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LONGAN PRODUCTION IN ASIA

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by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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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despite its importance, there is a paucity of published information on longan and where available, the publications are outdated.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
Assistant Director-General
and FAO Regional Representative
for Asia and the Pacific

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LONGAN PRODUCTION IN ASIA

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 ('lamyai kradook' or small 'lamyai'), 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 ('lamyai kraloke') 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 globular 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*).

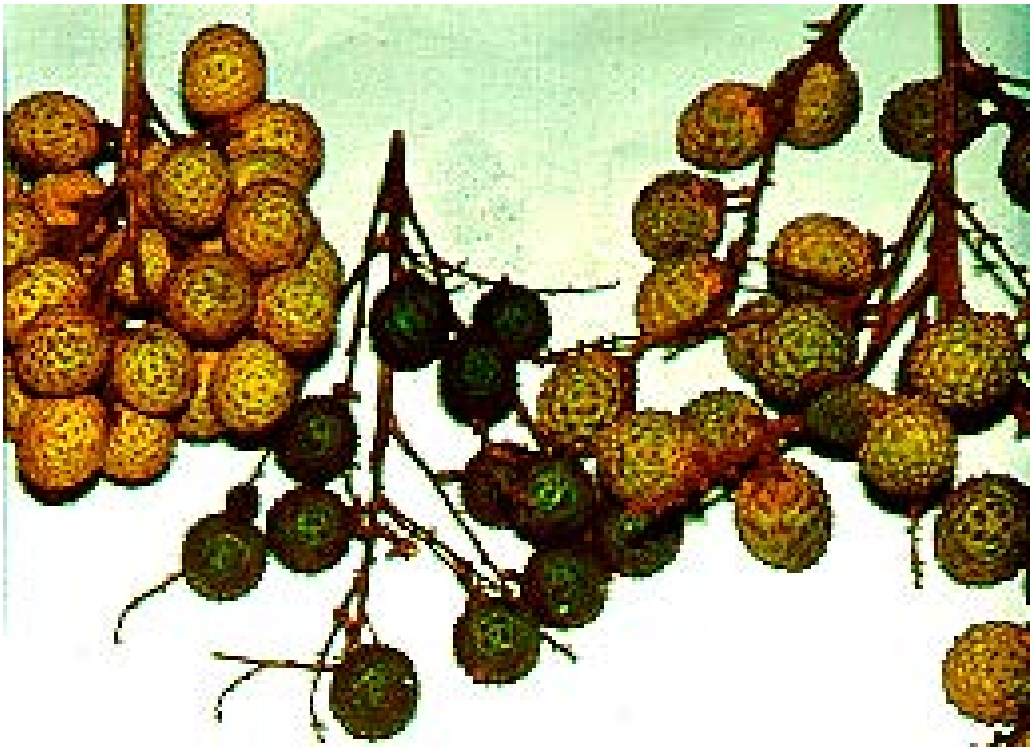

Figure 2. Relatives of the commercial longan - *Dimocarpus longan* ssp. *malesianus* var. *malesianus* (from left to right: 'kakus', 'isau' and 'sau').

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

Calorie Unit	Moisture (%)	Protein (g)	Fat (g)	Carbo-hydrate (g)	Fibre (g)	Ca (mg)	P (mg)	Fe (mg)
109.0	72.4	1.0	0.5	25.2	0.4	2.0	6.0	0.3
Vit. A (I.U.)	**Vit B1 (mg)**	**Vit B2 (mg)**	**Niacin (mg)**	**Vit. C (mg)**				
28.0	0.04	0.07	0.6	8.0				

Source: Wong and Saichol (1991).

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 hermophrodite 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 hermophrodite 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 hermophrodite 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^{o}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^{o}C is detrimental for fruit development and temperature above 40^{o}C causes fruit damage and fruit drop. In Thailand the best temperatures for flowering and fruit set are 20 - 25^{o}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 marcotting, 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 been 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.

Figure 6. High density planting of 'Shixia' longan in China (from: Anon., 1992).

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 'Chuliang' 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 ($N:P_2O_5:K_2O$ 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 cinturing (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 cinturing of branches or stems (Subhadrabandhu and Yapwattanaphun, 2000a). The cincturing knife used for lychee can be used for longan (Figure 7).