LONGAN PRODUCTION IN ASIA
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by

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FOREWORD

The commercial longan (Dimocarpus longan Lour) is an economically important crop in a number of countries of the Asia-Pacific Region. Its role in the rural economy has been increasing, especially with respect to employment and income generation. However, despite its importance, there is a paucity of published information on longan and where available, the publications are outdated.

This document provides a fair coverage of available information on longan, covering a wide range of specific topics. It also highlights several production constraints and future prospects for its expansion as a commercial crop.

In many regions where both lychee and longan are grown, more attention has been given to lychee production and longan has often taken a backseat. However, there are exceptions, particularly in Thailand, where longan's contribution towards the local economy far exceeds that of lychee. Longan is less demanding and more predictable than lychee in its environmental requirements. Moreover, production of off-season longan is now a reality. The crop is currently gaining more and more acceptance in the Region, sometimes in preference to lychee. Consumption of longan is expected to increase further when more people outside Asia develop a taste for this fruit.

I do hope that this publication will contribute to the future development of the crop. It can be a useful reference source for students, researchers, extension officers, growers and entrepreneurs who are interested in this crop. I recommend this book to all those who have an interest in longan, and I am confident that it will prove valuable as a source of information to all users.

R.B. Singh
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1. INTRODUCTION

The commercial longan (Dimocarpus longan Lour.) is a highly esteemed arilloid fruit species in Asia and belongs to the family of Sapindaceae. It grows and crops satisfactorily in a range of tropical and subtropical countries but is exploited commercially only in Thailand, China, Taiwan Province of China and recently, Vietnam. Other areas which grow longan include Queensland in Australia and Florida and Hawaii in USA. The longan resembles the lychee (Litchi chinensis) in that the tree is grown for its fleshy, translucent, white aril which surrounds a red brown to black seed from which it separates easily. Fruit can be eaten fresh, frozen, canned or dried. In many countries where both the fruit species are grown, longan has not achieved the importance of the lychee. However, in Thailand longan production is regarded to be more economically important than lychee. Despite this importance there is a general lack of published material on the statistics and production of longan.

Under the family Sapindaceae, the genus Dimocarpus is reported to contain six species of trees and shrubs (Leenhouts, 1971, 1973). Five of the species (Dimocarpus longan, Dimocarpus dentatus, Dimocarpus gardneri, Dimocarpus foveolatus, and Dimocarpus fumatus) are found in Asia from Sri Lanka and India to eastern Malaysia; one (Dimocarpus australianus) exists in Queensland, Australia. Among these species, the most commonly cultivated species is Dimocarpus longan where the taxon Dimocarpus longan spp. longan var. longan is commonly known as the commercial longan. The word ‘longan’ or ‘long yan’ or ‘lungngan’ comes from the Chinese and literally means ‘dragon-eye’ which is an apt description of the fruit after the skin has been removed. Other vernacular names for longan include ‘lam-yai’ (Thailand), ‘leng-keng’ (Malaysia and Indonesia), ‘kyet mouk’ (Myanmar), ‘mien’ (Cambodia), ‘lam nhai’, ‘nam nhai’ (Laos), and ‘nhan’ (Vietnam).

Many other scientific names have been given to the longan. These include Nephelium longana (Lam.) Cam. and Euphoria longana Lam. Beside lychee, other related fruits under the Sapindaceae family include the ‘rambutan’ (Nephelium lappaceum) and ‘pulasan’ (Nephelium mutabile).
2. ORIGIN

The origin of longan is disputed. Whereas some authors limit the area of origin of longan to the mountain chain from Myanmar through Southern China, others extend it to southwest India and Sri Lanka, including the lowlands. In China, it has been suggested that the primary centre of origin of longan was Yunnan, and the secondary centres were Guangdong, Guangxi and Hainan provinces (Ke et al., 2000). This was based on studies made on the morphological characteristics of pollens of longan cultivars and their wild species in five zones in China as well as the analysis of botanical geography and evolution.

3. GENETIC DIVERSITY

The species *Dimocarpus longan* contains two subspecies i.e. subspecies *longan* and subspecies *malesianus*, each with several varieties. Within the subspecies *longan*, the most commonly cultivated taxon is *Dimocarpus longan* ssp. *longan* var. *longan*, which is the commercial longan (Figure 1). Three edible longan types can be distinguished within the variety *longan* in Thailand (Subhadrabandhu, 1990). The first type is a large forest tree with small fruits and a very thin aril, possibly of interest for breeding purposes. The second one is the native longan (‘lammay kradook’ or small ‘lammay’), growing in the northern part of the country as an erect tree producing small fruits with large seeds and is recommended as a rootstock for commercial cultivars. The third type is the commercial longan (‘lammay krakoke’) which produces large fruits and small seeds. Beside the variety *longan*, there exist at least three other varieties, viz. variety *longepetiolulatus*, variety *obtusus* and variety *magnifolius*. All three varieties have been found growing wild in China (Huang, 1999).

The other subspecies, that is the subspecies *malesianus*, contain mainly unexploited genetic materials which may have great potential to be developed into commercial fruits in their own right or as breeding materials for the commercial longan. These include variety *malesianus* and variety *echinatus*. While the commercial longan is adapted only to the subtropics and will not flower when grown in the true tropics, the subspecies *malesianus* are fully adapted to the unchanging heat, humidity, daylength and other conditions of the equatorial zone. For example, the subspecies *malesianus* var. *malesianus* are native to Southeast Asia with the greatest variation found in Borneo where it might be possible to distinguish between 30 to 40 local races (Leenhouts, 1971; van Welzen et al., 1988). The diversity of this subspecies in Sarawak in the Borneo island has been documented by Wong and Gan (1992) and Wong (2000). The fruits are globose to slightly oblong and smooth to warty. In Peninsular Malaysia, the most common form of this taxon is the one with globose smooth fruits which turn brown when ripe. This is the true ‘mata kuching’ or ‘cat’s eye’ which has often been identified as *Euphoria malaiensis*. It has a very thin aril and is hardly worth eating. This form also exists in Borneo and Sumatra. The more superior forms are found in Sarawak, all with densely thick warty fruits and greater aril recovery percentage. These forms can be roughly grouped into three types (Figure 2) based on the fruit characteristics: the ‘isau’ with fruits which are globular and remain green when ripe; the ‘sau’ with fruits which are slightly oblong and also remain green when ripe; and the ‘kakus’ with globular fruits which turn brown when ripe. The leaves, flowers and tree forms also differ. The ‘kakus’ is more widespread in
Sarawak, while the ‘isau’ and ‘sau’ are mainly confined to the river banks of the Rajang river and to the Bareo valley.

The variety *echinatus* differs from the variety *malesianus* in that the fruits have rather long spines resembling the ‘rambutan’ (*Nephelium lappaceum*). This variety is found in Sabah where the ‘kakus’ also exists (van Welzen et al., 1988).

Thus the true tropical longan offers the greatest opportunity for selecting superior material and thus offers an attractive possibility of longan becoming a new fruit crop for the humid lowlands throughout the tropics.

4. USES

The longan fruit is normally eaten fresh like that of lychee. It is particularly popular among Asians, particularly the Chinese. There are claims among some people in China and Thailand that the taste of longan equals or is superior to that of lychee. Fresh longan fruit has a short shelf-life. To extend the uses of the fruit the longan can be frozen, canned or dried. Longan fruit can be frozen in its skin in airtight containers. Upon thawing, the fruit can be used in similar manner as freshly picked fruit without any loss of quality. The fruit can be canned in its own juice with little or no added sugar. This is possible because the longan flesh contains a high level of soluble solids. For canning, cultivars with large fruit and small seed are preferably used. Canned longan retain their individual flavour better than lychee or ‘rambutan’. Drying the fruit, either intact or after removal of the pericarp, is a practical way of preserving the longan fruit. The dried aril is black, leathery and smoky in flavour and is used mainly to prepare a refreshing drink. This drink is very popular among the Chinese. A liqueur is made by macerating the longan flesh in alcohol. Dried longan flesh is also an ingredient in herbal medicine used for stomach ache, insomnia and as an antidote for poison.

The seed is used as a shampoo, like soapberries (*Sapindus saponaria* L.), due to its saponin content. Dried leaves, which contain quercetin and quercitrin, and flowers of longan are also sold as ingredients in Chinese herbal medicine.
Figure 1. The commercial longan (*Dimocarpus longan* ssp. *longan* var. *longan*).

Figure 2. Relatives of the commercial longan - *Dimocarpus longan* ssp. *malesianus* var. *malesianus* (from left to right: ‘kakus’, ‘isau’ and ‘sau’).
5. PROPERTIES

The edible portion of export quality fruit ranges from 67 to 78 percent of the whole fruit. The energy value averages 458 kJ/100g. The sugar content is very high. Composition of longan per 100g edible portion is presented in Table 1.

Table 1. Nutritional composition of longan fruit

<table>
<thead>
<tr>
<th>Calorie</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Fibre</th>
<th>Ca</th>
<th>P</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>109.0</td>
<td>72.4</td>
<td>1.0</td>
<td>0.5</td>
<td>25.2</td>
<td>0.4</td>
<td>2.0</td>
<td>6.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vit. A</th>
<th>Vit B1</th>
<th>Vit B2</th>
<th>Niacin</th>
<th>Vit. C</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.0</td>
<td>0.04</td>
<td>0.07</td>
<td>0.6</td>
<td>8.0</td>
</tr>
</tbody>
</table>


6. BOTANICAL DESCRIPTION

The longan is an evergreen tree which can grow up to 20 m and possesses a spreading or erect habit, depending on the cultivars. The brittle trunk and branches have a corky bark which gives a split and peel appearance, unlike those of lychee which are smooth. The compound leaves are alternate and paripinnate with 6 - 9 pairs of leaflets which are dark glossy green on the upper surface and paler green on the lower surface. The young leaf flushes are reddish brown in colour and with maturity turn to light green. Inflorescences are terminal (Figure 3), 8 - 40 cm long, densely tufted-tomentose, leafless and greatly branched (Figure 4). They are borne on new growth produced during mid-summer or autumn, although sometimes they are borne on shoots produced in spring on terminals which have not set panicles. Cymules 3 - 5 flowered and normally only the central flower developed into fruit. Flowers are small and yellowish brown, calyx lobes 2 - 5 mm x 1 - 3 mm; petals 5, 1.5 - 6 mm x 0.6 - 2mm, densely woolly to glabrous.

The flowers of longan within a panicle are made up of staminate (pistil non-functional), pistillate (stamens non-functional) and hermaphrodite flowers. The staminate flower has 8 or less hairy stamens arranged in a single row on a light brown disc. The pistillate flower has anthers which are sterile and non-functional. Hermaphrodite flower contains bicarpellated and densely-hairy ovary with bilobed stigma. Normally, only one carpel develops into fruit. The stamens of the hermaphrodite flower consist of 8 sessile filaments with anthers producing viable pollens.

The longan is a cross-pollinated species. In order to achieve cross-pollination it has duodichogamy, that is, the tree has three stages of flowers, which open directly after each other, with a certain degree of overlapping. Generally within a panicle the first phase in the sequence of opening is the staminate flowers, follow by the pistillate flowers and then the hermaphrodite flowers and finally the staminate flowers again. Male and female phases of flowering overlap 4 - 6 weeks depending on cultivars. Pollination is mainly carried out by insects and is most effective between 08.00 - 14.00 hours. Fruit set per
panicle improves greatly with bloom rating for the tree, leading to a sharp progression in yield per tree (and an obvious risk of biennial bearing). The period from bloom to harvest is 5 - 7 months, depending on cultivars and climate. In Thailand a panicle may carry up to 80 individual fruits which vary in weight from 5 to 20g. The premium commercial grades of longan fruits are in the range of 14 to 18g. The fruit rind is thin but tough and leathery and changes colour from greenish yellow to yellowish brown with advancing maturity. Tubercles are typically flattened or indistinct. However, in related species, the rind tubercles are very distinct. The aril has total soluble solid values ranging from 15 to 25 percent. It is translucent white to off-white and may constitute from 60 to 75 percent of the total fruit weight. Texture of the aril ranges from juicy to very crispy and flavour ranges from bland to sweet and aromatic, but seldom acidic. The seed is small, round to ovoid in shape and glossy reddish brown to black in colour and easily detached from the aril. Only one seed is present in each fruit and in some cultivars there are a certain percentage of small-seeded fruits.

Longan seeds are recalcitrant and, therefore, short-lived and best sown fresh. Germination takes 7 - 10 days. Seedling growth is slow and the juvenile phase lasts about 7 years. Longan trees grown from air layers come into bearing during the third or fourth year and yields tend to increase with tree size over a very long trajectory.

7. ECOLOGY

The commercial longan is a subtropical tree that grows well in the tropics but requires a prominent change of seasons for satisfactory flowering. A short (2-3 months) but cool (mean temperature 15 - 22°C) winter season brings out a prolific bloom; in this respect longan is less demanding and more predictable than lychee. However, longan is sensitive to frost and is likely to be killed or badly injured by prolonged temperatures below freezing. From fruit set onwards high night temperature beyond 25°C is detrimental for fruit development and temperature above 40°C causes fruit damage and fruit drop. In Thailand the best temperatures for flowering and fruit set are 20 - 25°C.

Ample soil moisture is needed from fruit set until maturity. Suitable annual precipitation is about 1,500 mm. Drought during the flowering and fruit set period can reduce fruit productivity. However, excessive rainfall during flowering can result in poor pollination and increase in flower drop, while overcast weather prior to harvest leads to fruit shedding, possibly due to poor production of photosynthate.

Longan is sensitive to wind damage and strong cyclonic winds can cause branch splitting and fruit shedding. Trees in China and Thailand are sometimes mounded after planting and/or branches supported by posts and bamboo pole fences to reduce wind damage, especially when the tree is carrying a heavy crop. The mounds are built up gradually over time around the trunk of the tree to about 1 m high (Menzel et al., 1990).

Longan thrives on rich sandy loams, it does well on oolitic limestone; moderately acid sandy soils are more marginal and on organic muck soils flowering is deficient, probably because shoot growth continues for too long. In Thailand, the soils yielding high
Figure 3. Longan tree with terminal inflorescences.

Figure 4. Terminal, greatly branched and leafless inflorescence of longan.
fruit production are the heavy alluvial soils with access to water table. The roots grow down 2-4 m to the water table. In eastern Australia, the preferred soils for longan growing are heavy, fine textured soils and red loams with high fertility and good water holding capacity. In general wet lowlands or heavy clay soils are best avoided.

8. PROPAGATION

Longan can be propagated from seed, air-layering, budding, grafting, cutting and inarching. Propagation by seed is not advisable since the seedling takes a long time to bear fruit (7-8 years) and the planting material is not true to type. Vegetative propagations are, therefore, recommended means of propagating the planting material. Among the vegetative propagations, air layering (marcottage) is the most popular method and has been widely used for a long time in China, Taiwan Province of China and Thailand. This method yields a high percentage of successful planting material as the marcotted branches produce roots readily. Claims of success rates of 80 to 90 percent with air-layering are very common.

Marcotting is usually carried out during the wet season. A strong healthy branch with matured leaves is chosen. The branch is first girdled or a strip of bark (2 to 2.5 cm wide) is completely removed to the cambium layer. The exposed surface is then scraped to remove the phloem and cambial tissue to prevent premature healing. IBA or any other rooting hormone is usually applied onto the cut surfaces of the cincture (towards the tip of the branch) to encourage rooting. A rootball made up of a suitable medium which holds moisture and is well aerated (e.g. wet peat, sphagnum moss or suitable soil mixture) is then wrapped around the cincture. This is followed by wrapping a polythene film, 20 to 25 cm square, around the rootball making sure that it is completely covered and the two ends of the wrapping are tied securely to prevent water from seeping inside. The marcot is removed after two to four months (Figure 5), when the roots have turned from white to creamy brown. In Thailand, the marcotted branches produce roots in about a month when propagation is carried out during the wet season. Pruning of the rooted marcot to reduce the top in proportion to the roots is usually necessary. The rooted marcot is potted in a suitable container and placed under warm, humid and partially shaded conditions in the nursery to allow the plant to acclimatize prior to planting out in the field. Under normal conditions, the marcotted tree is planted out in the field after 6 to 12 months in the nursery.

Trees obtained by marcottage are more susceptible to wind damage when compared to grafted trees. This is because tap roots are absent in the marcotted trees. To prevent wind damage in the field, the marcotted trees are either supported by permanent bamboo props, by soil mounded around the trunk, or by rooted seedlings planted close by for later inarching.

Beside marcottage, longan can also be propagated by grafting. In China, whip-and-tongue graft has been practiced as far back as the late 1970s. Approach grafting is also carried out using seedlings of the same cultivar as the rootstock. Eight to twelve months old seedlings (commonly cultivar ‘Wuyuan’) are used as rootstocks. They are approach-grafted to a similar sized branch of the scion cultivar. After a union has occurred within 40 - 60 days, the top of the rootstock plant is removed above the graft and the base of the scion plant is removed below the graft. The grafted plant is nursed in a pot or polythene
bag for 2-4 weeks before planting out in the field. Sometimes, double or triple graftings (successive grafting operations on top of the previous graft) are carried out by the Chinese growers as they believe that such graftings can give added strength to the tree and produce larger and sweeter fruit. Currently, propagation by budding (patch budding with a single bud) has become popular and the success rate has been reported to be over 85 percent.

In Thailand, grafting is commonly done in winter when vegetative growth has ceased. One year old longan seedlings which show signs of good growth are chosen as rootstocks. In this respect fast growing longan such as the native longan (or ‘Kradook’) can be used as rootstock. After the grafting operation, the grafted plants are covered by plastic bags to provide a high humidity condition around the graft union. The plants are well watered for about one month before the plastic covers are removed. The newly grafted plants are usually nursed in the nursery for about 2 months before planting out in the field.

Forket budding and cuttings have been found to be successful with longan cultivars introduced into Australia (Menzel et al., 1990).

Work from Thailand and Queensland suggest that some scions/rootstocks are incompatible. In China, graft incompatibility has recently been reported to occur in Guangdong. The rate of incompatibility for cultivar ‘Chuliang’ has attained 36 percent (Liu and Ma, 2000). Researchers recommend grafting a cultivar onto seedlings of the same cultivar. In Australia, grafting is preferred onto seedlings of the same cultivar or at least not Thai cultivars on Chinese rootstocks or vice versa (Menzel et al., 1990).

9. PLANTING

Trees are best planted at the beginning of the wet season. Planting holes of 60 x 60 x 60 cm are dug and allowed to weather for about two weeks prior to planting. If the planting materials are planted in polybags, make sure that the bags are removed at the time of planting. Organic manure and phosphate fertilizer can be incorporated into the soil to be used to fill the planting hole. Compact the soil after planting to ensure that there is firm contact between the root system and the soil mass. The plant should be firmly staked and tied to avoid being blown over by strong wind. Tree spacings range from 6 x 6 m to 12 x 12 m; giving tree densities ranging from 70 to 300 trees/ha. Mature orchards in Thailand have a tree density of 50 trees/ha. In Taiwan Province of China, tree spacings of 4 m to 6 m with a density of 300 to 600 trees/ha are common in mature orchards. Tree densities in Fujian province in China range from 195 to 300 trees/ha with an average of around 270 trees/ha. Under normal spacings, well-grown trees are able to fill their spacing in 6 to 7 years. At the Yehai Litchi Science and Technology Garden in Dongguang, Guangdong province, dwarf ‘Shixia’ longan (through heavy pruning) has been planted under a high density of about 1,500 to 1,800 trees/ha (Figure 6).

In order to spread the workload in a commercial orchard it is essential to plant a range of cultivars having different maturity times in any one orchard.
Figure 5. Marcots which have been removed from a parent tree.
10. HUSBANDRY

In newly established orchards young trees should be grown as vigorously as possible for the first four years to attain the greatest tree size and bearing surface. Vigorous growth is achieved by strategic pruning, proper water and nutrient management and protection from weeds, pests and diseases.

When the trees are mature and ready to bear fruits, appropriate management in regulating vegetative and flowering cycles is required. It is important to know the phenology of each cultivar so that the vegetative, flowering and fruiting patterns for the cultivar can be monitored. For each year the tree should be limited to one or two significant vegetative flushes between harvest and the next flowering. Once flowering commences, there should be minimum flower and fruit shedding. This annual cycle can be achieved by strategic applications of water and fertilizer and appropriate timing of pruning of shoots, flowers and fruit.

In China, researchers have achieved three successive years of high and stable yields in ‘Chulian’ cultivar in Gaozhou, Guangdong province, by effective cultural techniques (Huang et al., 2000). These include:

- Fostering two autumn flushes after harvest so as to form high quality fruiting shoots,
- Integrated measures for manipulation of flushing cycles so as to promote flower retention,
• Prevention of change of reproductive flush to vegetative flush, and thus increasing flowering rate,
• Proper thinning of fruit panicles to obtain good fruit quality, and
• Prevention and control of pests and diseases.

10.1 Pruning

Immature young longan trees (first 3-4 years from planting) are subjected to formative pruning to obtain ‘open’ canopy which allows good light penetration. Only limited numbers of main branches are retained to obtain the desired structure. Surplus branches and all water shoots are removed and the skirt is maintained about 1-2 m above the ground level. In China, one strong branch is retained after every growth flush to form a natural round-shaped crown of 6 to 10 main branches. In Thailand, trees are cut to a 1.2 m trunk and 3-4 vigorous young shoots selected from the regrowth to form the main framework of the tree. These laterals are forced into wide angles from the trunk with the aid of sticks. Two branches are left on each lateral shoot. Similarly, two sub-branches are left on each branch and so on. Finally, the canopy consists of 24-32 sub-branches, which may be achieved in the third or fourth year. Pruning at the immature stage produces well-formed tree canopy, strengthens fruit bearing branches, ensures annual cropping and limits insect pests and diseases. It also reduces the height of the tree to a manageable level. The flower spikes of young trees less than five years of age are normally removed in China and Thailand to encourage growth and crown expansion during summer.

In bearing trees pruning is an essential cultural practice. Harvesting itself is a form of pruning, since the entire panicle is cut. Soon after harvest this should be followed by pruning any remaining panicle or cutting out some of the subtending twigs. Cutting out these twigs completely simplifies the canopy structure and admits more light to the interior of the tree; it also removes twigs that are least likely to fruit next year, since they have fruited this year. If this is not done side shoots emerge below the cuts of the harvested panicles. These shoots make the canopy denser and come too late to initiate inflorescences for the next crop.

Besides pruning, which is carried out during and immediately after fruit harvest, maintenance pruning is also practiced during the period between harvests. This involves pruning water shoots and branches that are dead or infested by pests and diseases. Weak branches, which have lost their vitality, are also pruned. However, too much pruning or removal of too much leaf and wood with the fruit panicles at harvest can reduce flowering the next season and aggravates biennial bearing.

In China, Taiwan Province of China and Thailand, prunings of flower and fruit panicles are usually practiced to overcome alternate bearing phenomenon which is common especially with trees which yield heavily and are older than ten years. Production in an ‘off’ year is usually about 20 to 40 percent of the ‘on’ year (Menzel et al., 1990). In China, pruning of flower panicles involves removal of about 40 percent of the flower spikes when they are about 10 - 12 cm long. For pruning of fruit panicles about 30 percent of the young fruits are removed. The degree of pruning of flower and fruit panicles depends on the crop load and tree vigour.

Thinning of fruit in China not only reduces biennial bearing but also increases fruit size. Only large fruits (2.5 cm in diameter or 18g in weight) attract a premium price.
Fruits are thinned about four to six weeks after fruit set when they are of the size of a pea. Fruit thinning is essential after flower thinning because of the high rate of fruit set and greater competition for developing fruit.

In Thailand, longan growers reduce the number of flowers by half (each flower spike is retained) before fruit set in an ‘on’ year. After fruit set, they remove 10 percent of the fruit.

10.2 Water Management

An ideal annual rainfall regime for good longan production falls between the range of 1,200 - 1,400 mm over 100 - 150 rainy days during the period from panicle emergence to maturation of post-harvest vegetative flush. Any rainfall outside this pattern requires proper water management in the form of irrigation. In Thailand, it is generally accepted that irrigation overrides other factors in determining yields, which are usually higher on trees growing along the rivers. In two of the main longan growing provinces of Chiang Mai and Lamphun, trees are normally irrigated during the first four years of planting. A drip irrigation system is commonly installed in the longan orchard. For bearing trees, irrigation is required from the time of panicle emergence, during flowering, fruit set and fruit development and after harvest until the maturation of the post-harvest growth flush. Irrigation is withdrawn before the next flowering so that the water stress condition allows flower initiation for the next season’s crop. Water management is more easily controlled in dry areas and on light soils with low water holding capacity.

Mulching is recommended to reduce water loss from the soil and increase soil organic matter and structure, reduce extremes of soil temperature and encourage growth of feeder roots. If applied correctly, under-tree mulching also assists weed control (Menzel et al., 1990).

10.3 Fertilization

During the immature stage, a combination of organic and inorganic fertilizers may be used. Organic fertilizer such as animal manure is recommended at the rate of about 10 kg/tree/year, applied about 3-4 times in a year. The organic manure may be supplemented by inorganic fertilizer such as 15:15:15 (N:P₂O₅:K₂O ratio) at the rate of 5-10 kg/tree/year.

Fertilizing bearing trees is directed at manipulating the crop cycle, especially towards promoting panicle growth, fruiting and vegetative flushing after cropping. The recommended fertilizer schedule for longan production in Thailand is as follows:

- The first application is carried out at two weeks after harvesting to encourage new growth flush. Inorganic fertilizer of 20:10:10 ratio is applied at the rate of 1 kg per tree together with organic manure at 6-10 kg per tree. Calcium nitrate may be added as a supplementary fertilizer.

- The second application is applied when the panicle is about 5 cm long. The recommended inorganic fertilizer is 16:11:14 or 15:15:15 ratio at the rate of 1 kg per tree. This is to help in fruit setting.
• The third application is done at 2 weeks after fruit set by repeating the second application. This is to help in fruit development.

• The final application is done at the seed colouration stage by applying inorganic fertilizer of 14:14:21 ratio at the rate of 2 - 3 kg per tree.

The inorganic fertilizer is applied by making a small trench of 20 - 30 cm around the canopy and applying the fertilizer in the trench which is then covered with soil to be followed by watering.

In China, fertilizers are applied to bearing trees at a frequency of five to six times a year (Liu and Ma, 2000). Application of fertilizer at N:P:K ratios of 1:0.5:1 or 1:1:4 has been reported to increase yield significantly.

In Taiwan Province of China, fertilizer is recommended to be applied three rounds per year for immature trees while only one round per year is applied for bearing tree, particularly after flower bud formation.

In Australia, fertilizer is recommended to be applied four times during the crop cycle: (i) panicle emergence in July to August (Southern Queensland), (ii) one month before fruit set in September to October, (iii) one month after fruit set in December to January, and (iv) two weeks after harvest in March to April. These times will be one to two months earlier in north Queensland. Suggested rates which have proved reliable for well grown high yielding five year old trees under southern Queensland conditions are 625g N, 150g P and 800g K increasing by 20 to 30 percent per year to 1,250g N, 300g P and 1,600g K at year ten. Micronutrients, including zinc, boron, iron and copper, are also applied every two to three years (Menzel et al., 1990)

10.4 Cincturing

It was reported in Thailand that cincturing (of branches and stem) can induce dormancy and give rise to better flowering, fruiting and production. However results have been too inconsistent to justify the recommendation for commercial application. The easy to flower cultivar ‘Phetsakon’ can be induced to produce early and uniform flowering by cincturing of branches or stems (Subhadrabandhu and Yapwattanaphun, 2000a). The cincturing knife used for lychee can be used for longan (Figure 7).
10.5 Regulation of flowering for off-season production

The technique of producing off-season longan has been practiced by Thai growers (Subhadrabandhu and Yapwattanaphun, 2000b). Under normal conditions, the commercial longan will require a period of cool and dry climatic conditions for induction of flowering. The Thai longan growers, however, have discovered an alternative method of floral induction in the absence of suitable climatic conditions. This is by the use of potassium chlorate which is applied to produce off-season longan. With off-season production the growers are able to obtain a better price for their product. There are many methods of applying potassium chlorate to induce flowering in longan. Many Thai growers apply the chemical as a soil drench and the rate of application is dependent on the tree size. Other factors which need to be taken into consideration are soil type, availability of water supply, the general health of the tree and the management of the orchard. Trees grown on a sandy soil respond better to potassium chlorate than those on a heavy soil type. Watering is essential in an area with a long dry spell, and the tree must be healthy and dormant in vegetative growth at the time of chemical application. Different cultivars are found to require different rates of potassium chlorate for induction of 100 percent of flowering. Cultivar ‘Daw’ requires 8g/m² while ‘Chompoo’ needs 1 - 4g/m² of potassium chlorate as soil drench. The suitable time for good flower induction by potassium chlorate is from October to February where the average temperature is rather cool with relatively dry condition. Besides soil drenching, the chemical can also be applied as a foliar spray at about 1,000ppm or as trunk injection at 0.25g per 1 cm diameter of stem size less than 10-15 cm in diameter. Sodium chlorate may be able to substitute potassium chlorate for the induction of flowering in longan.

The combination of potassium chlorate application and use of easy to flower cultivars such as ‘Phetsakon’ has led to the expansion of longan growing areas in
Thailand. These include the central, warm tropical region and also the eastern provinces such as Chanthaburi and Trat where early cultivars are been grown.

10.6 Use of growth promoting substances

Growth promoting substance such as ethephon when used as a foliar spray has been reported to be beneficial for floral initiation and inflorescence development (Qiu et al., 2000). A single foliar spray with 400 µL/L ethephon on ‘Shixia’ longan cultivar was found to increase cytokinin, ABA and cytokinin/gibberellins (GA$_{1+3}$) ratio in the flower buds, while inhibiting gibberellins activity. The increase in cytokinin level led to the promotion of flower differentiation and morphogenesis. The higher level of ABA exerted a positive effect on bud dormancy and morphogenesis. Also, higher cytokinin/ GA$_{1+3}$ ratio favoured flower initiation during the period of floral initiation and inflorescence development. In addition, higher starch content in the ethephon-sprayed trees seems to be beneficial for floral initiation and inflorescence development.

10.7 Pests and Diseases

Numerous pests are found on longan. Of particular importance is the longan stink bug (Tessaratoma javanica) which can ruin bloom in a year with light flowering. The adult bug feeds on flower panicles, young fruits and newly developed shoots of longan, causing withering and later abscission of those infested organs. The infested fruit ceases to develop. In Thailand, this stink bug can be of epidemic level during March to April, which coincides with the flowering and fruit setting times of longan. The suggested control is to get rid of the eggs as well as the adults. The bugs usually mate in February, thus it is recommended that the tree be sprayed at that time with insecticide such as azodrine at the rate of 10 - 20g chemical diluted in 20 litres of water at about 2 - 3 weeks intervals from February to April. At the same time the population of the bug’s natural enemies in the orchard should be maintained at a satisfactory level. The natural predators of this stink bug are identified as Anastatus sp., Micropanurus sp. and Eupelmid sp.

Other insect pests found on longan include Erinose mite, scales, fruit flies, aphids, stem borers, leaf eating caterpillars, flower eating caterpillars, mealy bug, fruit spotting bug, elephant beetles and fruit piercing moth.

Of particular importance is fruit bats or flying foxes, which can devour the longan fruits during fruiting seasons. This pest has been reported to cause serious damage in Thailand and Australia. The only effective means of reducing damage is to erect a protective net around the perimeter of the orchard or over each tree (Figures 8 and 9). However, this method can be very expensive. Alternatively, a draconian control method is electrocution by a high screen of thin, parallel electric wires in the orchard.

A serious disease in longan is the rosette shoot or witches’ broom. The latest report from China indicated that the disease is caused by a filamentous virus which is transmitted by vectors such as litchi stink bug (Tessaratoma papillosa) and longan psylla (Cornegenapsylla sinica). It is also transmitted through infected seeds and budwoods of longan and dodder weeds (Cuscuta campestris) (Chen et al., 2000). In Guangdong province a new species of gall mites (Eriophes dimocarpi Kung) has also been included as a vector for the transmission of the virus (He et al., 2000). Affected trees show abnormal growth with distorted mature leaves and unexpanded young leaves while the shoots on
infected branches become compact clusters. Flowers are poorly developed and the deformed inflorescence lose all flowers on an infected branch (the flowerless panicle resembles a broom).

The earliest description of this disease in China was in 1941. In 17 cities of Fujian province, the percentage of trees infested by witches’ broom varies from 20 to 100 percent, the higher infestation occurs in mature trees. The disease causes an average crop loss of 10-20 percent. However, in severe cases, the loss can exceed 50 percent. This disease also occurs in other provinces such as Guangdong, Guangxi, and Hainan. Beside China other longan growing countries in Asia have also reported the presence of this disease, for example, Thailand and Taiwan Province of China.

Figure 8. Prevention from birds and bats using netting over individual tree (from: Nicholls, 2000).
Figure 9. Prevention from birds and bats using netting around perimeter of orchard in Queensland, Australia (from: Nicholls, 2000).

No cure is known for witches' broom disease. However, there are cultivars which have been reported to be free from this disease. In Thailand, the cultivar ‘Daw’ has been reported to be free from this disease (Subhadrabandhu and Yapwattanaphun, 2000a). In China, cultivars such as ‘Lidongben’ and ‘Shuinan No.1’ in Fujian province are highly resistant to the disease. Chen et al. (2000) suggested that top grafting with scions of resistant cultivars can effectively reduced the morbidity of the disease in severely infested orchards. They have outlined an integrated management programme against the disease, viz., strict quarantine inspection; selection and use of disease-resistant cultivars; establishment of virus-free nurseries; timely control of insect vectors; removal of infected branches, inflorescence and infected seedlings in the nurseries and orchards; and improving tree vigour by judicious fertilization, irrigation and soil management. Shoot tip culture has been successfully employed to produce virus-free plantlets of longan (Wang, 2000).
11. HARVESTING

11.1 Production seasons and Productivity

Flowering of longans is quite early in Thailand compared to those grown in other countries like China, Taiwan Province of China and Queensland (Table 2). In Thailand, flowering commences in late December to late February, while in China and Taiwan Province of China longan flowers from late February to early April. In the Southern Hemisphere such as in Queensland flowering commences in August to October and October to November, depending on location. Harvest in Thailand is from late June to late August whereas harvest in China is from late July to late September. In Queensland longan can be harvested from mid-January to mid-March and late February to early April, depending on location.
Table 2. Flowering and harvesting seasons of longan-growing locations

<table>
<thead>
<tr>
<th>Country</th>
<th>Flowering Season</th>
<th>Harvesting Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Late December - Late February</td>
<td>Late June - Late August</td>
</tr>
<tr>
<td>China</td>
<td>Late February - Early April</td>
<td>Late July - Late September</td>
</tr>
<tr>
<td>Taiwan Province of China</td>
<td>February - April</td>
<td>July - October</td>
</tr>
<tr>
<td>Australia</td>
<td>August - October (North Queensland)</td>
<td>Mid-January to Mid-March</td>
</tr>
<tr>
<td></td>
<td>October - November (Southeast Queensland)</td>
<td>Late February to Early April</td>
</tr>
</tbody>
</table>

In Thailand the marcotted longan tree starts bearing in the fourth year after planting. The yield in the fifth year is about 2 - 5 kg per tree, and this yield increases to 20 kg per tree in the seventh year. In the tenth year, the yield is 60 kg per tree and this increases to about 100 - 190 kg per tree in the fifteenth season. After fifteen years, the yield is in the range of 150 - 200 kg per tree and this figure will last for the next ten years. The yield starts to decline when the tree is over thirty five years old. However, there is considerable variation in yield from year to year and biennial bearing occurs in most cultivars. For mature trees of 12 to 15 years of age, the yield averages one poor crop, one fair crop and one excellent crop over three years. Small fruited, inferior types are reputed to bear more heavily (300 - 400 kg) and consistently.

In term of productivity on a per hectare basis, yield ranges from a high of 7,325 kg/ha/year (1990) to a low of 2,512 kg/ha/year (1989). The productivity varies from year to year and the biennial bearing phenomenon is clearly seen in these yields (Table 3). For example, 1989, 1991, 1993 and 1995 were ‘off’ years when productivity was low. These are alternated with ‘on’ years such as 1990, 1992, 1994 and 1996 when productivity was high.

Table 3. Productivity of longan as affected by years of production in Thailand

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha/yr)</td>
<td>2,512</td>
<td>7,325</td>
<td>3,756</td>
<td>6,137</td>
<td>3,375</td>
<td>6,269</td>
<td>4,137</td>
<td>6,175</td>
<td>5,500</td>
<td>5,730</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

Beside variations in productivity due to the biennial bearing phenomenon, different locations also resulted in variations in yields. Among the three provinces which produced about 70 percent of longan in Thailand, yield for 1993 was lowest in Lamphun (3,712 kg/ha/year) followed by Chiang Rai (5,194 kg/ha/year) and highest in Chiang Mai (6,837 kg/ha/year) (Table 4).
Table 4. Productivity of longan as affected by locations in Thailand (1993)

<table>
<thead>
<tr>
<th>Province</th>
<th>Lamphun</th>
<th>Chiang Mai</th>
<th>Chiang Rai</th>
<th>Nan</th>
<th>Phra Yao</th>
<th>Lampang</th>
<th>Phrae</th>
<th>Chanthaburi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha/yr)</td>
<td>3,712</td>
<td>6,837</td>
<td>5,194</td>
<td>8,400</td>
<td>4,512</td>
<td>6,287</td>
<td>3,006</td>
<td>2,625</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

In China, the average yield is 36 kg per tree in Fujian province and 18 kg per tree in Guangdong. Productivity of longan in China is, therefore, far inferior than that of Thailand. The low productivity of longan in China may be attributed to several factors. Among these are:

- Inferior longan cultivars, although Thai material was originally derived from China,
- Greater emphasis is placed on lychee production over longan production, and
- Longan is grown on poor sites with shallow soils in hillsides and foothills, with no irrigation and little or no pest management; this is true for longan in Guangdong.

The low productivity of longan in China is also reflected on the yield per hectare basis. In Guangdong, the yields range from a high production of 2,506 kg/ha/year (1987) to a low production of 1,004 kg/ha/year (1995) (Table 16). Similarly in Fujian the yields range from 1,650 kg/ha/year (1987) to 1,023 kg/ha/year (1993). Yield figures are generally much lower in the province of Guangxi when compared to those in Guangdong and Fujian provinces. As in Thailand, the annual productivity per hectare varies from year to year as well as from province to province (Table 5).

Table 5. Productivity of longan as affected by years and locations in China

<table>
<thead>
<tr>
<th>Province</th>
<th>GUANGXI</th>
<th>GUANGDONG</th>
<th>FUJIAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha/yr)</td>
<td>2,435 1,385 923 751 978 634</td>
<td>2,506 1,758 1,364 1,429 1,004 1,043</td>
<td>1,650 1,700 1,559 1,023 1,301 1,160</td>
</tr>
</tbody>
</table>

Source: Liu and Ma (2000).

In Taiwan Province of China, the average yield per tree varies with years of production. In an ‘off’ year, the production per tree per year can be as low as 14 kg/plant/year and in an ‘on’ year it can be a high of 36 kg/plant/year (Table 6). This
productivity on a per plant basis is comparable to that of China but far inferior to that of Thailand.

Productivity on a per hectare basis ranges from a high of 12,701 kg/ha/year (1995) to a low of 4,506 kg/ha/year (1996) (Table 6). These figures are far superior to those in China and comparable, if not much higher, than those in Thailand. Since the productivity on a per plant basis is comparatively low, the higher production on a per hectare basis can be explained by the higher tree density in Taiwan Province of China. Tree densities of 300 to 600 trees per hectare are found in Taiwan Province of China compared to the lower figures of 195-300 in China and about 50 in Thailand. Alternate bearing phenomenon is very clearly seen in the productivity figures in Taiwan Province of China. The ‘off’ years (1994, 1996 and 1998) alternate with the ‘on’ years (1995 and 1997).

Table 6. Productivity of longan as affected by years in Taiwan Province of China

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha/year)</td>
<td>9,284</td>
<td>12,701</td>
<td>4,506</td>
<td>11,058</td>
<td>4,637</td>
</tr>
<tr>
<td>Yield (kg/plant/year)</td>
<td>26</td>
<td>36</td>
<td>14</td>
<td>32</td>
<td>14</td>
</tr>
</tbody>
</table>


Crops in Florida from trees 6 m tall and broad, have varied from light (22.5-45 kg) to medium (68-113) and heavy (135-225 kg). The variation is largely due to alternate bearing.

Yields of 40-50 kg per tree have been obtained for six to eight years old trees in Australia.

11.2 Picking of fruits

Longan takes about 5 months from blooming to harvest. The fruits are non-climacteric and have to be harvested when ripe. Maturity is determined by fruit shape, skin colour and taste. Immature fruits are tasteless. The mature longan fruit has a dark, smooth skin, the inside of which is netted and tastes sweet. Longan trees should be picked twice at an interval of 7 - 10 days. Most cultivars lose flavour if harvesting is delayed, when fruits are mature. The whole panicle of fruits with one or two leaves is cut with a knife or scissors. Removal of too much leaves and wood with the fruit panicles at harvest reduces flowering in the next season. Panicles should not be dropped. They are sorted for size, insect damage and skin blemishes and bunched in a bulk tray. In Thailand, longan fruits with stalk intact (about 21 - 22 kg) are packed in 35 cm x 50 cm round woven bamboo baskets lined with longan leaves. Stalked fruits are reputed to remain fresher than separated fruits after harvest. Fruit for export, often detached from the panicles, may be packed in corrugated boxes or plastic baskets. It is recommended that fruit should not be picked during rainy weather as this increases the risk of breakdown after harvest.
11.3 Grading

The Thai farmers have established grading of longan fruits into Grades A, B and C. The Grade A fruits consist of 55-75 fruits per kg (14-18g per fruit), Grade B consists of 76-80 fruits per kg (12.5-13.2g per fruit) and Grade C consists of more than 80 fruits per kg which encompasses most small-fruited seedling types (Subhadrabandhu, 1990).

11.4 Post-harvest handling

Because of the high sugar content, longan fruit has a short shelf-life. Under ambient temperature (25°-31°C) harvested longan fruit rind turns brown within 3 - 4 days, and the aril turns rotten within a week and loses its commercial value. An extended few days of keeping is possible when temperature is lowered to 18°C. Prior to storage longan fruit can be subjected to hydrocooling or forced air cooling which can lead to longer storage duration when combined with low storage temperature. To prevent fungal growth on the fruit surface during storage, the fruit can be fumigated with sulphur dioxide. Short term sulphur dioxide fumigation combined with low storage temperature is currently considered to be the ideal and practical method of storage of longan fruit. Fumigation of sulphur dioxide for 20 minutes and storing the ‘Shixia’ longan fruits at 4°C produced 100 percent of good fruits after 28 days of storage without chilling injury (Han et al., 2000). However, improper handling can cause high sulphur dioxide residue and reduce the flavour of the aril. Sulphur dioxide fumigation can affect both the external as well as the internal qualities of the longan fruit.

In a study on the shelf-life of cold-stored longan fruits, Lin et al., (2000) reported that longan fruits which have been fumigated with sulphur dioxide and then packed in polychloroethylene (PE) film (0.03 mm thick) bags and stored at 3°C for 46 days are able to retain the original skin colour and aril eating quality when moved out of cold storage to room temperature for as long as 78 hours. When the fruits were moved out of cold storage an oxidation retardant was added to them.

Sulphur dioxide injury to the rind depends on the application concentration and the fumigation period (Tongdee, 1992). Injury to the rind occurs at intermediate concentrations. There is an important balance between the amount of sulphur dioxide applied, the sorption of the fruit and the residual sulphur dioxide detected on the fruits.

Recent studies showed that modified atmosphere storage (50 percent air + 50 percent nitrogen) of longan fruits treated with antifungal agent resulted in a 92.3 percent marketable fruit ratio and high percentage of nutrient composition in fruits stored at 24° - 26°C for seven days (Liu and Ma, 2000).

11.5 Processing of longan

Due to the short shelf-life of fresh longan fruits, their uses can be extended by processing them into various products. In Thailand, the longan fruits have been processed into canned longan, dried ‘longan nuts’, longan nectar and frozen longan (Subhadrabandhu, 1990). There are substantial canning factories for longan in Thailand, China and Taiwan Province of China. Large fruits are generally used for canning. The cultivars ‘Biew Khiew’ and ‘Daw’ are preferred for this purpose in Thailand. Due to the high brix content, little sugar additive is required as the fruits are canned in their own
juice. It is believed that canned longan retained their individual flavour better than ‘rambutan’ and lychee.

Subhadrabandhu (1990) has described in detail the processing of longan into dried fruits in Thailand. According to him longan fruits are dried either intact or with pericarp removed. Small and medium fruits are used for drying. The process of drying longan fruits can be done by boiling the fruit for five minutes, followed by sun or oven drying at 55°C. When the fruits start to dry the temperature is raised to 70°C until they are completely dried. The total drying period is 19-20 hours. Dried intact fruits can retain better their flavour and aroma when compared to fruits which have been dried without the pericarp. The dried longan fruits contain moisture of about 18-19 percent and have very high sugar content of 60-65° brix.

12. PRICING OF LONGAN

The farm gate price of longan is often influenced by the production. During the ‘on’ years when production is good, the price obtained by the farmers is usually low. The reverse is true when production is low during the ‘off’ years. This trend is clearly seen in Thailand (Table 7) and Taiwan Province of China (Table 8).

Table 7. Production and Average farm-gate price of longan in Thailand
(25 Baht = 1 US dollar)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (metric ton)</th>
<th>Average Price (Baht/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>44,661</td>
<td>28.00</td>
</tr>
<tr>
<td>1990</td>
<td>145,869</td>
<td>7.46</td>
</tr>
<tr>
<td>1991</td>
<td>81,842</td>
<td>25.63</td>
</tr>
<tr>
<td>1992</td>
<td>145,047</td>
<td>22.86</td>
</tr>
<tr>
<td>1993</td>
<td>92,742</td>
<td>11.49</td>
</tr>
<tr>
<td>1994</td>
<td>193,079</td>
<td>7.72</td>
</tr>
<tr>
<td>1995</td>
<td>143,592</td>
<td>18.87</td>
</tr>
<tr>
<td>1996</td>
<td>236,426</td>
<td>16.17</td>
</tr>
<tr>
<td>1997</td>
<td>227,979</td>
<td>23.90</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).
Table 8. Production and Average farm-gate price of longan in Taiwan Province of China

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (metric ton)</th>
<th>Average price (N.T.$/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>109,460</td>
<td>34.48</td>
</tr>
<tr>
<td>1995</td>
<td>151,388</td>
<td>17.34</td>
</tr>
<tr>
<td>1996</td>
<td>53,215</td>
<td>74.40</td>
</tr>
<tr>
<td>1997</td>
<td>130,495</td>
<td>25.34</td>
</tr>
<tr>
<td>1998</td>
<td>53,385</td>
<td>64.00</td>
</tr>
</tbody>
</table>


13. BREEDING AND BIOTECHNOLOGY RESEARCH

Seedling progenies are extremely variable and small fruit size appears to be a dominant characteristic. Therefore, through the centuries improved cultivars have resulted merely from selection amongst existing cultivars or selections amongst open-pollinated seedlings from such cultivars. Selection is based particularly on large fruit size, high edible portion, crisp flesh, good flavour and high sugar content. In so doing, heavy and regular yields appear to have been sacrificed. Future selection has to include marketing characteristics, such as early or late harvest, a long shelf-life and a pure white aril for the canned product.

In Fujian province, China, a selection programme was initiated over 30 years ago to select abort-seeded longan cultivars. Five promising strains with abort-seeded fruits, namely, ‘Minjiao No.1’, ‘Minjiao No.2’, ‘Minjiao No.3’, ‘Minjiao No.4’ and ‘Minjiao No.5’ have been successfully selected (Huang et al., 2000) (Figure 11). Among them ‘Minjiao No.4’ is the most promising due to its stable and higher rate of seed abortion, large fruit size, thick and good quality aril, and high yield.

For germplasm collections, various programmes have been established in longan growing centres worldwide. The national longan germplasm repository of China was established in the Fujian Academy of Agricultural Sciences in 1981 and so far 202 cultivars have been collected and preserved. There are also collections of longan in Fujian, Guangdong and Taiwan Province of China. Collections of accessions are also reported in Hawaii, Florida, Australia, Indonesia, Israel and Thailand.
In China, biotechnology research has achieved great progress in terms of its contribution to longan production, especially genetic improvement through modern high technology (Lai et al., 2000). Some of the biotechnology research includes tissue and organ culture, i.e., studies on plant regeneration obtained from explants such as cotyledons, immature embryos, anthers, leaves of bearing trees, stem apices and stem axes. Plant regeneration has been successfully carried out via somatic embryogenesis from calli derived from the cotyledon of an immature embryo. A breakthrough was achieved in the induction and long-term maintenance of friable embryogenic calli, and somatic embryogenesis at high frequency. Single cell cloning technology and a highly effective protoplast regeneration system have been established from embryogenic suspension cell lines by isolating single cells and protoplasts. Agrobacterium-mediated genetic transformation has been established and transgenic plantlets of longan have been obtained (Zeng et al., 2000). Culture of shoot tips and shoot segments has been successfully carried out to obtain virus-free plantlets for overcoming witches’ broom disease.
14. CURRENT WORLD STATUS, DISTRIBUTION AND TRADE

Longan is normally grown in regions with subtropical climate where a short (2-3 months) but cool (mean temperatures 15-22°C) winter season is necessary for floral induction. As such, the longan thrives well in southern and southwestern China, northern Thailand and central and southern Taiwan Province of China. Elsewhere the longan has been grown on a smaller scale such as in Vietnam and other Southeast Asian countries as well as in Queensland (Australia) and Florida (United States). With the recent introduction of longan cultivars suited for true tropical conditions, longan growing has been extended to other parts of the countries, particularly the tropical lowlands. Currently only China, Thailand and Taiwan Province of China have exploited the commercial growing of the longan, although Vietnam has recently started exporting longan to other countries.

**China**

China has a history of over 2,000 years of longan cultivation. The total cultivated area in China in 1997 reached 432,400 ha with a production of 232,000 metric tons (Liu and Ma, 2000). Longan growing provinces in China include Guangdong, Guangxi, Fujian, Sichuan, Yunnan and Hainan, with the first three provinces dominating longan production. Inspite of her own production, China is a net importer of longan.

**Thailand**

Thailand is currently the biggest exporter of longan in the world. Total planted area in 1998 was 41,504 ha with a production of 238,000 metric tons (Subhadrabandhu and Yapwattanaphun, 2000a). Longan production is concentrated in the upper northern provinces with cultivation recently extended to eastern and central regions. Major longan growing provinces include Lamphun, Chiang Mai, Chiang Rai, Nan, Phra Yao, Lampang, Phrae and Chanthaburi.

Longan has contributed more towards Thailand’s economy when compared to lychee. About 50 percent of the total production were exported in 1997 (Table 9). This compares favourably to lychee where less than 10 percent of the country’s production was exported. Longan is not facing the strong competition which lychee is experiencing in international markets from producers such as China, Taiwan Province of China, India and Australia (Subhadrabandhu and Yapwattanaphun, 2000a). In 1997, a total of 135,923 metric tons of longan with a value of US$ 201 million were exported from Thailand in the forms of fresh, dried, frozen and canned fruits. The two years of 1996 and 1997 saw a 2-3 fold increase in the export of longan when compared to 1993 and 1995.
### Table 9. Export of longan from Thailand

<table>
<thead>
<tr>
<th>Year</th>
<th>Fresh</th>
<th>Dried</th>
<th>Frozen</th>
<th>Canned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount (metric ton)</td>
<td>Value (US $1,000)</td>
<td>Amount (metric ton)</td>
<td>Value (US $1,000)</td>
</tr>
<tr>
<td>1989</td>
<td>3,205</td>
<td>2,850</td>
<td>154</td>
<td>1,110</td>
</tr>
<tr>
<td>1990</td>
<td>14,355</td>
<td>8,440</td>
<td>837</td>
<td>3,240</td>
</tr>
<tr>
<td>1991</td>
<td>7,618</td>
<td>6,500</td>
<td>780</td>
<td>4,210</td>
</tr>
<tr>
<td>1992</td>
<td>12,811</td>
<td>11,910</td>
<td>724</td>
<td>4,710</td>
</tr>
<tr>
<td>1993</td>
<td>21,310</td>
<td>15,920</td>
<td>879</td>
<td>3,840</td>
</tr>
<tr>
<td>1994</td>
<td>32,628</td>
<td>30,260</td>
<td>3,335</td>
<td>9,930</td>
</tr>
<tr>
<td>1995</td>
<td>31,719</td>
<td>35,280</td>
<td>7,820</td>
<td>160</td>
</tr>
<tr>
<td>1996</td>
<td>61,053</td>
<td>51,450</td>
<td>41,840</td>
<td>231</td>
</tr>
<tr>
<td>1997</td>
<td>81,632</td>
<td>84,790</td>
<td>39,710</td>
<td>241</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

Countries which import fresh longan from Thailand are shown in Table 10. It can be seen that the demand for longan is ethnically biased as these countries have a Chinese population. Hong Kong has been a major market for fresh longan from Thailand and in 1997, the export value of longan into Hong Kong amounted to about US$ 64 million. Other countries importing substantial amounts of fresh longan from Thailand included Malaysia, Indonesia, Canada and Singapore. Some fresh longan has also been exported to China.

### Table 10. Amount and value of fresh longan exported from Thailand to different countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount (metric ton)</td>
<td>Value (US $1,000)</td>
<td>Amount (metric ton)</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>22,714</td>
<td>24,110</td>
<td>48,774</td>
</tr>
<tr>
<td>Indonesia</td>
<td>3,075</td>
<td>3,120</td>
<td>4,539</td>
</tr>
<tr>
<td>Singapore</td>
<td>2,620</td>
<td>2,510</td>
<td>2,236</td>
</tr>
<tr>
<td>Canada</td>
<td>1,309</td>
<td>2,390</td>
<td>1,550</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1,357</td>
<td>2,340</td>
<td>2,830</td>
</tr>
<tr>
<td>China</td>
<td>283</td>
<td>400</td>
<td>453</td>
</tr>
<tr>
<td>UK</td>
<td>93</td>
<td>120</td>
<td>77</td>
</tr>
<tr>
<td>France</td>
<td>57</td>
<td>80</td>
<td>96</td>
</tr>
<tr>
<td>Others</td>
<td>211</td>
<td>220</td>
<td>498</td>
</tr>
<tr>
<td>Total</td>
<td>31,719</td>
<td>35,280</td>
<td>61,053</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).
Beside fresh longan, Thailand is also exporting substantial amounts of dried longan. The total value of dried longan export in 1997 amounted to about US$ 86 million. There has been an increasing trend in the export of dried longan from Thailand in past years (Table 11). Dried longan is consumed mainly by the Chinese and this is attested to by the enormous import of the product by China and Hong Kong.

Table 11. Amount and value of dried longan exported from Thailand to different countries

<table>
<thead>
<tr>
<th>Country</th>
<th>1995 Amount (metric ton)</th>
<th>1995 Value (US $1,000)</th>
<th>1996 Amount (metric ton)</th>
<th>1996 Value (US $1,000)</th>
<th>1997 Amount (metric ton)</th>
<th>1997 Value (US $1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,764</td>
<td>2,340</td>
<td>9,279</td>
<td>9,320</td>
<td>15,508</td>
<td>32,600</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>327</td>
<td>1,330</td>
<td>16,426</td>
<td>28,790</td>
<td>20,924</td>
<td>45,610</td>
</tr>
<tr>
<td>Singapore</td>
<td>159</td>
<td>1,270</td>
<td>140</td>
<td>1,050</td>
<td>221</td>
<td>2,000</td>
</tr>
<tr>
<td>Korea</td>
<td>138</td>
<td>720</td>
<td>31</td>
<td>140</td>
<td>316</td>
<td>1,670</td>
</tr>
<tr>
<td>Malaysia</td>
<td>78</td>
<td>350</td>
<td>54</td>
<td>210</td>
<td>96</td>
<td>450</td>
</tr>
<tr>
<td>UK</td>
<td>23</td>
<td>260</td>
<td>40</td>
<td>270</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Canada</td>
<td>24</td>
<td>90</td>
<td>7</td>
<td>80</td>
<td>13</td>
<td>190</td>
</tr>
<tr>
<td>France</td>
<td>8</td>
<td>60</td>
<td>3</td>
<td>30</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Others</td>
<td>1,139</td>
<td>1,350</td>
<td>870</td>
<td>1,900</td>
<td>9,904</td>
<td>3,050</td>
</tr>
<tr>
<td>Total</td>
<td>3,655</td>
<td>7,770</td>
<td>26,850</td>
<td>41,790</td>
<td>38,075</td>
<td>85,670</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

Taiwan Province of China

Taiwan Province of China had a total planted area of 12,015 ha in 1997 and 11,808 ha in 1998 with production of 130,500 and 53,385 metric tons, respectively. Production areas are mainly in the central and southern regions of the country. Taiwan Province of China exports longan mainly in the form of dried, preserved and canned fruits (Table 12). Of these, dried fruit constitutes the major form of export. Total export value of longan from Taiwan Province of China in 1997 was about US$ 2.8 million and in 1998 it was about US$ 1.3 million. Fluctuation of export is a reflection of the biennial bearing habit of the longan crop. Hong Kong, USA and Singapore are major importers of dried longan from Taiwan Province of China (Table 13).

Table 12. Exports of Longan from Taiwan Province of China

<table>
<thead>
<tr>
<th>Year</th>
<th>Dried longan</th>
<th>Preserved longan</th>
<th>Canned longan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity (metric ton)</td>
<td>Value (US $1,000)</td>
<td>Quantity (metric ton)</td>
</tr>
<tr>
<td>1994</td>
<td>588</td>
<td>1,723</td>
<td>8</td>
</tr>
<tr>
<td>1995</td>
<td>3,545</td>
<td>5,054</td>
<td>90</td>
</tr>
<tr>
<td>1996</td>
<td>386</td>
<td>607</td>
<td>17</td>
</tr>
<tr>
<td>1997</td>
<td>1,368</td>
<td>2,546</td>
<td>56</td>
</tr>
<tr>
<td>1998</td>
<td>857</td>
<td>1,104</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 13. Amount and value to longan export from Taiwan Province of China to various countries (1998)

<table>
<thead>
<tr>
<th>Country</th>
<th>Dried longan</th>
<th>Preserved longan</th>
<th>Canned longan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity (metric ton)</td>
<td>Value (US $1000)</td>
<td>Quantity (metric ton)</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>815</td>
<td>818</td>
<td>0</td>
</tr>
<tr>
<td>USA</td>
<td>11</td>
<td>124</td>
<td>5</td>
</tr>
<tr>
<td>Singapore</td>
<td>22</td>
<td>112</td>
<td>9</td>
</tr>
<tr>
<td>Japan</td>
<td>3</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>


**Vietnam**

Vietnam grows longan mainly in the Mekong delta, with smaller areas in southeast and northern regions. Total planted area was 33,914 ha in 1998 and 41,600 ha in 1999 with production of 320,000 and 365,000 metric tons, respectively (Nguyen, 2000). About 10 percent of longan production were exported mainly to China in the form of fresh and dried fruits.

**Australia**

Longan was originally introduced to north Queensland by Chinese miners. During the last 10 years the yield and quality of 28 cultivars introduced from China (13), Taiwan Province of China (2), Thailand (5), Florida (4), Hawaii (3) and local selection (1) have been under evaluation at the Atherton Tableland and in southern Queensland (Chacko and Downton, 1995). Total planted area in 1995 was estimated to be 200 ha. Over the last five years about 72,000 trees have been planted (Singh et al., 2000) using such cultivars as ‘Kohala’, ‘Biew Khiew’, ‘Chompoo,’ ‘Haew,’ ‘Dang’, ‘Kay Sweeney’, and ‘Fuhko2’ (Chacko and Downton, 1995; Sing et al., 2000). Current production of longan is between 300 to 1,000 metric tons of fruit each season.

**Florida**

The current planted area of longan is between 140 to 180 ha in Southern Florida (Campbell and Campbell, 2000). Germplasm introduction began on a significant scale with the importation of seeds from China in the 1940s. These seedling trees have never attained any commercial success due to their small fruit size, unreliable bearing and poor propagation success by air-layering. Due to the market demand for large fruit size, the cultivar ‘Kohala’ tops the list of desirable fruit types. Introduced by William F. Whitman in 1954 from Hawaii the ‘Kohala’ is also reliable in its bearing and can be easily propagated by air-layering. Other cultivars currently under testing include ‘Biew Khiew’ and ‘Diamond River’. Longan produced in Florida is mainly sold as fresh fruit for the local ethnic market.
Others

Elsewhere longan is grown on a smaller scale, for example Cambodia, Laos, Myanmar, Indonesia and Malaysia (Figure 12). Countries such as India and South Africa grow little longan since priority has been given to lychee cultivation. There is also some growing of longan, mainly cultivars from Thailand, in Israel (Blumenfeld et al., 2000).

Figure 12. Large scale cultivation of the commercial longan in Malaysia.

15. PLANTED AREA AND PRODUCTION OF MAIN LONGAN CENTRES IN ASIA

China

In 1997 the cultivated area of longan was 432,400 ha with a production of 232,000 metric tons (Liu and Ma, 2000). Major provinces growing longan are Guangxi, Guangdong, Fujian, Sichuan, Yunnan and Hainan (Table 14). The first three provinces accounted for about 97 percent of the total planted area.

Table 14. Planted area and production of longan in China (1997)

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (ha)</th>
<th>Production (metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangxi</td>
<td>210,100</td>
<td>133,300</td>
</tr>
<tr>
<td>Guangdong</td>
<td>119,600</td>
<td>124,700</td>
</tr>
<tr>
<td>Fujian</td>
<td>90,300</td>
<td>104,800</td>
</tr>
<tr>
<td>Sichuan</td>
<td>1,900</td>
<td>600</td>
</tr>
<tr>
<td>Yunnan</td>
<td>1,500</td>
<td>1,000</td>
</tr>
<tr>
<td>Hainan</td>
<td>9,000</td>
<td>900</td>
</tr>
</tbody>
</table>

Source: Liu and Ma (2000).
A large increase in area under longan cultivation during the period 1987 to 1997 was recorded in the three main longan growing provinces of Guangxi, Guangdong and Fujian (Table 15).

**Table 15. Increase in planted area of longan in the main longan growing provinces in China**

<table>
<thead>
<tr>
<th>Year</th>
<th>Guangxi Area (ha)</th>
<th>Guangxi Production (metric ton)</th>
<th>Guangdong Area (ha)</th>
<th>Guangdong Production (metric ton)</th>
<th>Fujian Area (ha)</th>
<th>Fujian Production (metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>9,200</td>
<td>22,400</td>
<td>8,700</td>
<td>21,800</td>
<td>22,600</td>
<td>37,300</td>
</tr>
<tr>
<td>1989</td>
<td>16,900</td>
<td>23,400</td>
<td>15,300</td>
<td>26,900</td>
<td>25,700</td>
<td>43,700</td>
</tr>
<tr>
<td>1991</td>
<td>27,300</td>
<td>25,200</td>
<td>23,600</td>
<td>32,200</td>
<td>40,600</td>
<td>63,300</td>
</tr>
<tr>
<td>1993</td>
<td>49,000</td>
<td>36,800</td>
<td>29,400</td>
<td>42,000</td>
<td>53,100</td>
<td>54,300</td>
</tr>
<tr>
<td>1995</td>
<td>121,300</td>
<td>118,600</td>
<td>75,700</td>
<td>76,000</td>
<td>66,400</td>
<td>86,400</td>
</tr>
<tr>
<td>1997</td>
<td>210,100</td>
<td>133,300</td>
<td>119,600</td>
<td>124,700</td>
<td>90,300</td>
<td>104,800</td>
</tr>
</tbody>
</table>

Source: Liu and Ma (2000).

There are over 400 cultivars of longan in China (Liu and Ma, 2000). Among these cultivars 14 percent are early-maturing, 68 percent are mid-maturing, and 18 percent are late-maturing. Common cultivars and their characteristics are described in Appendix 1.

**Thailand**

The production of longan in 1998 was about 238,000 metric tons with a planted area of 411,504 ha (Subhadrabandhu and Yapwattanaphun, 2000a). There was an annual increase in planted area from 1989 - 1998 (Table 16) attributed to the prospect of exporting the fruits. Although there was an annual increase in planted area, the production has not increased at the same pace as the planted area. Such a scenario is attributed to the sensitivity of longan to the changing climatic conditions from year to year. Variable field management has also accounted for the varying production in different years.
Table 16. Planted area and production of longan in Thailand

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
<th>Production (metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>17,757</td>
<td>44,661</td>
</tr>
<tr>
<td>1990</td>
<td>19,922</td>
<td>145,869</td>
</tr>
<tr>
<td>1991</td>
<td>21,770</td>
<td>81,842</td>
</tr>
<tr>
<td>1992</td>
<td>23,635</td>
<td>145,047</td>
</tr>
<tr>
<td>1993</td>
<td>27,480</td>
<td>92,742</td>
</tr>
<tr>
<td>1994</td>
<td>30,789</td>
<td>193,079</td>
</tr>
<tr>
<td>1995</td>
<td>34,715</td>
<td>143,592</td>
</tr>
<tr>
<td>1996</td>
<td>38,303</td>
<td>236,428</td>
</tr>
<tr>
<td>1997</td>
<td>41,434</td>
<td>227,979</td>
</tr>
<tr>
<td>1998</td>
<td>41,504</td>
<td>238,000</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

Longan production in Thailand is confined mainly to the northern provinces of Lamphun, Chiang Mai and Chiang Rai where the planted area makes up 37.6, 24.1 and 8.0 percent of the total planted area, respectively (Table 17). Though longan cultivation has extended to the eastern and central regions of the country, they constitute only a small percentage of total production.

Table 17. Planted area and production of longan in the major growing provinces of Thailand (1993 data)

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (ha)</th>
<th>Production (metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamphun</td>
<td>11,008</td>
<td>44,031</td>
</tr>
<tr>
<td>Chiang Mai</td>
<td>6,436</td>
<td>40,932</td>
</tr>
<tr>
<td>Chiang Rai</td>
<td>2,252</td>
<td>11,700</td>
</tr>
<tr>
<td>Nan</td>
<td>1,129</td>
<td>9,486</td>
</tr>
<tr>
<td>Phra Yao</td>
<td>922</td>
<td>4,161</td>
</tr>
<tr>
<td>Lampang</td>
<td>849</td>
<td>5,340</td>
</tr>
<tr>
<td>Phrae</td>
<td>830</td>
<td>2,498</td>
</tr>
<tr>
<td>Chanthaburi</td>
<td>563</td>
<td>1,478</td>
</tr>
</tbody>
</table>

Source: Subhadrabandhu and Yapwattanaphun (2000a).

The longan industry in Thailand is based on seedlings developed from cultivars which were brought in from Southern China. In 1896 a Chinese trader brought five marcotted longan trees from China which were presented to Queen Saopvabhapongsri, Consort of King Rama V. These trees were planted in Bangkok and Chiang Mai. It is believed that these trees were the source of the present longan cultivars in Thailand (Subhadrabandhu and Yapwattanaphun, 2000a). The present Thai cultivars are generally considered to be more superior in fruit quality to the Chinese cultivars. Common cultivars and their characteristics are described in Appendix 1.
Taiwan Province of China

Longan production areas are concentrated in central and southern Taiwan Province of China. The area planted and the production from 1994 to 1998 are shown in Table 18. There is minimal or no increase in planted area for the period shown and the production pattern is evidence of the alternate bearing phenomenon.

Table 18. Planted area and production of longan in Taiwan Province of China

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
<th>Production (metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>12,142</td>
<td>109,460</td>
</tr>
<tr>
<td>1995</td>
<td>12,192</td>
<td>151,388</td>
</tr>
<tr>
<td>1996</td>
<td>12,168</td>
<td>53,215</td>
</tr>
<tr>
<td>1997</td>
<td>12,015</td>
<td>130,495</td>
</tr>
<tr>
<td>1998</td>
<td>11,808</td>
<td>53,385</td>
</tr>
</tbody>
</table>


Taiwan Province of China’s longan cultivars originated from mainland China. There are over 52 longan cultivars existing in the country. However, over 98 percent of the longan area are planted with the cultivar ‘Fengko’. This is followed by the cultivars ‘Hongko’ and ‘Chingko’. A great variation exists in fruit weight (5.2 - 18.2g), TSS (10.3 - 26.0 percent), seed weight (0.5 - 2.5g), and aril recovery percentage (50.0 - 70.8 percent) among 52 longan cultivars grown at different locations and years of production (Yen and Chang, 1991). Most cultivars flower from March to early April and harvesting of fruits is from August to early September. Common cultivars and their characteristics are described in Appendix 1.

Vietnam

Longan production in Vietnam is concentrated mainly along the Mekong delta, the northern region and the southeast region. Among these longan areas, the Mekong delta accounted for 70 - 80 percent of the total planted area (Table 19). There was an increase in the longan planted area from 1998 to 1999. Common cultivars and their characteristics are described in Appendix 1.
Table 19. Planted area and production of longan in Vietnam

<table>
<thead>
<tr>
<th>Year</th>
<th>Region</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mekong delta</td>
<td>Northern region</td>
<td>Southeast region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Production (metric ton)</td>
<td>Area (ha)</td>
<td>Production (metric ton)</td>
<td>Area (ha)</td>
<td>Production (metric ton)</td>
</tr>
<tr>
<td>1998</td>
<td>28,600</td>
<td>270,000</td>
<td>4,000</td>
<td>40,000</td>
<td>1,314</td>
<td>10,000</td>
</tr>
<tr>
<td>1999</td>
<td>30,030</td>
<td>280,000</td>
<td>5,000</td>
<td>50,000</td>
<td>6,570</td>
<td>35,000</td>
</tr>
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16. PROBLEMS FACED BY LONGAN PRODUCTION

Countries producing longan, including China, Thailand and Taiwan Province of China, have reported almost common problems in longan production. These common problems include:

   a) Biennial bearing: The main problem faced by commercial orchards is irregular flowering and biennial bearing. Trees tend to overcrop some years and this is followed by a light crop the next year. In Thailand, the production figures for 1990-1994 (Table 16) reveal a very clear pattern of biennial bearing. A similar pattern of biennial bearing is exhibited by the production figures for Taiwan Province of China during 1995-1998 (Table 18). Prices obtained by the longan growers have been dictated by the quantum of production. When there is a good harvest the price of longan drops to a low level and vice versa.

   b) Small fruit size: This problem is particularly acute in Taiwan Province of China where there is a need to have cultivars producing large fruits (Yen and Chang, 1991). In Florida, the demand for large fruit is most critical. So far, the cultivar ‘Kohala’ has been able to produce the desired fruit size through pruning of flower panicles (Campbell, 2000). In Thailand, ‘Biew Khiew’ produces large fruit size but is limited by its biennial bearing habit.

   c) Witches’ broom disease: This disease is prevalent in producing countries in Asia. Though there are resistant longan cultivars, the lost of production through infection by this disease can be quite substantial as revealed by the figures from China.

   d) Fruit bats: This pest has been reported to cause serious problems during fruiting seasons of longan in Thailand and Australia. A high cost has been incurred to put up protective netting around the perimeter of the orchard or over each tree.

   e) Large unmanageable tree-size: Under the conventional planting system the trees tend to grow very tall and management and harvesting of such trees can be difficult. Thus a way has to be developed to prune the trees to a manageable height. Also high density planting together with pruning or root restriction can be practiced to reduce the tree height.
f) **Limited market:** The demand for longan comes mainly from an ethnic community, Asians in general and Chinese in particular. Sales of longan outside this ethnic market are limited.

**17. PROSPECTS**

Longan is one of the top export earners for Thailand with an export value of US$201 million in 1997. This compared favourably to the export of lychee in the same year. The longan is gaining acceptance, sometimes in preference to lychee. There are, however, a number of limitations which need to be taken into consideration.

At present longan is mainly targeted for ethnic markets especially those of Asian communities. In Australia and Florida, the demand from ethnic Asians far exceeds the supply. Other communities have yet to develop an acquired taste for longan. Once more people have acquired the taste of longan, there is certainly an increase in its demand. There is, therefore, a need for more promotion of the longan among other communities.

Highly perishable longan fruits have limited distant markets. To extend the use of longan, the fruits can be processed into various products such as canned and dried longan. Dried longan is popular among Asians, particularly the Chinese, who make a refreshing longan drink out of it. Again there needs to be aggressive promotion of the longan drink to other communities in foreign markets.

Biennial bearing is a major constraint for expansion of the longan crop. However, it is probably easier to attain good and stable yields of longan than of lychee. Since these fruits substitute for one another this considerably enhances the prospect of longan. If trees bore regularly, growth would be moderated and it would be easier to prune to keep trees to a manageable size. Small trees, coupled with closer spacing and regular yields would allow production to be intensified. This work has already been practiced in Guangdong Province in China.

Small fruit size may be a constraint for some longan cultivars. However, through planting the right cultivars coupled with proper pruning technique of the flower panicle, large fruit size can be achieved.

Expansion of longan cultivation to tropical regions can be achieved with the existence of superior races of subspecies *malesianus*, in particular the variety *malesianus* in Sarawak and other parts of Borneo. This may offer an attractive alternative to the commercial longan for the humid tropical lowlands. In addition there are in existence commercial longan cultivars which are adapted to the constantly high temperature of humid tropical conditions as in the case of the cultivar ‘Phetsakon’ in Thailand. This cultivar is now planted in non-traditional regions of Thailand. The use of potassium chlorate to produce off-season longan adds to the future prospects of the crop and needs to be encouraged. With off-season production, prices obtained by longan growers will be higher.

In view of the above, there is a bright future for the longan.
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CULTIVARS OF MAIN LONGAN CENTRES IN ASIA

China

The popular longan cultivars are:

Guangxi province : ‘Dawuyuan’
‘Guangyan’

Guangdong province : ‘Chuliang’
‘Shixia’
‘Wuyuan’

Fujian province : ‘Fuyan’
‘Wulongling’
‘Chike’
‘Dongbi’
‘Honghezi’

The characteristics of the more popular longan cultivars are as follows:

‘Chuliang’

‘Chuliang’ is a native and superior quality longan cultivar in Gaozhou area within the Guangdong Province. It is characterized by:

- large fruit size (average fruit weight of 12.0 - 16.5g),
- thick and firm aril,
- high aril recovery rate (edible part of 69 - 74 percent),
- sweet with Total Soluble Solids (TSS) of 20 - 23 percent, and
- fragrant flavour.

The dry fruit rate ranges from 35-38 percent and the dry flesh rate from 13-16 percent. The colour of processed dried flesh is golden yellow. The cultivar produces high and stable yield. Its clones show the features of early bearing, high and stable yielding, and hereditary stability. Presently the cultivar covers a total area of over 100,000 ha in the country. About 30,000 ha were planted in Gaozhou where 12,000 ha are in production with an output of more than 60,000 metric tons (Huang et al., 2000).

The cultivar was awarded the Gold Prize at the First China Agricultural Exposition in 1992 and won the title of “Famous Brand Produce” at the Third China Agricultural Exposition in 1997 and also at the China International Agricultural Exposition in 1999 (Liu et al., 2000).
‘Shixia’

‘Shixia’ is another popular longan cultivar in Guangdong Province with a history of about 140 years. The fruit is small, but has crisp, thick and sweet aril with TSS value of 19-20 percent and with good flavour. It is the best cultivar for consuming as fresh fruit and produces heavy crops regularly on unusually large panicles (Menzel et al., 1990).

‘Shixia’ is planted extensively with lychee by the Yehai Lichee Science and Technology Garden in four localities within Guangdong Province (Dalang town, Dongguan city; Shuikou town, Huiyang city; Silin town, Huadu city; and Jinghong city) and in Jiuzhou town, Qiongtshan city, Hainan province. The longan trees are planted under a high density planting system coupled with constant pruning to produce dwarf trees (Figure 3). This system is reported to be early yielding and produces high and stable yield of quality fruits. Yield of an 8 years old high-density planted dwarf tree was reported to be 2,250 kg per mu (120 trees per mu; 15 mu = 1 ha)(Anon., 1992).

‘Wuyuan’

‘Wuyuan’ (Black Round) is another important longan cultivar in Guangdong province. The fruit is medium in size (15g) with large seed and soft and juicy aril of average quality. Yield is high and TSS value is 14-15 percent. The fruit is suitable for eating fresh and dried. Seedlings are vigorous and consequently useful as rootstock (Menzel et al., 1990).

‘Fuyan’

This is an important longan cultivar in Fujian province and accounted for over 90 percent of plantings in the province. It has a long planting history with total tree numbers exceeding one million. The fruit is large (18g) with thin skin, small seed and thick crisp aril. Yield is high. It is best used for canning since the fruits have a low TSS value of 15-16 percent (Menzel et al., 1990).

‘Wulongling’

This is also a major longan cultivar in Fujian province. It has been in existence for more than 150 years. The fruit is medium in size (15g) with thick skin, good aril recovery and sweet flavour (TSS of 21-23 percent) (Menzel et al., 1990). ‘Wulongling’ has a distinct alternate bearing cropping.

Thailand

Popular longan cultivars in Thailand include:

‘Daw’

This is the most popular cultivar in Thailand and about 73 percent of the total longan area in the country are planted with this cultivar. It is an early-maturing cultivar as indicated by the name ‘Daw’ meaning early. Flowering takes place in December and fruit harvesting occurs in late June to early July. The fruits fetch high premium from foreign
markets due to the early harvest. This cultivar is the most consistent bearer and has no alternative bearing problem. In addition, the cultivar is relatively free from infection by witches’ broom disease (Subhadrabandhu, 2000). Although the fruit is large it has a big seed and, therefore, low aril recovery rate. The aril, which is sweet and with good flavour, is rather tough and not as crispy when compared to the aril of ‘Biew Khiew’. Fruits do not keep well on the tree and the seed may even germinate within the fruit. The fruits can be consumed fresh or processed. This cultivar is normally grown in the northern provinces where the cool winter months are necessary for induction of flowering.

‘Chompoo’

This cultivar is well sought after by the Thai people. It is a mid-maturing cultivar which flowers in December to early January and the fruits can be harvested from middle July to early August. The fruit is of medium size, oval in shape and with greenish light brown skin. Its small seed leads to high aril recovery percentage. The aril is slightly pink and thus the name ‘Chompoo’ meaning pink. It is very sweet (TSS of 21-22 percent) and has a pleasant aroma. The weakness of this cultivar is its irregular cropping habit as a result of poor flowering. For high production, the tree requires high fertilizer application and good management. The cultivar is normally grown in the northern provinces where the cool winter months are necessary for induction of flowering.

‘Biew Khiew’

This is another well sought after cultivar. It is a late-maturing cultivar with flowering in late January and harvesting of fruits in late August to September. Mature fruit is round, large, brownish green in colour and has good aril recovery percentage. The aril is crispy, pleasant scented and sweet (TSS of 22 percent) and of excellent quality. The fruit skin is rather thick and, therefore, advantageous to longer shelf life. This cultivar exhibits irregular bearing and is susceptible to witches’ broom disorder. It is normally grown in the northern provinces where the cool winter months are necessary for induction of flowering.

‘Haew’

This is a late-maturing cultivar with flowering in late January to early February and harvesting of fruits in mid to late August. The fruit is medium to large in size with rather small seed and has an average recovery percentage. The aril is firm and of good eating quality. The fruit rind is rather rough and thick and, therefore, advantageous for longer shelf life. This cultivar flowers easily and produces heavily. Its weakness is its alternate bearing habit. The fruits are suitable for canning. This cultivar is normally grown in the northern provinces where the cool winter months are necessary for induction of flowering.

‘Dang’

This is a mid-maturing cultivar whose fruits can be harvested in mid-July to early August. Fruit is large with reddish brown rind. However, it also has quite a large seed leading to rather poor recovery percentage. With maturity the fruit’s quality declines. Its productivity and quality are similar to those of ‘Daw’. The trees are susceptible to waterlogging.
‘Baidum’

This is a mid-maturing cultivar which flowers in late December to early January and harvesting of fruits is around mid-July to early August. The fruit is medium in size with rough rind, small seed and an average aril recovery percentage. The aril is of acceptable flavour, crispy, very sweet and is bright white in colour. This cultivar is a regular bearer and can withstand drought quite well.

‘Talub Nak’

This is an early-maturing cultivar whose fruits are harvested in mid to late July. Fruit is medium in size, with small seed and a high aril recovery percentage. The aril, which is bright white in colour, is less sweet when compared to those of other cultivars. This cultivar can produce well when given good management.

‘Phetsakon’

This cultivar is different from all the other cultivars described in the preceding section. It is a lowland cultivar which does not require a cool climate for induction of flowering. ‘Phetsakon’ is an early-maturing cultivar and it flowers readily. It is grown in the central region of the country in Samut Sakhon and Ratchaburi provinces.

**Taiwan Province of China**

The characteristics of the more popular longan cultivars in Taiwan Province of China are as follows:

‘Fengko’

This is the most popular longan cultivar in Taiwan Province of China and over 98 percent of the longan area are planted with this cultivar. The cultivar is a good yielder. Fruit is evenly large in size. Colour of fruit rind is yellowish brown which becomes brighter at low temperature. The aril is very sweet with a TSS value of about 20 percent. Fruits are not easily detached from the stalk which is considered as a good quality. Propagation by grafting usually yields a high percentage of success.

‘Hongko’

This cultivar is grown mainly in the southern region of Taiwan Province of China. It is a good yielder. The fruit is of reasonably large size with fruit rind dark brown in colour. The sweetness of the aril is less than that of ‘Fengko’.

‘Chingko’

The fruit rind is light brownish green when ripe. The quality of the fruit is easily affected by environmental conditions. The aril is less sweet when compared to that of ‘Fengko’. Fruits are easily detached from the stalk and this is considered to be of a poor quality.
Vietnam

The cultivars planted in the various regions in Vietnam are:

- **Mekong delta**: ‘Longhan’, ‘Tieuhue’, ‘Xuongcomvang’
- **Northern region**: ‘Longhungyen’
- **Southeast region**: ‘Tieuhue’, ‘Xuongcomvang’

The characteristics of the more popular longan cultivars in Vietnam are as follows:

- **‘Longhan’**
  
  This is a truly tropical longan which can yield two crops per year.

- **‘Tieuhue’**
  
  This is also a true tropical longan which can yield three crops in two years.

- **‘Longhungyen’**
  
  This longan thrives only in subtropical conditions and produces only one crop per year.

Other important longan cultivar

- **‘Kohala’**
  
  In Florida, the ‘Kohala’ is reliable in its blooming and fruiting. The trees are also easily propagated by air-layering. Fruit of ‘Kohala’ is light and thin-skinned. It is large in size, and has a sweet aroma with a spicy flavour. Fruit generally has a high aril recovery percentage. Air-layered trees will begin bearing very early, and a three-year old tree may carry 10 kg of fruit. The flower panicle is normally pruned to \( \frac{2}{3} \) its size in order to obtain large fruit size.