thick with a TSS of 17.5° Brix and is 62 percent of the whole fruit by weight. The owner claims that this variety is a regular bearer. The other is an unnamed selection of the DA. The fruits are ovate, weigh 18 g and turn rose red when fully ripe. The aril is 6 mm thick, with a TSS of 17° Brix and is 72 percent of the whole fruit by weight.

### **3. PRODUCTION OF PLANTING MATERIAL**

Lychee is propagated by seeds or by vegetative means. Seedling trees however take a much longer time to bear fruits and they do not reproduce true-to-type. Outstanding varieties are therefore propagated asexually and seedlings are used only as rootstocks in asexual propagation.

The common means of asexual propagation of lychee in the Philippines is by marcotting (air-layering) and grafting. Marcotting is preferred by lychee growers in the highlands since it is simple and gives very satisfactory results. One objection to marcotting is the absence of a strong taproot. The resulting marcotted plants only produce adventitious roots, which do not have a strong anchoring ability and are therefore easily toppled over in times of strong typhoons. Grafting, on the other hand, is popular among propagators in the lowlands since it is less wasteful of propagating materials than marcotting. In addition, grafted plants possess a strong taproot and can therefore anchor the plants better than marcotted plants.

There are a few Government and private nurseries producing asexually propagated lychee planting materials. In the highlands, four nurseries (three private and one Government nursery under the Bureau of Plant Industry of the Department of Agriculture) were identified as sources of planting materials. These nurseries are all producing marcotted plants at a selling price of US\$ 2 to US\$ 3 per piece. In the lowlands, four nurseries (three private and one Government nursery under the Department of Horticulture of the University of the Philippines Los Baños) have also engaged in the multiplication of lychee planting materials. These nurseries produce both marcotted and grafted plants and sell these at US\$ 2 to US\$ 30 per piece depending upon the size of the planting material. The number of nurseries producing planting materials of lychee is few due to the limited demand since lychee could be successfully grown only in limited areas of the country.

### **4. ESTABLISHMENT OF ORCHARDS**

Lychee is grown predominantly in mixed plantings. It is intercropped with other fruit crops such as banana, chico, mango and starapple. Elaborate land preparation is not practiced especially when only a few trees are planted. The usual practice in backyard planting is to dig a hole large enough to accommodate the root system of the planting material. The plant is then set in the hole, covered with soil and watered.

For small orchards, the land is first cleared. After clearing, stakes are laid out at a planting distance of 7m x 7m accommodating 204 plants per hectare or 8m x 8 m accommodating 156 plants per hectare. Holes are then dug manually at a size of 50 cm x 50 cm x 50 cm at the places occupied by the stakes. Before planting, the holes are filled with

compost materials or dried manure mixed with topsoil. The plants are set in the previously prepared holes with their stems straight and properly aligned with the other plants in all directions. The soil is packed firmly to remove large air spaces.

The general practice is to plant at the onset of the rainy season, so that the plants can make use of the moisture in the soil for fast establishment in the field. Ridging is recommended in low-lying areas in order to prevent waterlogging. In addition since the tree is not tolerant to wind due to its brittle branches, adequate windbreaks are needed.

Planting of nitrogen-fixing crops like legumes and other vegetables in-between lychee trees is recommended during the early years after planting. This is to maximize the use of the land and for the farmers to derive an income while waiting for the lychee trees to bear fruits.

## **5. CARE AND MANAGEMENT OF ORCHARDS**

### **Training and Pruning of Plants**

Training and pruning of trees are unknown and not practiced by the farmers resulting in trees with a multitude of branches. It is, however, recommended that the shape of the tree be established during the first two years of planting. Regular pruning should be practiced to control the attack of insect pests and diseases. In addition, heavy pruning should be avoided as it induces profuse vegetative growth instead of floral growth.

### **Application of Manure and Fertilizers**

Application of manure and inorganic fertilizers depend on the level of resources of the farmers. Compost and farm manure are usually used as basic sources of nutrients. In some cases, chemical fertilizers are also added. The fertilizers help the trees recover from nutrient depletion, which occurs during heavy fruit loads, and also improve the quality of the fruit produced.

### **Weeding and Mulching**

Farmers do not generally practice weeding and mulching although some fruit growers limit their weeding activity to the removal of weeds by hand around the canopy area. This is done to avoid nutrient competition and to prevent pests from breeding.

### **Supplementary Irrigation**

The practice of irrigating lychee trees is uncommon. If carried out, irrigation is done on a minimal basis. Irrigation of the trees is first done immediately after planting to allow the roots get in contact with the soil. During their growing period the plants are mostly grown under rainfed conditions. At certain times of the year, especially when the dry season is extended, supplementary irrigation is practiced. This is usually done manually.

## Control of Pests and Diseases

No serious insect pests or diseases have been known to infest lychee in the country. However, some of the pests, which have been reported to attack lychee, are leaf miners, beetles, Erinoe mites and stem and fruit borers. The larvae of the leaf miners tunnel and feed on young flushes producing blisters, blotches or tunnels in the leaf. Spraying with systemic insecticide before and during flushing controls this pest. The larvae of the beetles, on the other hand, feed on stems causing punctures and partial girdling of the stem causing them to wilt or break. Spraying of systemic insecticides, pruning and burning of infested branches effectively controls this pest. Erinoe mites cause gall-like symptoms or velvety swellings on the underside of the leaves causing abnormal development of the leaves and premature leaf fall. Control measure consists of spraying with dimethoate every 10 to 14 days before flushing. The larvae of the stem borers, on the other hand, bore tunnels under the bark of the stem which later dry up and die. In addition, the larvae of the fruit borers bore into the fruit and into the seed resulting in rotting of the fruit caused by fungal infestation through the wounds on the fruit. Fruit and stem borers are controlled by spraying with systemic insecticides.

Of particular importance is 'bat attacks' during fruit ripening months. Bats have been recorded to decrease production per tree by as much as 50 percent. Some lychee growers cover their trees with protective nets but this is a tedious and costly practice. Other growers group adjacent fruit clusters together and cover these with plastic bags.

Most lychee growers claim that they have not encountered any serious disease in lychee. Just recently, root rot, which was suspected to be caused by *Clitocybe* sp., has killed a number of trees in the highlands. The growers were advised not to plant on poorly drained soils as this may cause sudden death of the trees even during the juvenile stage.

## 6. HARVESTING OF FRUITS AND YIELDS

In the Cordillera, flowering to fruit maturity of lychee takes eight months, from September to April while the harvesting season takes four months, from May to August. In Ilocos Sur, flowering to fruit maturity is from February to April while harvesting is in May. Growers observed that in Ilocos Sur, it takes only three months from flowering to maturity, which was relatively shorter than that in the Cordillera provinces.

Lychees are normally ready for harvesting if the tubercles have become flat and smooth and the colour changes from light green to bright red. Growers in Ilocos Sur and the Cordillera however, considered only the colour as their maturity index. Harvesting was done as soon as the fruits exhibit reddish colouration.

Lychee fruits are usually harvested by cutting or breaking the entire cluster of fruits with a picking pole. Picking the fruits individually is time and effort consuming, thus it is not recommended. Besides, it may cause ruptures on the skin at the stem end, which could serve as an entrance for decay-causing micro-organisms. Fruits are usually kept away from the sun after harvest to avoid browning of the skin. The fruits are then packed or sold immediately after harvesting.

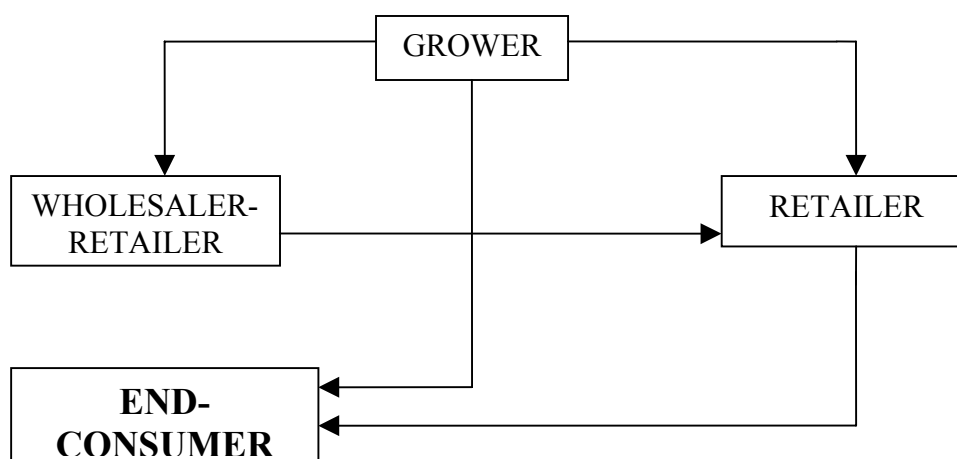
Based on the 1995-1996 figures, production averages per tree ranged from 10-50 kg/tree. This is rather low in comparison to the level of productivity in other lychee producing countries. It has been reported that yields ranging from 125-130 kg/tree were obtained in India and Australia. The primary reason for the variable quality and low yields obtained locally is the low level of cultural management employed.

## 7. MARKETING

Traders use plastic bags for retail selling and trays or cartons for the bigger volumes, which are provided by importer-wholesalers. Lychee fruits are sold on a per kilogram basis. Farm gate price ranges from P80/kg to P120/kg.

The channels of distribution of lychees in the country consist of two types of market outlets namely, wholesaler-retailer and retailer. Wholesaler-retailers cater to the needs of retailers, institutional buyers and end-consumers. They sell either in bulk or small quantities within the locality through the fruit stalls which they occupy. Retailers, on the other hand, operate either as ambulant vendors or fruit stand owners and sell small quantities of fruits to the consumers. Wholesaler-retailers and retailers obtain fruits directly from the growers.

The trade flow of lychee is illustrated in figure 1 below.



**Figure 1. Marketing channels of lychee.**

The small harvest volume limits the marketing flow of the fruits within the area or vicinity of the municipality or province. The small quantity of fruits harvested is directly sold by the growers themselves who regularly transport vegetables to the market and sell excess production of lychees to increase their income. The low yield of lychees in some areas resulted to the direct marketing of the fruits by the growers to neighbours and friends within the municipality.

Farmers with a sizeable production either deliver the fruits to the market or have them picked up from the farm or house by the trader. The 'suki' system is the most common relationship between the farmer and trader. This is characterized by the trader becoming the regular customer of the farmer as a result of the good relationship between these two players

in the trading system due to the good prices offered by the trader who often buys the majority of the farmer's produce.

Table 1 shows the quantity and value of lychees imported from 1991 to 1995. The average annual growth rate of lychee imports is 8.18 percent. The country is generally a net importer of lychee due to its limited production owing to the crop's subtropical characteristics. In 1995, the Philippines imported 1,374 metric tons of lychee valued at US\$ 0.52 million. This is 5.48 percent lower than the previous year recorded at 1,454 metric tons. In terms of value, the price of lychee has dropped by approximately 24 percent from US\$ 383.76 per metric ton in 1995 to US\$ 290.70 per metric ton in 1996.

**Table 1. Quantity (metric ton) and value (FOB US\$) of Philippine lychee imports from 1991 to 1995.**

	1991	1992	1993	1994	1995
<b>Quantity</b>	1,481.225	681.030	1,009.411	1,453.835	1,374.099
<b>Value</b>	485,755	212,536	385,392	554,345	527,328

**Source: National Statistics Office, Bureau of Agricultural Statistics**

## **8. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT**

Highland areas of the Philippines have potential for the commercial production of lychee. In fact, previous attempts to grow this crop in the country have shown that it performs well in certain areas. For example, 'Sinco' and 'Mauritius' lychee were found to be highly promising in the Cordillera highlands. In addition, there were reports and observations on fruiting trees of lychee in some lowland areas of the Philippines. However, despite these potentials, only limited attention has been given to this crop.

Lychee is considered a traditional high value crop and it possesses good consumer acceptance. Because of this, substantial local demand for lychee exists. This offers good market opportunities, which should encourage commercial production of this crop in the country. The increasing trend in the demand for sub-tropical fruits translate to large market potential available locally that is being taken advantage of by imported products. If the trend continues, liberalization could continue to allow imported fruits to penetrate the domestic market. As of the moment, the low importation for lychee opens possibilities to introduce this fruit in key cities in the Philippines once volume is available. This would only be possible through expansion of production not only in the highlands but in the lowlands as well. Suitable cultivars for tropical conditions should therefore be identified and proper growing techniques should be practiced so as to produce a large volume of high quality fruits.

With available highland areas suitable to sub-tropical fruit production and the introduction and planting of cultivars suited to lowland growing conditions, the Philippines can save on the precious foreign exchange and maintain balance of trade through reduction in volume of lychee imports. The development of the lychee industry will also contribute to improvement of employment and income of highland farmers and rural women and will encourage better land use and protection of the fragile highland areas of the country.



Some of the immediate concerns at present include the continuous monitoring of existing lychee trees, conducting trials of the existing materials at various locations and introduction of known superior varieties for inclusion in the trial. Trial plantings of lychee trees may be conducted in the farmer's fields where verification experiments on technologies like cincturing, irrigation and fertilization could be done.

Studies conducted by the RP-German Fruit Tree Project from 1987-1989 suggested two factors that would determine the potential of lychee to penetrate the market. These are the capability of the producers to bring whatever produce they could to the market at the best possible price and the ability of the local cultivars to be introduced and accepted into the fruit market that is dominated by imported lychee cultivars. The main concern and challenge therefore, is whether or not the locally produced lychee can compete with the imported ones in terms of sustained supply, fruit quality and prices. An integrated research and development programme on lychee to adequately address these concerns is therefore in order.

## **9. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

### **Lack of suitable varieties**

Varietal improvement of lychee has been very limited. Varieties of lychee were introduced into the country but their field performance has not been thoroughly evaluated in potential growing areas. For example, between 1986 and 1996, varieties of lychee were introduced by the RP-German Fruit Tree Project of the Bureau of Plant Industry and preliminary evaluation indicated that some of the collection has potential for commercial planting in the Cordillera highlands. These varieties had not been tested in other highland areas of the Philippines. In addition, there were reports that certain varieties of lychee have been fruiting in the lowland areas of Laguna and Batangas. With such available genetic materials, it is important that they be tested under various elevations of the country to identify which cultivar performs best in a particular area. In addition, varieties that are adapted to the constantly high temperature of the humid tropical lowlands should be introduced for trial planting in the country.

### **High cost of production inputs including planting materials**

Expansion of lychee cultivation to other highland and lowland areas can be achieved with the intensification of asexual propagation of selected cultivars. Some promising cultivars have already been identified and are being propagated in a few nurseries. However, these are very expensive and ordinary farmers could not afford to buy these materials in great quantities. Inexpensive high quality planting materials should therefore be produced by both Government and private nurseries to facilitate dissemination of outstanding lychee cultivars.

### **Limited production technology**

As of the moment, there is no locally developed technology available on plant nutrition and irrigation, flower induction, pests and diseases and post-harvest handling. The technology available is patterned from other countries. The present state of fertilization programmes for lychee is wanting for specific information on the amount of fertilizer to use and method of fertilization. Fertilizers are not applied according to the requirements of the

trees. Most of the available recommendations are on an interim basis usually projected and derived from farmer's actual experience, which varies according to locations and existing conditions. No extensive or integrated research has so far been conducted to answer many of the important questions on fertilization of lychee under local conditions.

It is perceived that the adoption of improved production technology developed by the research system for lychee can bring about visible and significant changes to the fruit industry of the Philippines.

### **Weak technology promotion and adoption**

Technology transfer is weak, thus the need for technical capability enhancement. To have sustainability in technology promotion and adoption, institutional linkages need to be strengthened, thus, the need for the involvement of the local government units, state colleges and universities and the Department of Agriculture. Available knowledge and technology is often confined mainly to a few research institutions. Fine-tuning of these technologies is needed before they can be recommended to commercial growers.

### **Limited government support**

Despite the potential of lychee production in the Philippines, the Government has not accorded this crop a priority status for research and development. Currently, in the Cordillera the attention remains on rice and vegetable crops. In fact, the priority fruits identified by the Department of Agriculture in this region are banana and citrus. As of the moment, the Government believes that local lychee production can not compete successfully in the global market.

### **Physical constraint**

The major physical constraint to lychee production development in the country is the absence of adequate irrigation facilities, especially in the remote mountainous areas. The lack of water resources for irrigating newly transplanted crops and for the crops' maintenance is a key concern among the growers.

## **10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE**

There have been a few research and development projects conducted on lychee. Below is a brief historical profile of these projects from 1989 to 2000.

On May 17-19, 1994, the Philippines participated in the Expert Consultation on Tropical Fruit Species, which was held in Malaysia at the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia. This consultation came up with three recommendations for lychee research and development in the country. First was the collection and introduction of lychee varieties that can adapt to tropical conditions. The other two recommendations were the evaluation for better performing varieties and the conduct of compatibility studies using *L. chinensis* ssp. *Philippinensis*.

<b>Title of Project</b>	<b>Implementing Agency</b>	<b>Duration</b>
Propagation technique in lychee and longan	RP-German Fruit Tree Programme – Bureau of Plant Industry – National Crops Research and Development Centre	1989-1994
Performance trial of lychee	RP-German Fruit Tree Programme – Bureau of Plant Industry – National Crops Research and Development Centre	1989-1997
Varietal trials of lychee	Department of Agriculture – Cordillera Administrative Region	1990-1991
Developing a lychee based farming system	Department of Agriculture – Cordillera Administrative Region	1991-1994
Micro-propagation of <i>Litchi chinensis</i> Sonn.	RP-German Fruit Tree Programme – Bureau of Plant Industry-National Crops Research and Development Centre	1996-1998
Performance trials of promising varieties of lychee and rambutan	Department of Agriculture – Southern Tagalog Integrated Agricultural Research Centre	1996-1998
Breeding of selected fruit crops: 1. Citrus, cashew, jackfruit, durian, lychee, longan, chico and mango	Institute of Plant Breeding – University of the Philippines Los Baños	1996-2000

In 1999, an Integrated Research and Development Programme (IRDP) for sub-tropical fruits in the highlands was conceptualized. The sub-tropical fruits included apple, longan, loquat, lychee, macadamia, peach and pear. The IRDP covered selected areas in six geo-political regions of the country (CAR, 4, 7 10, 11 and 12) and had three basic components, namely: a) market and technology assessment; b) technology promotion and adoption; and c) technology generation. The University of the Philippines Los Baños, University of the Philippines La Granja, Cavite State University, Mindanao State University, Bureau of Plant Industry, and the Department of Agriculture would implement the programme for 5 years. Overall coordination and monitoring would be provided by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. Unfortunately, this programme was not implemented since the Government believed that the development of the sub-tropical fruit industry in the country to compete globally is not possible. Its recommendation was to use the scarce financial resources for research and development programmes to develop and commercialize major fruit crops such as banana, citrus and mango.

On March 23, 2001, the National Network for the Conservation and Sustainable Use of Plant Genetic Resources (PGR) for Food and Agriculture was launched. This network is composed of the Bureau of Plant Industry, the National Plant Genetic Resources Laboratory,

the Department of Agriculture and State Universities and Colleges (SUC's). It was created to establish a national system for collecting, conservation, regeneration, multiplication, characterization, evaluation, documentation and utilization of plant genetic resources of the Philippines. With the establishment of this network, the Bureau of Plant Industry - Baguio National Crops Research and Development Centre, which is a member of the PGR Network, plans to improve their germplasm activities on sub-tropical fruits, which include lychee among others.

## **11. CONCLUSIONS**

The lychee is an introduced sub-tropical crop in the country that bears attractive fruits and has good consumer acceptance. Although it has a strong appeal, its production has not expanded to other parts of the country due to its exacting ecological requirements. Only when the grower is guaranteed of a regular flowering and dependable yields can the crop be grown commercially throughout the country. However, this would require concerted efforts on the part of the Government and the private sector.

Two specific strategies could be put forward to develop the lychee industry in the country. The first strategy is to increase volume of production. This could be realized by planting varieties that are suited to both upland and lowland conditions. Appropriate production technologies should be practiced and additional training should be given to the farmers so that they could attain the maximum harvest per tree. Adequate physical infrastructures should also be in place especially the irrigation facilities since it has been observed that harvest and fruit quality is lowest when water supply is scarce.

The second strategy is to put an added value to the product. One way of doing this is by processing. Though processing is an opportunity, it is not an immediate option due to the currently low level of production and lack of processing technologies. The majority of the canned lychees in the Philippine market come from Thailand. The country could therefore learn from Thailand, thus the need for a strong regional cooperation with countries possessing a high level of production and processing technologies.

Another way of adding value to the produce is by packaging, which protects the product and at the same time makes it attractive to the consumers. A technique that could be adopted is 'price bundling' which makes use of several kinds of fruits that are available in one season. These fruits could be bundled together in a fruit basket and given a 'bundled price'. For instance, lychees could be packaged together with lemons and pears to be sold at a premium price to specialized customers. This strategy would allow the different fruits with limited volume to be introduced to as many customers as possible while commanding a higher price brought about by its packaging.

Fruit festivals like the lanzones festival of Camiguin which promotes lanzones and the Apo Duwaling festival in Davao which promotes the durian, should likewise be done for lychee. This promotion strategy would encourage the lychee growers and update them on the current trends and technology developed for the crop. It would also be on these occasions that the growers' promising selections would be flushed out and introduced to interested individuals and institutions.

Lastly, the Government should take the initiative in funding research activities that would encourage production development of the lychee. Developed technologies should be popularized and education campaigns should target both the growers and the consumers. The Government and the private sectors should therefore work hand in hand to widen the scope for lychee production in the Philippines.

## REFERENCES

- Cablog, N., A. Reyes and L. Iguid. 1995. Technoguide Series No. 2. Production guide for lychee. RP-German Fruit Tree Project, Bureau of Plant Industry. 9 p.
- Foundation for Resource Linkage and Development, Inc. 1997. An assessment of the market potential of selected Philippine fruits in the Cordillera Autonomous Region. RP-German Fruit Tree Project. 136 p.
- Galang, F.G. 1955. Fruit and Nut Growing in the Philippines. Chapter 46. Family Sapindaceae. AIA Printing press, Malabon, Rizal. pp. 399-406.
- Menzel, C.M. 1991. *Litchi chinensis* Sonn. E.W.M. Verheij and R.E. Coronel (eds.). Plant Resources of Southeast Asia No. 2. Edible fruits and nuts. Pudoc, Wageningen, The Netherlands. pp.191-195.
- Namuco, L.O. and R.T. Calendacion. 1988. Techguide Series No. 15. Potentials of lychee in the Philippines. Technology and Livelihood Resource Center-University of the Philippines Los Baños. 8 p.
- Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. 1999. Integrated research and development programme for sub-tropical fruits in the highlands. PCARRD. 89 p.
- Sauco, V.G. 1989. FAO Plant Production and Protection Paper 83. Litchi cultivation. Food and Agriculture Organization of the United Nations. 136 p.
- Sotto, R.C., R.E. Coronel, N.O. Aguilar, D.E. Angeles and J.B. Sangalang. 1997. Morphological investigations on three Sapindaceous species: longan (*Dimocarpus longan* Lour. ssp. *longan* var. *longan*), lychee (*Litchi chinensis* Sonn. ssp. *chinensis*) and alupag (*L. chinensis* ssp. *philippinensis* (Radlk.) Leenh.). Phil. J. Crop Sci. Vol. 22. Suppl. No. 1:14.
- Torres, J.P. 1961. Fruiting litchi trees are now found in the Philippines. Plant Industry Digest 24 (7-8): 8-9, 26-27.
- Wester, P.J. 1916. Food plants of the Philippines. Phil. Agric. Rev. 9:199-256.

# LYCHEE PRODUCTION IN THAILAND

Ravie Sethpakdee \*

## 1. INTRODUCTION

The first record about lychee in Thailand was dated back to the year 1854 (King Rama IV). However, introduction of lychee to this country must be earlier than 150 years ago. It is very likely that the lychee fruit first came along with Chinese traders and immigrants during the Ratanakosin Era (since 1782). Some trees which are older than 100 years still exist in Samut Songkhram province. Also, in the two eastern border provinces of Trad and Chanthaburi the native lychee called 'Seeraaman' is found in the dense tropical rainforest. The diameter of these trees is usually greater than 1 m and they rarely bear fruit. Whether this lychee tree is an indigenous plant or left over from old settlement is very difficult to ascertain.

Lychee seems to have been introduced to this country via two major routes: by sea along with the Chinese immigrants and traders and by land with the hill tribe people. The first route could date back two centuries and lychee probably came in the form of seeds from imported fruit as well as accompanied seedlings. These lychee trees were able to adjust to the tropical climatic conditions, therefore the cultivars were named according to domestic language. Cultivars that came by the northern land route, probably from South China several decades ago, could have been in the form of marcottages. Names of these lychee cultivars have remained in Chinese.

Lychee production in Thailand can be divided into two planting types: (i) lowland or raised-bed type, and (ii) upland type. Trees of both planting types usually set fruit after 3 years. Thailand has an advantage in a longer production period of up to 3 months. Earliest harvesting can be from mid-March through last fruiting in mid-June.

Production Zone	Month			
	March	April	May	June
Chanthaburi	_____			
Samut Songkhram		_____		
Kanchanaburi		_____		
Nakhon Ratchasima		_____		
Phayao			_____	
Chiang Mai and Chiang Rai			_____	_____

Flowering and fruiting of lychee varies from year to year. Nonetheless, climatic influence, especially temperature, remains the major threat to lychee production throughout the country

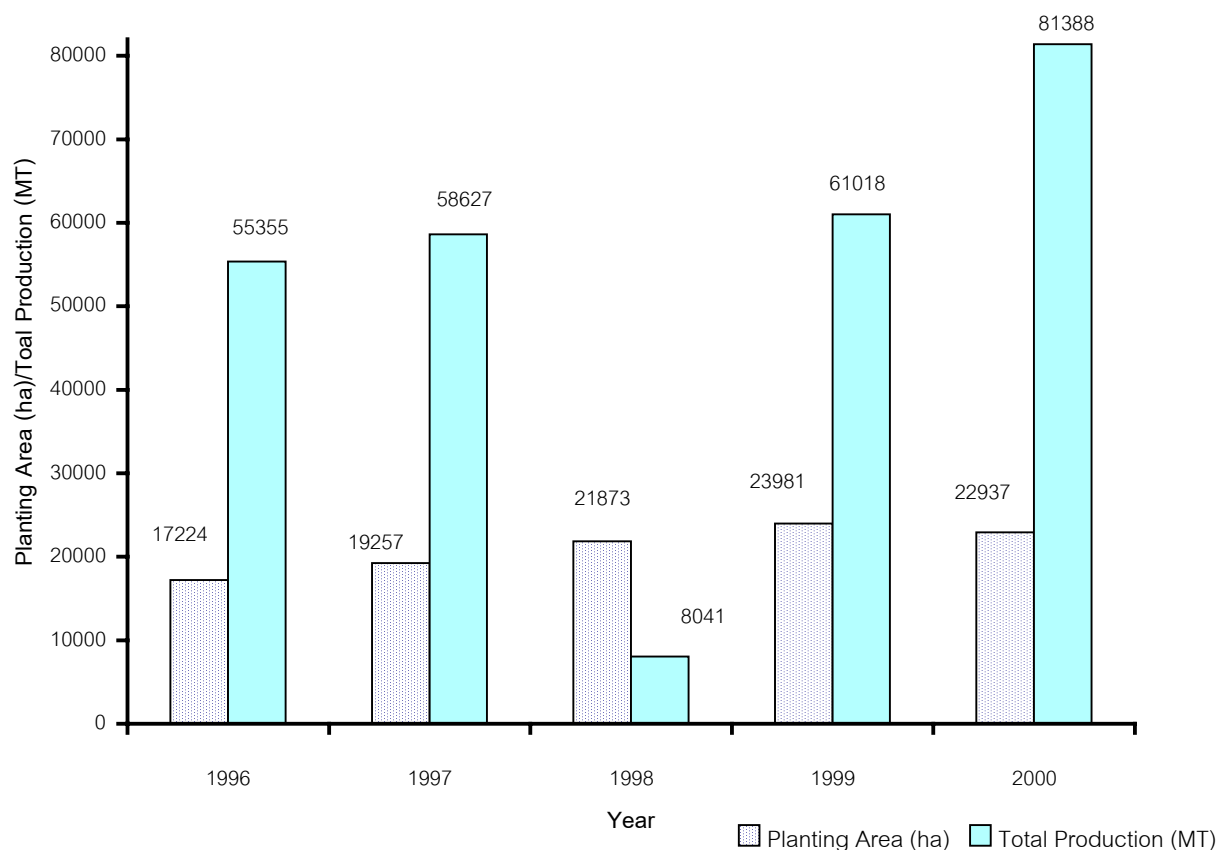
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## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN THE COUNTRY

Lychee growers in Thailand are smallholders with lychee planting ranging from a few trees to orchards of a few hectares. Upland growers may possess up to several thousands trees, however, such growers are few in number. Production zones are located in the central lowlands, and uplands of both the eastern and western regions. Most are concentrated in the north. Chiang Mai (8,322 ha) and Chiang Rai (5,763 ha) are the two major provinces that contribute more than 60 percent of the overall acreage (22,937 ha).

Statistically, the production yield showed an increasing trend from 1996-2000 except for the 1998 crop year, which was affected by the El Nino phenomenon (Figure 1). During the last cropping year (2000), a long period of low temperature resulted in a bumper crop (81,388 MT). However, Sub-zero early morning temperature with frost was observed in several northern provinces resulting in small-scale shoot injury.

Figure 1. Lychee Production Statistics of Thailand (1996-2000)



Lychee cultivars growing in Thailand can be divided into 2 groups based on their cool temperature requirements.

**(i) Moderately low temperature cultivars:** Cultivars in this group normally possess Thai names and are grown mainly in the lowland and the central area (including eastern and western regions). Adaptability of these cultivars to the local climate is probably the main season. More than 10 cultivars have been recorded but the most famous one is the 'Kom' (dwarf) cultivar due to its compact canopy size. Other cultivars of less importance are Kra-lok Bai-Yaw, Sampao Kaew, Sa-rack Tong, Jean, Jean Yak, Tai, Tai Yai, Chor Rakum, Kiew Waan, Dang Payom, Kratone Tong Pra-rong and Kra-lok Bai Dum. Recently, 'Pantip' lychee variety emerged and is grown mainly in Kanchanaburi province.

**(ii) Low temperature cultivars:** There are a few cultivars in this group which are grown mainly in the north. The lowest temperature requirement belongs to 'Hong Huay', which contributes more than two-thirds of the whole group. This is followed by Chakrapad, Kim Cheng, O-Hia and a few other less important cultivars. Chakrapad usually fetches the highest price due to its larger fruit size.

### **3. PRODUCTION OF PLANTING MATERIAL**

Air-layering or marcotting is the only method used in propagation. Growers and private nurseries are the major source of planting material. A few Government agencies provided cheaper as well as free of charge planting material to small-scale growers.

### **4. ESTABLISHMENT OF ORCHARDS**

In the lowlands of the Central Plain the raised-bed or ridge system is generally used to grow lychee as well as other crops. Each bed is 4 m (sometimes 6 m) wide alternating with a 2 m wide ditch. The water level is kept constantly at 50 cm and controlled by an outer dyke. Irrigation and chemical sprays are employed by boat through the ditches all over the orchard. Coconut, pomelo, banana and other crops are planted along with the main lychee trees. Planting distances range from 3, 4, 5, 6 or 8 m apart depending upon the grower's preference.

A square planting system is mainly employed in the upland orchards, but some new growers have switched to a rectangular system. Spacing of older orchards can be as wide as 10-12 m, but 5, 6 or 8 m are the most preferable. No orchards use the high density planting (HDP) system.

The technically recommended pit size is 1 x 1 x 1 m, but growers usually reduce this size to 0.8-0.5 m in both lowland and upland types. As much as one-half of the pit volume of farmyard manure or compost is incorporated during preparation. The Planting season starts from May at the onset of the Southwest monsoon. Sufficient rain minimizes the mortality rate and replanting chore.



## **5. CARE AND MANAGEMENT OF ORCHARDS**

### **Training and Pruning of Plants**

No exact training system is used but the tree is likely to become a modified leader type. A bush type, without main trunk, is frequently found among older lychee trees. Pruning usually done only on the inner, shaded twigs and branches. This practice results in uncontrolled canopy size. In order to reduce the tree size and height some growers employ a stub pruning method. Hard pruning of both the height and 4-sided perimeter is also practiced in some orchards. Recently, top opening of centre branches between 1-1.5 m wide has become a common practice among growers.

### **Application of Manure and Fertilizers**

Farm manure as well as plant residues (peanut husk, rice straw), compost and chemical fertilizers are applied annually. The exact amount of manure applied is not known. Foliar fertilizers are added to every spray programme along with soil application. Use of foliar fertilizers is not only as a soil supplement, but also regulates tree growth and development. Since lychee growers believed that phosphate fertilizer stimulates tree flowering high P formulae are frequently used. The common NPK+Mg formulae used are 8:24:24, 9:25:25, 15:15:15, 16:16:16, 25:7:7, 13:13:21, and 12:12:17+2. Up to 10-12 kg per tree per year seems to be common. Mono-potassium phosphate or MKP (0:52:34) 0.5 percent is being used to inhibit undesirable flush during the flowering induction period. Beside manure and fertilizers other chemicals, such as seaweed extract, trace elements, polysaccharides etc., are also added.

### **Weeding**

Control of weeds has to be done several times during the rainy season. Both mechanical and chemical control measures are almost equally employed. Two main herbicides commonly used are glyphosate and paraquat.

### **Mulching**

Mulching is normally practiced during the dry season, which coincides with fruit setting and fruit growth period. Mulching can prevent fruit cracking due to fluctuation in soil moisture content. Rice straw and dried grass are the two main sources of mulching material. No plastic film mulching has been used.

### **Irrigation**

The older and cheaper method of flood irrigation is practiced in the older orchards. Irrigation sprayed from a boat is commonly used in the raised-bed plantations. No irrigation system is employed on the higher slopes of the northern hilly areas. Modern orchards have switched to the mini-sprinkler system, which has been found to be more reliable. Several commercial growers have practiced Fertigation along with this irrigation system.

## Control of Pests, Diseases and Physiological Disorders

Among insect pests a few are seriously threatening lychee growers. They are the fruit borer (*Conopomorpha sinensis*), longan sucking bug (*Tessaratoma papillosa*), fruit piercing moth (*Othreis fullonia*), twig borer (*Zeuzera coffeae*) and leaf miner (*Conopomorpha litchiella*). All of these pests can infect the longan as well as lychee (the acreage of longan is more than 100,000 ha or about 5 times that of lychee). This provides a longer host range from May-September. The fruit borer has a devastating effect in some years. Other insects occasionally threaten lychee, such as the leaf eating caterpillar (*Oxyodes scrobiculata*), scale insects and mealy bugs. Even though they are not of much concern, the lychee rust mite (*Aceria litchii*) or erinose mite can damage all newly flushed shoots of neglected trees.

Control of these pests essentially requires integrated management. Chemical sprays along with mechanical methods e.g. bagging, light-traps, pruning and other biological control strategies must be eventually incorporated.

Diseases in lychee can infect the leaf, branch, flower and fruit. The important ones are fruit rot (*Peronophythora litchii*), leaf spot (*Lasiodiplodia theobromae*), and sooty mold (*Capnodium* sp.). The leaf spot disease is also able to infect the fruit at the post-harvest stage causing fruit rot.

Sunburn, fruit cracking and undeveloped seeds are the major physiological disorders. Sunburn poses a threat to growers almost every year. Normally, the southwest face of the tree is prone to sunburn. Damage to the late blooming panicles from late February-March usually affects more than one-half of the tree. The time of fruit colour change (about 1 month before harvest) is the most vulnerable stage for cracking (splitting). Fluctuation in soil moisture content and a wider range of dry and wet regimes encourage more fruit cracking. Total crop loss has been observed in a non-irrigated tree after heavy rainfall. Undeveloped seed, an undesirable parthenocarpic fruit, is found mainly among the lowland cultivars such as 'Kom'. This phenomenon occurs during a crop year with a cool climate after fruit set has taken place. Probably, the cold temperature has a lethal effect on the young and tender embryo.

## 6. HARVESTING OF FRUITS AND YIELDS

The harvesting season starts from mid-March in Chanthaburi followed by Samut Songkhram (early to mid-April) and Kanchanaburi (mid-late April). These early cultivars are of the lowland 'Kom' and 'Pantip' type. The northern lychee ripens almost 2-4 weeks later than the moderately low temperature cultivars from mid-May through mid-June. Hand picking is the sole harvesting method. Fruit skin must be stretched out almost to its limit at the time of harvest to ensure fruit maturity. Bagging is also practiced in several commercial orchards in order to protect the fruit from pest damage. Newsprint, and other types of paper are used as bagging material. HDPE bags with open ends have been used for bagging in Chiang Mai. This bagging method creates a micro-climate inside the bag. Even fruit colouring as well as size was observed from this bagging method.

Average yield of 'Kom' and 'Hong Huay' in a regular crop year ranges from 4.3-5 MT per hectare. Prices vary from year to year depending upon several factors.

Lychee fruit deteriorate rapidly from both desiccation and fungal infection. Pre-cooling with ice-water is a common practice in order to prevent post-harvest loss. Currently, fruit is packed in 10 kg cartons lined and covered with leaves. Sulphur dioxide treatment has been used to stabilized skin colour and prevents mold infection.

## 7. MARKETING

Exporters and middlemen have the greatest influence on the marketing system. Temporary packing houses with a fruit buying post are set up by the exporters. Distribution of fruit depends on the individual trader's channels. Export of lychee to Malaysia and Singapore is by land but export over longer distances, such as Hong Kong and European countries, is by air cargo. The below grade fruit is sold as raw material for processing. Export of fresh and canned lychee from 1995-1999 is shown below.

	1995	1996	1997	1998	1999
<b>Fresh</b>	3,257	11,603	11,158	1,511	12,496
<b>Canned</b>	8,930	14,084	15,525	5,404	12,886

Unit: MT

In 1999 Hong Kong was the largest importer of fresh Thai lychee (8,644 MT), while Malaysia and USA were the major importers of canned lychee (3,767 and 2,049 MT, respectively).

## 8. POTENTIAL FOR LYCHEE PRODUCTION DEVELOPMENT

Currently, Thailand is ranked among the world's major lychee exporting countries. There are several advantages for lychee production development, as follows.

- i. Cultivar: Thailand has a wide range of cultivars especially of the moderately low temperature type. Selection of these cultivars for a particular location and/or purpose is highly feasible.
- ii. Geographic location: With the production areas ranging from the tropical lowlands to the sub-tropical climate of the highlands of the north and northeast regions, the fruiting season could lengthened up to a full 3 month period. There are several areas where selected cultivars could fill up any gap of supply throughout this 3 month period. Thus better confidence in supply could strengthen marketing planning strategy.
- iii. Agricultural materials: The supply of agricultural materials such as fertilizer, plant growth regulators, chemicals, etc., is abundant and easy to access. This would enhance and facilitate any production development.

## **9. CONSTRAINTS IN LYCHEE PRODUCTION DEVELOPMENT**

There are several problems that either inhibit or restrict lychee development in the country as follows:

- i. Alternate bearing habit: Growers are tired of the flowering uncertainty of their crop. Climatic conditions play an important role in each cropping season.
- ii. Perishable nature: Lychee fruit is considered to be a highly perishable crop. Fruit deteriorate rapidly after harvest hence it has a very short shelf-life.
- iii. Poor marketing management: Almost all lychee marketing is under the control of middlemen and exporters. Growers have very low bargaining power in order to get a better price.
- iv. Low fruit quality: Poor lychee growers are unable to invest in agricultural materials such as chemical fertilizers, which results in low quality fruit. Such poor quality crops could bring down the overall price.
- v. Longan mania: High demand for longan from China during the last few years pushed the longan price ahead of lychee. The situation worsened with the discovery of the use of chlorate in forcing longan to flower. Currently, growers can bring the longan trees to flower at will with chlorate application. Consequently, lychee is no longer a favourite crop for growers. Some plantations in the north replaced lychee with either longan or the more profitable mandarin citrus.

## **10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF LYCHEE**

The Thailand Research Fund (TRF) has been organized and has provided funds to about 6 research projects in lychee since 1996. Chiang Rai Horticultural Research Centre is authorized by Department of Agriculture, Ministry of Agriculture and Cooperatives, to handle all the lychee projects under their guidance. Several academic institutes such as Chiang Mai University, Kasetsart University, etc. have also carried out their own research. However, the present economic circumstance coinciding with 'longan mania' has resulted in sluggish lychee production development.

## **11. CONCLUSIONS**

Lychee has been grown commercially in Thailand for more than 100 years. There are two types of cultivars that exist in Thailand: (i) the moderately low temperature cultivars which mainly grow in lowland and central areas, and (ii) the low temperature cultivars that grow in the uplands of northern provinces.

Under present circumstance several problems remain, namely: (i) control of flowering, (ii) nutrition and (iii) post-harvest treatment.

Alternate bearing in lychee remains a big task for physiologists around the world. The El Nino effect resulted in a poor harvest of only 40 percent. There is no single solution in lychee flowering control. Climatic conditions, especially inadequate cold temperature may cause poor flowing in such years. However, manipulation of several events such as shoot maturity, irrigation, cold spell, tree health, and bud breaking must be well organized with proper synchronization.

There is no proper recommendation on lychee nutrient requirements. Insufficient and improper fertilizer application may result in lower crop yield and poor fruit quality. Currently, a research project on a nutrient analysis system is funded by TRF.

Fumigation with sulphur dioxide has been used in colour stabilization as well as fungal inhibition in lychee in recent years. Treated lychee fruit can retain its shelf-life much longer in cold storage. However, improper use may result in higher residues of SO<sub>2</sub>. All of this could be regulated under a quality assurance system.

# LYCHEE PRODUCTION IN VIET NAM

Vu Manh Hai <sup>1</sup> and Nguyen Van Dung <sup>2</sup>

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## 1. INTRODUCTION

Lychee is a native of South China and is also considered to have existed in Viet Nam for a long time. At the foot of Bavi Mountain, wild lychee trees were found by a French scientist in 1942. In 1970 Professor Vu Cong Hau (late director of the Industrial and Fruit Crop Institute) and his colleagues discovered lots of wild lychee trees in Tamdao (Vinhphuc province) and Tuyenhoa (Quangbinh province) forests.

A Vietnamese legend also recounts that one of Vietnamese Kings of the Mai Dynasty once offered lychee fruits, which were regarded as precious fruit of Viet Nam, to the Emperor of China. This evidence partly shows that lychee can be considered as a native of Viet Nam lychee and that the climate of northern Viet Nam, where winter is short, dry and a little bit cold and summer is long and hot with high rainfall and humidity, is quite suitable for the growth of lychee.

## 2. PRESENT SITUATION OF LYCHEE CULTIVATION IN VIET NAM

### Area and production

Lychee can be considered to have originated from Haiduong province (Thanhha district) where the most important variety has been commercially developed and over time it has spread to other locations in the northern Viet Nam and even to some places in the central part. At present lychee is commercially cultivated in Lucngan, Lucnam and Yenthe districts of Bacgiang province (about 100 km North of Hanoi); Thanhha, Chilinh and Tuky districts of Haiduong province (approximately 60 km east of Hanoi); Dongtrieu, Yenhung and Hoanhbo districts of Quangninh province (nearly 200 km east of Hanoi); and Quocoai, Chuongmy and Unghoa districts of Hatay province (About 40 km northwest of Hanoi).

Data in Table 1 was collected directly from the Provincial Departments of the Agricultural and Rural Development Ministry in the year 2000. Small cultivated areas are not taken into account.

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**Table 1. Area and production of lychee in Viet Nam**

<b>Province</b>	<b>Area (ha)</b>	<b>Production (MT)</b>	<b>Remarks</b>
Bacgiang	20,275	20,248	
Haiduong	9,325	11,645	
Quangninh	4,925	6,840	
Hatay	604	-	not available
Langson	223	-	not available
Whole country	35,352	Approx. 50,000	

### **Varieties of lychee grown in Viet Nam**

Up to now, the varieties of lychee grown in Viet Nam have not been scientifically classified, particularly local varieties.

Because of this, existing varieties of lychee are mainly named by local people and based significantly on appearance and morphology of the ripe fruits including the colour. It is obvious that the exact number of lychee varieties is much less than those named and recognized since the same varieties can be named differently from location to location.

In this paper, we try to describe the differences between varieties grown by some main characteristics and group them by harvesting time.

To date, the Research Institute of Fruits and Vegetables (RIFAV) has collected and characterized 33 accessions that can be identified as 33 cultivars of lychee grown in different locations in home gardens and consolidated farms. The names of cultivars collected and their areas of origin are presented in Table 2.

Of the 33 cultivars studied, 8 cultivars namely: Duong phen (as sweet as sugar), Hoahong (rose-like coloured fruits), Hunglong, Phudien, Phuchoa, Yenhung, and Thanhha (names of locations of origin) are considered to be promising and have been commercially developed in the main areas of lychee production. Main characteristics in terms of morphology and fruit quality are presented in Tables 3 and table 4.

**Table 2. List of lychee cultivars cultivated in Viet Nam**

No	Cultivars	Original area (Province)	No	Cultivars	Original area (Province)
1.	Duongphen	Hatay	18.	Thieuthanhha	Haiduong
2.	Hoahong	Hatay	19.	Thieu	Haiduong
3.	Banhtroi	Hatay	20.	Laithanhha	Haiduong
4.	Dua	Hatay	21.	Hunglong	Phutho
5.	Vanganh	Hatay	22.	Phudong	Phutho
6.	Vatkhan	Hatay	23.	Laihungyen	Quangninh
7.	Longvang	Hatay	24.	Laibinhkhe	Quangninh
8.	Luc	Hatay	25.	Phuchoa	Bacgiang
9.	Ongthieu	Hatay	26.	Laihuongson	Hoabinh
10.	Moidai	Hatay	27.	Lailienson	Hoabinh
11.	Nhonoï	Hatay	28.	Moga	From China
12.	Bieuquan	Hatay	29.	Phi Tu Tieu	From China
13.	Bop	Hanam	30.	Sau Yue hong	From China
14.	Chintrang	Hanam	31.	Pai thang ing	From China
15.	Laithuixuyen	Hanam			
16.	Laingocson	Hanam			
17.	Thachbinh	Hanam			

**Table 3. Morphological characteristics of promising cultivars of lychee grown in Viet Nam**

Cultivars	Fruit weight (g)	Percentage of edible part	Colour of peel	Fruit shape	Characters of pulp
Duongphen	23.61	65.35	bright red	heart shaped	light sweet, good flavour, soft
Hoahong	24.54	65.48	dark red	heart shaped	light sweet, soft
Hunglong	23.47	73.01	dark red	heart shaped	Sweet, firm and good flavour
Phudien	36.60	71.68	dark red	heart shaped with sharp bottom	Sweet, soft and good flavour
Phuchoa	23.08	71.88	pink	oblong	Sweet and good flavour
Laihungyen	30.10	73.18	yellowish red	heart shaped with flat bottom	Sweet and good flavour
Laibinhkhe	33.47	71.46	dark red	ovate	Sweet, soft
Thieuthanhha	20.70	75.48	bright red	sphere (round)	Sweet, good taste and flavour, firm

**Table 4. Characteristics of fruits of promising lychee cultivars.**

Cultivars	Brix (%)	TSS (%)	VtC (mg%)	Total acidity (%)	Dry matter
Duongphen	15.80	12.00	31.50	0.36	14.40
Hoahong	17.70	15.08	44.00	0.54	18.72
Hunglong	16.80	12.96	10.60	0.20	15.82
Phudien	17.50	12.31	12.50	0.17	16.20
Phuchoa	16.50	13.40	9.80	0.26	15.10
Laihungyen	17.50	13.75	17.09	0.57	14.50
Laibinhkhe	17.40	15.36	16.27	0.21	16.06
Thieuthanhha	20.50	16.24	24.00	0.28	18.20



### **3. PRODUCTION OF PLANTING MATERIALS**

Three methods of propagation i.e. seedling (sexual multiplication), marcotting and grafting have existed historically, but the first is now rarely implemented. Up to 1997, the general practice for lychee multiplication in Viet Nam was marcotting (air-layering). The advantage of this method is it retains the characteristics of the mother tree and is quite simple. The disadvantages are that the marcot does not have a strong root system as it lacks a taproot and is easily removed by strong wind. Also the shallow root system is easily affected by long periods of drought more than plants grown from seedling and grafted ones.

Though grafting was done by the Industrial and Fruit crops Institute in the 1970s, application on a large scale was not disseminated until 1997 when RIFAV had achieved significant success in collaboration with Quangxi Agricultural High School. The rootstock varieties of healthy and straight stem were selected from local varieties named 'vaichua' (sour taste). The scions were taken from healthy mother trees of well selected individuals, which have been properly managed and pruned to produce as many new branches as possible.

The total area of lychee nurseries in the north is estimated at about 7.6 ha that can produce one million grafted and marcotted trees from which RIFAV and satellite centres have begun to establish a network for lychee production by grafting.

### **4. ESTABLISHMENT OF ORCHARDS**

Generally, new plantation of lychee is done in two main seasons, namely spring (end of February to the first half of May) and autumn (second half of August to October). In some orchards where conditions for planting are favourable (water resource, labour availability, etc.) the planting season can be longer.

Normal spacing for lychee plantation is 7 x 7 m or 8 x 8 m depending on the fertility of the soil and the topography of the orchard. The dimensions of holes is recommended at 70 x 70 x 70 cm and in some case bigger dimensions up to 1 x 1 x 1 m are applied. Planting holes are filled with organic matter such as farmyard manure and compost, and phosphate fertilizer applied at least one month before planting. The young tree does not require watering since it normally obtains water from the rain during March to May (for spring planting) and September to early November (for autumn planting). However, it should be emphasized that watering of young litchi is definitely needed in areas where the rainfall is quite limited and irregular.

Since grafted young tree have been largely used as the main source of planting material and great attention paid to intensive production, the density of lychee has increased from 150-200 trees/ha to 300-400 trees/hectare.

The over-all design of lychee orchards should be established according to topography. The raised-bed model in the lowlands and contour making in steep land are the two main designs. Intercropping with annual crops such as legumes and vegetables is also applied in some lychee plantations at the first stage of the biological cycle, when land space is available between lychee trees.

## **5. CARE AND MANAGEMENT OF ORCHARDS**

In the past, training and pruning were rarely applied in lychee orchards and only pest affected shoots were removed. The situation changed when lychee growers became aware of the importance of these technologies through training courses and guidance given by extensionists. Most farmers now have sufficient knowledge for taking care of lychee plantations, particularly growers in traditionally concentrated areas of lychee production such as Thanhha district (Haiduong province), and Lucngan and Lucnam districts (Bacgiang province). In various orchards, weeding and mulching seems not to be necessary since healthy lychee plants are properly intercropped with annual crops such as soybean, groundnut, pea, etc.

On the other hand, supplementary irrigation is not a regular activity because of two main reasons:

- As mentioned above, lychee is often grown in spring and autumn in the north, the rainfall during these periods is considered to be sufficient for young trees.
- Lychee is largely grown in hilly areas where water resources are not easily exploited.

On the issue of pests and diseases, no serious problem is observed in lychee orchards. However, in certain conditions the brown bug, which sucks the sap of young shoots and fruit causing them to fall off, and the spider, which sucks leaf sap, are the main problems to be mentioned. In fact, both pests can be controlled easily by using insecticides. In 1998, lots of adult lychee trees in Lucngan district declined and died rapidly. Some fungus and nematodes were observed in the affected trees and fungicides were then applied in combination with proper cultivating technologies, i.e. making the soil aerobic, pruning, fertilizer application, etc., and the problem was solved.

## **6. HARVESTING AND MARKETING**

In northern Viet Nam the most popular variety namely 'vaithieu' ripens in May to June. Early varieties and accessions can be harvested in late-April and well-selected individuals of these varieties have been paid great attention to prolong the duration of harvesting.

Concerning the problem of consumption, it is estimated that about 70-75 percent of the total production of lychee fruit is consumed in local markets, the rest is exported to China, Hong Kong, ASEAN countries and some European countries such as France and Russia.

Lychee fruits are also processed as syrup and dried fruit. The juice of the latter is mainly exported to China or used for local consumption.

## **7. CONSTRAINTS AND POTENTIAL FOR LYCHEE PRODUCTION**

Because of irregular bearing resulting mainly from the cold temperature requirement for flower initiation, production of lychee may be quite low in some years. One of the

disadvantages of lychee is that its harvesting period is rather short (about one or one and a half months). This makes it difficult for growers to sell all their harvest as most fruit ripens during a short period.

Some other problems are as follows:

- Lack of elite varieties: Though some varieties have been studied and selected, there is one main variety of lychee that is extensively grown. This is likely to be wiped out by epidemic diseases or pests as the result of its narrow genetic base. It also makes the harvesting period short.
- Lack of post-harvest technologies involving equipment needed for conservation and packaging.

Though the above mentioned constraints are not easily solved in one or two years, the prospect for lychee production in Viet Nam is quite good due to the following advantages:

- Suitable climatic conditions for the growth of lychee. Even with rather poor hilly soil, lychee is growing well.
- High market demand: apart from local consumption that is quite high (in central and southern parts), lychee fruits can be exported to southern China, a country which also loves to consume lychee but cannot produce enough.
- High potential for processing: Lychee is a fruit with pleasing aroma and taste, either fresh or after processing. The latter includes canning of the flesh (seed removed) or by extracting its juice, both of which are on high global demand as few countries in the world can produce them.
- The authorities (Government and Ministry of Agriculture and Rural Development) consider lychee as one of the specially promising fruit crops and policies for encouraging the study and production of lychee have recently been formulated.

## **8. CONCLUSIONS**

Viet Nam in general and northern Viet Nam in particular has high potential for lychee development. In fact this fruit has an important role to play in improving the national economy and living standard of local farmers.

Although, some successes in research and development have been already obtained recently, constraints need to be solved accordingly.

In order to overcome the problems and improve the situation, the following issues should be mentioned.

- Strengthen International Cooperation in the fields of biological genetic exchange and cultivation technologies for application on a large scale.
- Encourage and improve the study of post-harvest treatment of lychee that includes increasing the investment for construction of cold storage and packaging.

## CONCLUSIONS AND RECOMMENDATIONS

1. Lychee is indigenous to Southeast Asia and makes a significant contribution to the lives and economic health of many millions of people in the Region. The species originated in southern China and northern Viet Nam, but has now spread to most countries that experience a sub-tropical climate for part of the year. The crop is most important in China, India, Viet Nam, Thailand, Bangladesh and Nepal. There is also interest in Australia, the Philippines and Indonesia. Production in the Asia-Pacific Region accounts for more than 95 percent of world cultivation, at about 2 million tonnes. The crop is very popular throughout the Region with strong domestic markets and increasing affluence. About 58 percent of the world's population live in this Region. There is also some trade within the Region with exports to Singapore, Hong Kong and Malaysia. Most of the fruits are sold fresh, with a third of the crop dried in China, and limited processing and canning. The bulk of the crop is produced by smallholders with less than 100 trees each. Orchards with more than 1,000 trees are rare, except in southern China where there are single plantings of more than 10,000 trees. The fruit has a high value, and can significantly add to the income of smallholders. A few trees may double the income of such families. Despite the long history of cultivation in the Region, many areas experience low productivity, with average yields generally below 5 tonnes per hectare. This can be due to the weather affecting flowering, poor cultivars or lack of tree care. In Israel and some other countries, yields of up to 15 tonnes per hectare have been achieved. This indicates that there is a large gap between actual and potential yields. Much work is required to raise productivity across different locations. Prospects for increasing production and marketing of this crop are high if some of the growing, post-harvest handling and marketing issues are resolved. Intra-regional cooperation would assist industry development and the importance of the crop to local economies. Training for extension and scientific staff is also a priority.

2. Lychee trees require temperatures around 15°C (or lower) to flower successfully. A period of dry weather at this time can also assist cropping. Once trees have set fruit, warm weather with good soil moisture is usually associated with heavy yields. Cropping is thus limited to areas with some cool weather before flowering. Production is very erratic in the true tropics where night-time temperatures seldom fall below 25°C. The majority of the industries are thus based in areas with night-time temperature falling below 15°C. However, there are examples of industries with cultivars that will flower at slightly higher temperatures (e.g. Central Thailand). These areas often supply early season fruit and return higher incomes than fruit from "traditional" sub-tropical areas, but can fail some years. The quality of some of these cultivars is often inferior compared with the traditional types. New cultivars that have better fruit quality need to be developed for these areas. More research is required to define the optimum temperatures for flowering in the major commercial cultivars. There are also some growing techniques that can assist cropping in the warmer areas, but they have not been evaluated across the different environments. The other constraints related to weather are poor fruit set during cool damp weather, and damage to trees and fruit after typhoons. The risk to orchards is greater with plantings close to the coast (e.g. China and Viet Nam).

3. Lychee has a long history of cultivation in the Region, with many cultivars available. However, there is a paucity of information on the yield of different cultivars in the various countries. It is generally considered that the performance of many cultivars is disappointing and makes lychee production unprofitable. There are also differences in production season and fruit quality which impact on marketing. Many industries are based on one or two

cultivars. Choice of cultivar along with growing area has a major influence on orchard viability. Lack of suitable cultivars probably limits lychee production in many countries. This is because the existing cultivars are low yielding or not well regarded in the marketplace. Exchange of germplasm would increase the production of the crop in many countries. There is only limited plant selection and plant breeding in the crop. Some countries such as India, China, Nepal and Viet Nam have many seedling trees, which could form the basis of a new genepool for future cultivars and industry expansion. A breeding programme is required in the long-term to develop better cultivars, and is best implemented with a regional focus. In the interim, the current genepool should be more systematically evaluated. Standardization of cultivar names and descriptions would assist cooperation. Based on the above, it can be concluded that there is a need for a much stronger varietal improvement programme in all countries.

4. Propagation is well described, with most orchards based on air-layers. However, grafting or budding is popular in China and grafting popular in Viet Nam. It is reported that grafted trees are more drought and wind resistant; however, little experimental evidence is available. Grafting also uses less planting material than air-layering. However, there are some disadvantages with grafting. Grafting is not as easy as air-layering and requires the growing of seedling rootstocks. Grafted trees are also slower to be planted out. There is little information on the compatibility between different cultivars and the impact on production and fruit quality. Lack of irrigation can be responsible for the failure of newly established young plants. Many countries reported serious loss of young plants at this stage. Education of nursery workers and growers in tree care and the provision of irrigation would improve success rates. It is apparent that further work is required to standardize nursery techniques.

5. Lychees can be grown on a range of different soil types, including soils with a pH ranging 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 probably best with sandy, sandy loam and clay loam soils. Heavy clay soils are best avoided. Lychee production is unlikely to be restricted by poor soils throughout most of the Region.

6. It was agreed that production is probably best with irrigation of the orchards, especially during the fruiting cycle. Rainfall varies from month to month across the different agro-ecological zones. Most of the lychee orchards are not irrigated and are therefore dependent on regular rainfall. Experiments in Australia and South Africa have shown that drought can affect growth and fruit production, but the impact for local farms in Southeast Asia is not known. Most growers cannot afford the cost of irrigation. In any case, irrigation water is not available in most areas. In the absence of irrigation it was suggested that mulching and some cover crops would probably assist water conservation,. It can be concluded that new orchards should be irrigated if possible.

7. Most growers apply fertilizers to their orchards. Tentative leaf and soil standards are available for lychee, but the tests are possibly too expensive for smallholders. Local government extension staff could provide this service on a provincial or district basis. Most growers use a mixture of organic and chemical fertilizers, although the source of the fertilizer is unlikely to have any impact on production. In contrast, the effect of time of fertilizer application on cropping has yet to be resolved. Crop nutrient removal data could be used as a basis for estimating fertilizer requirements. The role of nutrient recycling in the

lychee orchards was highlighted, with the possibility of organic farming in some circumstances.

8. High-density orchards are becoming popular in the Region, and would be expected to increase the returns to growers, especially in the early years of a planting. There is evidence that these orchards can have double the returns of traditional low-density plantings. Considerable experience has been developed in some countries such as China. These closer plantings would be expected to increase the returns for both small and large landholders. High-density plantings require some method of canopy management to control tree size, with close attention to water and nutrient management. Experiments in China and Australia have shown that trees should be pruned in the first few weeks after harvest. 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. There are also various methods for controlling flower initiation such as droughting, girdling, pruning and chemical defoliation that need evaluation across the Region.

9. Many insects and other pests affect the lychee tree, leaves, flowers and fruit; however, their impact on grower returns varies throughout the Region. Most countries need to develop their own systems of integrated pest management, although there could be cooperation for the control of erinose mite and some other pests. Pest management along with other methods of tree care must be suited to the needs and abilities of the smallholders. Diseases were not considered to have a strong affect on production, apart from anthracnose in China and Australia.

10. Lychee fruits are highly perishable and have a short shelf-life. This seriously limits the marketing and expansion of the crop across the Region. Much research has been initiated to reduce fruit browning and rotting; however, no protocols have been established which can guarantee fruit quality for more than a week or two. This includes heating and cooling the fruit, various packages, and application of various fungicides and other chemicals. Many of the industries in the Region are based on the treatment of the fruit with sulphur; however, this chemical may be withdrawn soon. This makes the development of a new post-harvest treatment more urgent. Many countries do not have reliable access to on-farm cool-rooms, hydro-coolers, or refrigerated transport.

11. Most of the lychees produced in the Region are marketed locally. There are some exports to Hong Kong, Malaysia and Singapore, and to a lesser degree Europe and the Arab States. There are certain problems with Japan and the USA because of quarantine issues with fruit flies. Disinfestation protocols need to be established for the various markets. The market potential within the Region is strong because of the rising affluence within Asia and the Pacific. Good quality fruit from the Region is also highly regarded in Europe. However, there has been very little market intelligence collected. The preferred cultivars, packaging, etc. for the different markets are not known. The potential size and value of each market is also unknown. Lack of freight space is a limit for some countries like Australia. Quality standards have been developed in some countries.

12. There is a growing awareness for organically produced food. Organic farming is one of several approaches to sustainable and environmentally friendly agriculture. Lychee farmers could have a share of the world organic market, which is growing at a rate of 15-20 percent every year. Therefore, it is worth exploring the possibility of organic farming.

13. The consultation revealed that there was a need for improving the skills and technological knowledge of research and extension staff in many of the participating countries, along with orchard management skills of lychee growers. This could be achieved through professional development of scientific and extension staff, seminars, workshops, study tours, and on-farm training across the Region. The establishment of a lychee network throughout the Asia-Pacific Region would assist this training, and foster the exchange of new cultivars and technology. However, much stronger Government support is required to assist expansion in the various countries. The consultation recommended the establishment of a lychee network to foster cooperation and exchanges within the Region.

14. National workshops are a possible way of increasing the understanding of the crop in the different countries. These would follow a FAO Regional Workshop on Lychee. Various stakeholders such as research scientists, extension staff and growers would be included in these national workshops.

15. There is a low base of information on growing and marketing lychee in many countries throughout the Region. A regional network as indicated above would assist the exchange of information. It was also suggested that a lychee production manual be produced by FAO to cover various aspects of the crop in the Asia-Pacific. The manual would be directed at research, extension staff and farmers, and provide information about improving returns from lychee enterprises, especially smallholders.

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