MANAGEMENT OF PHENOLOGY, FLOWERING AND FRUITING OF LONGAN, RAMBUTAN AND GUAVA

Tran Van Hau
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Abstract

In this review, management of phenology, flowering and fruit set of longan, rambutan and guava was discussed. Recently there have been three common longan cultivars growing in the Mekong delta, viz. ‘Tieu Da Bo’, ‘Xuong Com Vang’ and ‘E-dor’ (originated from Thailand). Their characteristics of shooting, flowering and fruit development are relatively different. Growth cycle of ‘Tieu Da Bo’ cultivar occurs within 7.5-8.0 months, as the trees only need two leaf-flushes before being able to be induced for flowering. For ‘Xuong Com Vang’ cultivar, three leaf-flushes should be completed; in addition, fruit development of ‘E-dor’ prolongs within 4.0-4.5 months thus extending the growth cycle of both cultivars to almost the whole year. The most common floral induction techniques on longan is using KClO₃ alone (‘E-dor’) or in combination with branch cincturing (‘Tieu Da Bo’ and ‘Xuong Com Vang’). Applied doses and time of application vary depending on cultivar and crop season. Regarding rambutan, the three cultivars grown in the Mekong Delta include ‘Rongrien’ (originated from Thailand), ‘Java’, and ‘Nhan’, in which the most popular one is ‘Java’. The growth cycle of ‘Java’ rambutan is about 9.5-10 months. The duration from fruit set to harvest is 14-16 weeks. Off-season floral induction on rambutan is implemented via drainage of irrigation channel combined with plastic mulching of the growing bed or foliar application of paclobutrazol at 400-600 ppm when leaf color of the third leaf flush is light green (50-60 days old). For guava, the most prevalent varieties grown in the Mekong Delta include ‘Xa Ly Nghe’, ‘Pink Flesh-Smooth Skin’, ‘Xa Ly Gion’, ‘Pink Flesh-rough Skin’. Guava is intercropped with the other fruit trees to increase income, particularly with citrus to expel aphids (Diaphorina citri). The most important techniques of guava cultivation include pruning, canopy management, and pinching. Guava flowers from axillary buds; therefore pinching implemented after flowering is necessary for fruit development. Fruit covering with a two layers bag when fruit diameter reaches 2-3 cm helps reduce damages caused by diseases and insects.


1. LONGAN

In Vietnam longan is one of the most important fruit tree grown widely from north to south of the country with an area of approximately 85,862 ha which primarily distributed in the Mekong delta, accounted for more than 40% of the area of the whole country. Longan is grown mostly in Vinh Long Province (9,354 ha), followed by Tien...
Giang (8,050 ha), Ben Tre (5,360 ha), and Dong Thap (4,628 ha) Provinces.

The most popular longan cultivars grown in the Mekong Delta include ‘Tieu Da Bo’, ‘Xuong Com Vang’, ‘Giong’ and ‘E-dor’ (originally from Thailand). ‘Tieu Da Bo’ is the main stand, accounted for more than 70% of the total area as a consequence of many of its favorable characteristics, i.e. strong growth, small seed, high yield (20-30 ton/ha), and high profit which makes it become high demand. However, the area of ‘Tieu Da Bo’ is decreasing because of its mild susceptibility to witches broom disease. ‘Xuong Com Vang’ is the cultivar cultivated originally at sandy coastal area in Vung Tau City. The cultivar was granted the highest price in a contest held by the Southern Horticulture Research Institute (De and Hung, 2006). However, it was unable to be developed further as of low yield (10-15 ton/ha). Recently, area of ‘Xuong Com Vang’ tends to increase results from being resistant to witches broom disease.

1.1. Phenology, flowering and fruiting

Logan is a terminal bud flowering fruit tree, hence inducing leaf flush after harvesting plays an important role to flowering and production of the next crop. For some common longan cultivars in the Mekong delta, growers used to induce the tree to produce 2-3 leaf flushes (Table 2). Floral induction, applied when the tree completes the third leaf-flush, produces more fruits per bunch in comparison to that when the tree only had two leaf-flushes. However, the ratio of shoots continue to the third flush is low, and not concentrated with prolonged duration; therefore it is very hard to apply techniques to foster leaf maturity via foliar application of MKP (monopotassium phosphate) at 0.5%, and to induce concentrated shooting by spraying Potassium nitrate (1%) on leaf. Duration of the development of three leaf flushes varies depending on the cultivar, from 90 days (‘Tieu Da Bo’) to 155 days (‘E-Dor’) (Table 1; in rainy season, the duration is longer than in dry season.

Duration from applying floral induction techniques to emergence of flower buds is from 25-30 days (‘Tieu Da Bo’) to 30-35 days (‘E-dor’). Fruit set period takes place within 7 days. Fruit development from fruit set until harvesting also depends on each cultivar, from 84-86 days for ‘Xuong Com Vang’ to 90-105 days for ‘Tieu Da Bo’, and even longer in the case of E-Dor, 121-126 days (Table 1a). As of difference in duration of fruit development, there is also difference in the fruit development process among cultivars. According to Tieng (1999), aril development is only started when seed development is finished; hence increasing of fruit weight is corresponded to aril weight whose commencement is relatively late. Fruit weight of ‘Xuong Com Vang’ starts to increase with the rise of aril weight at 56 days (Fig 1a) and reaches a maximum at 70 days after fruit set (AFS) (Fig 1b). Meanwhile, for ‘E-dor’ fruit weight increases greatly at 70 days (Fig 2a) and becomes highest at 98 AFS. In short, longan fruit development is toward a simple curve, slow at the initial due to seed development, then much faster thanks to the development of aril, and finally fruit maturity.

Fruit set and immature fruit drop are the most important factors reducing longan yield. To improve yield of ‘Tieu Da Bo’, Hong et al. (2007) reported about the foliar application of acid boric at 100 ppm or GA3 at 5-10 ppm twice, first when flower

1Data issued by the state department of crop production, 2011.
Inflorescence is about 5-10 cm length and second at 7 days after the first. For ‘Xuong Com Vang’ cultivar, Hong and Son (2008) suggested spraying 2‰ of borax when flower inflorescence reaches to 10 cm length and prior to blooming. In the case of ‘Xuong Com Vang’, to reduce immature fruit drop Hong et al. (2007) suggested spraying phyto-hormones, viz. 2,4-D 5 ppm, IBA 5 ppm, NAA 10-20 ppm or BA 5-10 ppm when fruit diameter is about 4-5 mm (2 weeks after fruit set), three times on a 7 days interval.

1.2. Floral induction

Flowering of longan is driven by low temperature period, 15-22°C within 8-10 weeks, and subsequently high temperature of spring which is favorable for the development of flower initiation (Paul and Nakasone, 1998). Under the climate conditions of the Mekong delta, low temperature occurs on January to February, which is also dry period. Therefore flower initiation is created on January-February, but started to develop on April-May when rainy season commences; thenceforth harvest time of longan is in August-September (Hau, 2009). Because price of longan in on-season is not high, growers have taken approaches to induce flowering in off-season to gain higher price.

Procedures of floral induction applied on ‘Tieu Da Bo’, ‘Xuong Com Vang’, and ‘E-dor’ are somewhat different (Table 2). Leaf age at the time of floral induction is among prerequisite factors. According to Hegele et al. (2004), although KClO3 is confirmed to be effective in year-round floral induction on longan, it is not effective or has low effect when floral induction is carried out while leaf is still young. The reason for such low effect is said to be of high auxin concentration in the leaf. Leaf age at floral induction is different for cultivars (Table 2). ‘Xuong Com Vang’ is induced for flowering when leaves are 35 days since emergence; whereas in the case of ‘E-dor’ induction implemented when leaves are 40 days old brings about higher yield. Leaf age can be assessed via leaf color (Hau and Binh, 2012). A favorable time for floral induction is when leaf is turning from light to dark green (Fig. 5).

Number of completed leaf flushes when floral induction is implemented is also an important factor influencing longan yield. ‘Tieu Da Bo’ is usually induced for flowering when the trees finish the second leaf flush, while it is at the third one in the case of ‘E-dor’. Nevertheless, if trees grow well and high benefit could be achieved in the crop season, growers also start to induce flowering when trees finish only one leaf flush for ‘Tieu Da Bo’, or two in the case of ‘Xuong Com Vang’ and ‘E-dor’.

Methods for floral induction are different depending on cultivar and crop season. Diczbalis and Drinnan (2007) reported that KClO3 is a powerful flowering inducing agent on longan trees. ‘E-dor’ cultivar of Thailand needs higher dose of KClO3 than for ‘Tieu Da Bo’ and ‘Xuong Com Vang’, but does not need to be combined with branch cincturing (Table 2). According to Manochai et al. (2005) in Thailand, a dose of 4 g KClO3 per m2 of canopy is effective for floral induction, and optimum at 6 g/m2. In the Mekong delta, higher doses are required which is said to be due to higher annual average temperature. Moreover, the cultivar ‘E-dor’ only flowers in low temperature condition while totally fails to flower in the natural condition of the Mekong Delta and when treated with cincturing as applied on ‘Tieu Da Bo’ (Hau, unpubl.). An explanation for the decrease of effectiveness of KClO3, according to
Diczbalis and Drinnan (2007), is that the sites for production of the flowering stimulus are reduced (e.g. damage of root hairs during the previous application); henceforth in the second application a higher threshold of the flowering stimulus is required to be able to shift the shoot from vegetative to reproductive.

Branch cincturing is only applied on ‘Xuong Com Vang’ and ‘Tieu Da Bo’ cultivar (Fig. 3a&b). Because growth strength of ‘Tieu Da Bo’ is probably stronger than that of ‘Xuong Com Vang’, cinctured width on branches of ‘Tieu Da Bo’ (5-7 mm) is larger than that of ‘Xuong Com Vang’ (3-5 mm). Only about 70-80% of number of branch on tree should be cinctured; a higher percentage will increase flowering ratio but reduce fruit size.

In addition to the mentioned techniques, to achieve high flowering ratio on longan it is necessary to apply fertilizer properly, particularly not too much nitrogen, to induce leaf flush. In addition, it is suggested to drain irrigation channel to create drought condition and reduce humidity at root zone, and to generate favorable conditions for water drainage in case there is rain. According to Diczbalis and Drinnan (2007), high leaf nitrogen content, more than 1.7%, correlates with poor flowering (only 0-25% of terminal buds flower), suggesting an overriding role of leaf nitrogen content in comparison to the other factors, including dose of KClO₃, on flowering.

2. RAMBUTAN

Rambutan in Vietnam is primarily grown in the southeast region and the Mekong Delta with a total area of 24,500 ha ², and a production of 304,400 ton/year. In the Mekong delta, there are 8,100 ha of rambutan, mostly distributed in Ben Tre (5,000), Vinh Long (1,300 ha), Soc Trang (1,000 ha), and Tien Giang (900 ha) Provinces. Average yield of rambutan in the Mekong Delta at 17.6 ton/ha is higher than that of the whole country (13.7 ton/ha).

The three most popular rambutan cultivars grown in Vietnam are ‘Java’, ‘Nhan’ (means longan in Vietnamese), and ‘Rongrien’ imported from Thailand. The most prevalent one is ‘Java’ because of its strong growth, higher yield (20-30 ton/ha) than ‘Nhan’. ‘Rongrien’ cultivar has comparable yield with ‘Java’, but higher than ‘Nhan’; its fruit quality is comparable to that of ‘Nhan’, but much better than ‘Java’ in term of sweetness, aril and skin thickness, and eatable ratio (Bay et al., 2005). Recently growing area of ‘Rongrien’ is increasing as result of its high quality, strong growth and high benefit; however the cultivar also has a disadvantage which is high ratio of splitted fruit. Rambutan grown in Vinh Long Province is currently infected with witches broom disease as occurring on longan, but at lower damage. The issue is a constraint for rambutan development in the Mekong delta.

2.1. Phenology, flowering and fruiting

Similar to longan, rambutan also flowers on terminal buds, therefore inducing leaf flush after harvesting is necessary. Rambutan is induced to produce 2-3 leaf flushes prior to floral induction. Total duration of one leaf flush is 30-45 days; henceforth the

²Data issued by the state department of crop production, 2011.
total time for leaf flushes prior to flowering is about 3.0-4.5 months (Hau et al., 2004). The process from floral induction to emergence of flower buds, blooming, and fruit set is presented in Table 6. The duration from application of paclobutrazol (PBZ) to creation and development of flower initiation (30-60 days) depends on many factors including drought condition, with or without PBZ application. Flower inflorescence develops and bloom within 39 days. Immature fruit drop occurs primarily in two weeks after fruit set, subsequently decreases and finishes at the 8th week after fruit set. Fruit develops fast at 10 weeks after fruit set, corresponding with the creation of aril, until harvest. Overall, the duration of a rambutan growth cycle, including development of leaf flushes, is from 9.0 to 10.5 months.

Fruit set ratio of ‘Java’ cultivar is relatively low, only 5-16%; however thanks to high number of hermaphrodite flowers (1.087±151 flowers) the cultivar is still able to provide high yield (Hau and Duong, 2006). Fruit set is one of the most important factors affecting yield of rambutan. According to Tindall et al. (1994), rambutan flowers are possibly apomictic. Failure of pollen fertilization will cause a phenomenon called ‘small fruit’ (translated from Vietnamese) in which abnormal fruits generated without fertilization will not develop, while the normal ones will increase size and weight (Fig. 9). The phenomenon is said to be because of lack of pollen, which greatly reduces rambutan yield in Cho Lach District, Ben Tre Province and Long Ho District, Vinh Long Province during the 90s. To improve fruit set on rambutan, Liem(1999) reported about the foliar application of NAA at 15-200 ppm, optimum at 30 ppm, on some inflorescences on the edge of the canopy of some trees in the orchard when blooming proportion of the inflorescence reaches to approximately 30%. The treatment fosters the development of stamens of hermaphrodite flowers, hence improving fruit set and yield of ‘Java’ rambutan. Currently, the treatment has been applied commonly by growers in Cho Lach and Long Ho Districts. The other widely applied treatments include growing trees only produce male flowers, or grafting some buds of male trees onto 5-10% of trees producing hermaphrodite flowers in the orchard (Hau, unpubl.).

Immature fruit drop occurs mainly at the third week after fruit set with dropped fruit ratio about 50% of fruit per inflorescence. Subsequently the process is decreased and finished at the 8th week after fruit set. The remained fruits on inflorescence are about 20% (Hau and Duong, 2006).

The duration of fruit development of rambutan, from fruit set to harvest, is about 16 weeks. Similar to longan, rambutan fruits develop toward a simple curve started with fruit initiation after fruit set, then seed and aril development, finally maturity. The first five weeks of fruit development process is of fruit initiation. Subsequently from the sixth week seed is generated, recognizable at the seventh week, and develops up to the twelfth week, succeeding no change until harvest. Aril is initiated at the seventh week, and then develops fast at the 10th week until harvest (Fig. 8). At the 13th week after fruit set, fruit skin turns yellow as an indication of turning into maturity; meanwhile, fruit weight still increase until fruit skin turning to red, an indication of fruit ripening. Therefore, early harvesting when fruits only start to mature will reduce yield.

2.2. Floral induction

Although rambutan is in the same family with longan and lychee, it does not require
low temperature condition for flowering and can adapt well to tropical climate with temperature from 22-30°C (Nakasone and Paul, 1998). A dry period of at least one month is essential to initiate rambutan flowering (Nakasone and Paul, 1998). Tindall et al. (1994) reported that in Malaysia rambutan can flower twice per year as there are two dry seasons. Growers in Cho Lach and Long Ho Districts drain irrigation channel to create drought condition within 40-61 days to induce flowering; drainage duration correlates positively with flowering rate (Hau et al., 2006a). Nakasone and Paull (1998) also stated that the intensity of flowering appears to be closely associated with duration of water stress.

In the Mekong delta, rambutan flowers naturally on January-February which are cold and dry months of the year; and the harvest time is on July-August. Price of rambutan in on-season is very low, only 25-30% of the price in off-seasons; thus growers are applying techniques inducing off-season flowering to increase the price of rambutan.

Floral induction on rambutan can be implemented via drainage of irrigation channel to generate drought condition, and applying plastic mulching alone or in combination with foliar spray of PBZ (Fig. 10). Procedure for off-season floral induction on rambutan is summarized in Table 7. Rambutan is induced to flower when the tree completes three, or at least two leaf flushes. Channel drainage or PBZ application is started when leaves have light green color, corresponding to 50-60 days old since emergence. The tree will not flower if the induction is implemented while leaves are still young. Hau et al. (2006b) reported that the amount of gibberellins (GAs) like compounds decreases with leaf age and correlates negatively with flowering rate. On mango, Davenport et al. (2001) also claimed that the older the leaf, the less the content of GAs in leaf; the authors explained that it is because of the transportation of GAs from leaf to the opposite meristem. Fertilizing to induce leaf flush prior to floral induction is also a factor affecting flowering. The amount of nitrogen used to induce leaf flush, particularly the last flush before floral induction, negatively correlates with flowering rate. According to Diczbalis (2002), studying on the relationship between nutrient status of leaf and productivity of longan, flowering rate is very low and not stable regardless of favorable climate conditions when leaf nitrogen content is high (1.8%, particularly ≥2%).

Since the prerequisite factor of flowering on rambutan is drought condition, the application of drainage of irrigation channel combined with air drying of growing bed and spell drought occurring in the rainy season also induce flowering on rambutan with a ratio of 60% (Table 8). However the treatment is not steadily effective since the flowering rate is low or even zero if there is rain while irrigation channel is drained. The treatment can be improved by mulching the growing bed with plastic sheet (Fig. 9), which can help increase flowering rate up to 75% with more stable effect. Besides treatments creating drought condition, foliar application of PBZ at 600 ppm can increase flowering ratio up to 80%; when combined with plastic mulching, PBZ sprayed at 400 ppm still brings about high flowering rate (Hau et al., 2006c). Tindall et al. (1994) reported that the optimum concentration of PBZ to induce flowering on ‘Rongrien’ cultivar is from 700-100pm, a higher concentration will cause abnormal growth.

In summary, to induce flowering on rambutan with high and stable flowering rate in unfavorable conditions, some treatments to be applied include drainage of irrigation
channel, mulching growing bed with plastic sheet, and foliar application of PBZ at 400-600 pm. In addition, to help flower buds generated concentratedly, it is necessary to spray thiourea at 0.01% when the emergence of flower buds is visible. Tindall et al. (1994) stated that flower buds only develop when they are sprayed with nitrogen in the form of either potassium nitrate or thiourea two months after the foliar application of PBZ.

3. GUAVA

3.1. Introduction

Guavas (Psidium guajava) are cultivated throughout the tropical and subtropical areas. For its wide adaptability, easy multiplication, it is a common wild or semi-wild plant in tropical and subtropical area widely distributed in more than fifty countries. Even though guava is widely distributed, the commercial cultivated area is small, and the production is not large. In Asia, production is concentrated in Taiwan, China, the Philippines, Vietnam, and Cambodia. The Caribbean, Hawaii and Florida in the United State, South Africa, Brazil, Dominica, Haiti, Cuba, Australia and New Zealand also have some productions. The reason for guava not being cultivated to a larger extent is because of the limited availability of good varieties and good management technology, e.g. control of pests and diseases, pruning management, dwarfing culture, fruit bagging, off-season fruit production and post-harvest technology.

Guava is one of the crops that are diverse in terms of varieties through selection. The fruit trees collection program of Southern Horticulture Research Institute started since 1999 has collected 27 varieties/lines guava planted in the southern provinces and imported from countries, viz. Malaysia, Thailand and India. Currently, guava demonstrations are set up in many provinces such as Binh Duong, Long An, Tien Giang, Dong Thap, Ben Tre, and Soc Trang as means to stimulate economic development in rural areas (Hoa, 2014).

3.2. Varieties

Characteristics of guava varieties are not as distinct as found in the other fruits. Important guava varieties in the Mekong Delta include ‘Xa Ly Nghe’, ‘Pink Flesh-Smooth Skin’, ‘Xa Ly Gion’, ‘Pink Flesh-rough Skin’ and some traditional varieties still grown in some small areas. Recently there have been a few new varieties imported from Taiwan and Thailand, i.e. seedless guava.

3.3. Cultivation

Planting

Guava trees can be planted in monoculture or intercropped in the early stages with some other crops to increase for growers. A recent study implemented by Southern Horticulture Research Institute in cooperation with other research agencies has shown that guava intercropped with citrus can help reduce damage on citrus caused by Diaphorina citri Kuwayama as of its expelling characteristic to the insect. (Hoa, 2014).
Field for planting of guava is prepared during summer season by ploughing, leveling and removing weeds. Pits of 1m x 1m x 1m size are dug and filled with a mixture of farmyard manure and soil. If soil is good and irrigation facilities are available the preparation of land and digging of pits are not required. The planting is done during the rainy season by adopting square planting system.

**Canopy management by training and pruning**

Canopy management is the manipulation of tree canopies to optimize the production of quality fruits. The canopy management, particularly its components like tree training and pruning, affects the quantity of sunlight intercepted by trees, as tree shape determines the presentation of leaf area to incoming radiation. An ideal training strategy centers around the arrangement of plant parts, especially, to develop a better plant architecture that optimizes the utilization of sunlight and promotes productivity (Singh, 2010).

Some of basic principles in canopy management are: i) Maximum utilization of light; ii) Avoidance of built-up microclimate congenial for diseases and pest infestation; iii) Convenience in carrying out the cultural practices; iv) Maximizing productivity with quality fruit production; v) Economy in obtaining the required canopy architecture. Level of pruning depends on the current state of growth, plant age and season for pruning decision middle or moderate or heavy (cut down), basically a tree is pruned and shaped canopy as follows:

- There is one main trunk healthy and upright (Fig.11a). The height of the tree trunk, depending on varieties of guava and method of propagation of guava. If only monocultural guava planting and planting density appropriate to the guava tree is usually planted from cuttings layering, canopy are distributed in space. Plants grown from seed at the branches of small trees stages, plants grow mainly along the cliff height.

- Having 3-5 branch level 1, level 1 branches primarily as a framework for plants in the different stages of development. From the main branches will produce many other branches (branch level 2) in order to be productive fruits. The first level branches to grow both directions. When the first level branches evenly distributed canopy toward making circles, keep balance in plants as well as natural fruit bearing stage (Fig. 11b).

**Pinching**

The aim of pinching is to stimulate new branches. Scissors are used to cut part of the tree or branch. If the main trunk or branch level 1 or the other secondary branches are small tray leaves then wait until the leaves turn to flame arresters buds in the leaf buds on the same stage. After flame arresters, trees need removing shoots a lot lower buds beneath or inside the canopy (Hoa, 2014).

Pinching is always accompanied with regular pruning. The purpose of pinching is to restrain excessive branch growth, reduce nutrient depletion, and induce blooming when new branches do not show blooming. Pinching stops young branches from growing all owing plant nutrients go directly to the fruit so that fruits can continue growing (Wang and Pech, 2011).
3.4. Flowering

For guava branch with flowers, if there is only one pair of flowers (buds), then left bud flowers are pressed but leave the top pair or two pairs of leaves that one to be able to add a couple new pairs of leaf bud that. After the guava branch with two pairs of buds are removed leaving a pair of leaf bud. In this phase should conduct regular press guava sprout concentrated nutrition to the left and this work should be conducted 1-2 weeks/times (Fig. 12).

3.5. Bagging of fruit

Bagging of fruit is conducted when fruit diameter is about 2-3 cm (Fig 13b). Two-three days before wrapping, pesticides are sprayed to exclude diseases and insects, e.g. pod borer, mealy bugs, aphids, fruit rot. Fruits are covered with white foam net inside (Fig 13a) the bag dedicated guava plastic bag (the kind not pressed both sides closed bottom wrapped with a diameter of about 1 cm per side), if the normal type plastic bag to punch 2 holes near the bottom cover both sides, each hole has a diameter of about 1 cm (Fig 13c). The selected fruit should be inserted in the foam net with the narrow side on the fruit and the fruit in the foam netting is placed in the bag. The mouth of the bag is tied to the branch or the peduncle of the fruit to prevent the entrance of insect pest (Wang and Pech, 2011).

Conclusion

Both longan and rambutan flower on terminal buds. While longan requires low temperature condition to be able to flower, drought condition is necessary for the flowering of rambutan. Except ‘E-dor’ longan cultivar, originated from Thailand, which cannot flower naturally in the climate conditions of the Mekong Delta, longan ‘Xuong Com Vang’ and ‘Tieu Da Bo’ as well as rambutan can flower naturally in such conditions but at low flowering rate, not concentrated, and low yield. To be able to sell products at high price, most of the rambutan and longan growers are applying techniques controlling flowering year-round. For longan, the most prevalent techniques, collar drenching with KClO₃ (‘E-dor’) at different leaf ages depending on the cultivar, or it can be integrated with branch cincturing, 3-5 mm and 5-7 mm for ‘Xuong Com Vang’ and ‘Tieu Da Bo’, respectively. For rambutan, flowering is induced by drainage of irrigation channel, application of plastic mulching the growing bed alone or in combination with foliar spraying of PBZ at 400-600 ppm when the third leaf flush was completed and laves have light green color.

Guava is adaptable to many kind of soils, grown easily and early flowering, hence it is grown commonly in the Mekong delta. Since 1999, SOFRI has collected 27 lines/varieties from many countries. The most prevalent varieties grown in the Mekong Delta include ‘ Xa Ly Nghe’, ‘Pink Flesh-Smooth Skin’, ‘Xa Ly Gion’, “Pink Flesh-rough Skin’. Guava is intercropped with the other fruit trees to increase income, particularly with citrus to expel aphids (*Diaphorina citri*). The most important techniques of guava cultivation include pruning, canopy management, and pinching. Guava flowers from the axillary buds; therefore pinching implemented after flowering is necessary for fruit development. Fruit covering with a two layers bag when fruit diameter is 2-3 cm helps reduce damages caused by diseases and insects.
References


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Table 1. Phenology of leaf flush, flowering and fruit development of longan cultivars in the Mekong delta

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Duration of shoot development (days)</th>
<th>Duration from fruitset to harvest (days)</th>
<th>Duration from pruning to harvest (days)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tieu Da Bo</td>
<td>60-90</td>
<td>90-105</td>
<td>195-225</td>
<td>Hau et al. (2002)</td>
</tr>
<tr>
<td>Xuong Com Vang</td>
<td>120</td>
<td>84-86</td>
<td>N/A</td>
<td>Hau and Vu (2008), Hau and Tram (2012)</td>
</tr>
<tr>
<td>E-Dor</td>
<td>155</td>
<td>121-126</td>
<td>330</td>
<td>Hau and Sen (2012)</td>
</tr>
</tbody>
</table>

Table 2. Floral induction method applied on longan cultivars in the Mekong delta

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Leaf age (day)</th>
<th>No of leaf flush</th>
<th>Method of floral induction</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tieu Da Bo</td>
<td>30-35</td>
<td>2</td>
<td>Collar drenching with KClO₃ (g/m canopy diameter)</td>
<td>Hau et al. (2002)</td>
</tr>
<tr>
<td>Xuong Com Vang</td>
<td>35</td>
<td>2-3</td>
<td>Cincturing (mm)</td>
<td>Hau &amp; Chan (2010)</td>
</tr>
<tr>
<td>E-Dor</td>
<td>44-45</td>
<td>2-3</td>
<td>N/A</td>
<td>Hau &amp; Binh (2012)</td>
</tr>
</tbody>
</table>

Table 3. Effect of KClO₃ doses on flowering and fruit set of ‘Tieu Da Bo’ longan cultivar at Chau Thanh district, Dong Thap province (Hau et al., 2002)

<table>
<thead>
<tr>
<th>KClO₃ dose (g/m canopy diameter)</th>
<th>Duration from application of chemical to emergence of flower (days)</th>
<th>Fruit set duration (days)</th>
<th>Flowering ratio of total number of shoot (%)</th>
<th>Inflorescence length (cm)</th>
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</thead>
<tbody>
<tr>
<td>Control (Cincturing)</td>
<td>23.6 a</td>
<td>13.4 a</td>
<td>80.4 b</td>
<td>20.1 a</td>
</tr>
<tr>
<td>20</td>
<td>33.4 b</td>
<td>25.6 b</td>
<td>91.0 d</td>
<td>39.7 b</td>
</tr>
<tr>
<td>40</td>
<td>33.2 b</td>
<td>27.6 bc</td>
<td>87.0 c</td>
<td>43.1 b</td>
</tr>
<tr>
<td>60</td>
<td>34.0 b</td>
<td>28.8 bc</td>
<td>85.0 c</td>
<td>43.2 b</td>
</tr>
<tr>
<td>80</td>
<td>35.2 b</td>
<td>29.8 c</td>
<td>76.1 a</td>
<td>47.0 b</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CV (%)</td>
<td>5.0</td>
<td>10.2</td>
<td>2.6</td>
<td>13.8</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>2.1</td>
<td>3.3</td>
<td>2.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Note: Within one column, treatments with identical letters are not significant different at α = 0.05 by Duncan multi-range test.

Table 4. Leaf color at different ages identified one day before collar drenching with KClO₃ on five years old ‘E-dor’ longan trees in Chau Thanh district, Dong Thap province (Hau and Binh, 2012)

<table>
<thead>
<tr>
<th>Leaf age (Days after emergence)</th>
<th>Leaf color difference (ΔE)</th>
<th>Leaf color index</th>
<th>Leaf color index</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 days</td>
<td>51.1 c</td>
<td>36.4 a</td>
<td>- 9.4 b</td>
</tr>
<tr>
<td>37 days</td>
<td>53.2 bc</td>
<td>34.6 a</td>
<td>- 7.5 b</td>
</tr>
<tr>
<td>44 days</td>
<td>55.7 ab</td>
<td>29.9 b</td>
<td>- 7.0 ab</td>
</tr>
<tr>
<td>51 days</td>
<td>58.6 a</td>
<td>26.8 b</td>
<td>- 4.7 a</td>
</tr>
<tr>
<td>F</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.50</td>
<td>7.30</td>
<td>26.7</td>
</tr>
</tbody>
</table>

Note: Within one column, treatments with identical letters are not significant different at α = 0.05 by Duncan multi-range test; *: significant difference at α = 0.05; Color and brightness in CIE color range: +L: white, -L: black, +a: red, -a: green, +b: yellow, -b: blue.
Table 5. Effect of leaf age at the time of collar drenching with KClO₃ on duration of flower bud emergence and flowering rate of 5 years old ‘E-dor’ longan tree in Chau Thanh district, Dong Thap province (Hau and Binh, 2012)

<table>
<thead>
<tr>
<th>Leaf age (Days after emergence)</th>
<th>Duration from floral induction to flower bud emergence (days)</th>
<th>Flowering rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (untreated)</td>
<td>N/A</td>
<td>00.0 d</td>
</tr>
<tr>
<td>30 days</td>
<td>37.8 a</td>
<td>75.3 c</td>
</tr>
<tr>
<td>37 days</td>
<td>31.0 b</td>
<td>84.3 b</td>
</tr>
<tr>
<td>44 days</td>
<td>28.8 bc</td>
<td>93.0 a</td>
</tr>
<tr>
<td>51 days</td>
<td>27.0 c</td>
<td>82.1 b</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>CV (%)</td>
<td>6.90</td>
<td>5.01</td>
</tr>
</tbody>
</table>

Note: Data was transformed into ‘Arcsine √%’ prior to statistical analysis. Within one column, treatments with identical letters are not significantly different at α = 0.05 by Duncan multi-range test; *: significant difference at α = 0.05

Table 6. Duration of development stages from floral induction to harvest of rambutan induced flowering by floral application of Paclobutrazol in combination with drainage of irrigation channel and plastic mulching of growing bed in Phong Dien district, Can Tho city (Hau et al., 2006c)

<table>
<thead>
<tr>
<th>Development stages</th>
<th>Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floral induction – flower bud emergence</td>
<td>43</td>
</tr>
<tr>
<td>Flower bud emergence – blooming</td>
<td>30</td>
</tr>
<tr>
<td>Total duration of blooming</td>
<td>9</td>
</tr>
<tr>
<td>Fruit set - harvest</td>
<td>98-112</td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
</tr>
</tbody>
</table>

Table 7. Methods of floral induction on ‘Java’ rambutan in the Mekong Delta (Hau et al., 2006c)

<table>
<thead>
<tr>
<th>Method of floral induction</th>
<th>Leaf age (day)</th>
<th>Leaf color when floral induction</th>
<th>No of leaf flush</th>
<th>Concentration of PBZ (ppm)</th>
<th>Bed mulching combined with channel drainage (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50-60</td>
<td>Light green</td>
<td>2-3</td>
<td>400-600 by foliar spraying</td>
<td>30-40</td>
</tr>
</tbody>
</table>

Table 8. Ratio of flowering shoot generated on 24 years old ‘Java’ rambutan trees under effect of foliar induction treatments alone or in combination, viz. Paclobutrazol foliar application, drainage of irrigation channel, and growing bed plastic mulching in Phong Dien district, Can Tho city (Hau et al., 2006c)

<table>
<thead>
<tr>
<th>PBZ concentration (PBZ) (ppm)</th>
<th>Bed plastic mulching (MP)</th>
<th>Mean</th>
<th>Difference (A-B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Practiced (A)</td>
<td>Not practiced (B)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>75.1</td>
<td>61.5</td>
<td>68.3 c</td>
</tr>
<tr>
<td>200</td>
<td>84.7</td>
<td>61.4</td>
<td>73.1 bc</td>
</tr>
<tr>
<td>400</td>
<td>92.3</td>
<td>74.4</td>
<td>83.3 ab</td>
</tr>
<tr>
<td>600</td>
<td>92.0</td>
<td>81.1</td>
<td>86.6 a</td>
</tr>
<tr>
<td>Mean</td>
<td>86.0</td>
<td>69.6</td>
<td>77.8</td>
</tr>
</tbody>
</table>

CV (%) = 14.4
F (MP) = *
F (PBZ) = **
F (MP*PBZ) = *

Within one column, treatments with identical letters are not significantly different at α = 0.05 using LSD; ns = non-significant difference at α = 0.05; *, ** significant difference at α = 0.05 and 0.01
Fig. 1. Weight increase (a) and growth rate (b) of fruit components of ‘Xuong Com Vang’ longan cultivar from fruit set to harvest at Chau Thanh district, Dong Thap province. Growth rate was calculated based on growth equation proposed by Robertson (1908), $Y' = kx (a – x)$ with ‘x’ as weight of fruit components (Hau and Tram, 2012).

Fig. 2. Weight increase (a) and growth rate (b) of fruit components of ‘E-dor’ longan cultivar from fruit set to harvest at Chau Thanh district, Dong Thap province. Growth rate was calculated based on growth equation proposed by Robertson (1908, Cited by Reed, 1920) (Hau and Huan, 2011)

Fig. 3. Branch cincturing applied as a floral induction treatment on (a) ‘Xuong Com Vang’ and (b) ‘Tieu Da Bo’ cultivar at Chau Thanh district, Dong Thap province (Hau and Chan, 2009)
Fig. 4. Flowering rate (%) of ‘Xuong Com Vang’ longan cultivar in off-season in Chau thanh district, Dong Thap province (Hau and Chan, 2009)

Fig. 5. Color of different leaf ages at one day prior to floral induction with KClO3 at Chau thanh district, Dong Thap province. (a) 30 days after emergence - DAE, b) 37 DAE, c) 44 DAE, d) 51 DAE (Hau and Binh, 2012)

Fig. 6. Flowering rate of ‘E-dor’ longan cultivar under floral induction with KClO3 at different doses in Chau Thanh district, Dong Thap province (Hau and Sen, 2012)
Fig 7: Yield of ‘E-dor’ longan cultivar under floral induction with KClO₃ at different doses in Chau thanh district, Dong Thap province (Hau and Sen, 2012)

Fig. 8. Weight increase of fruit components of ‘Java’ rambutan cultivar at Phong Dien district, Can Tho city (Hau and Duong, 2006)

Fig. 9. The ‘small fruit’ phenomenon as a consequence of failure of fertilization occurring on ‘Java’ cultivar in Cho Lach district, Ben Tre province. (a) Normal development of fruit after fruit set; (b) Abnormal fruit – ‘small fruit’ with non-changed fruit size until normal fruits are harvested (Hau, personal information)
Fig. 10. Floral induction on rambutan by plastic mulching of growing bed in combination with drainage of irrigation channel in Phong Dien district, Can Tho city (Hau et al., 2006c).

Fig. 11. (a) Five months old guava tree was pruned and trained with one main trunk and 1st branches at suitable distance. (b) Ten months old guava tree with well manipulated canopy.

Fig. 12. Pinching and flowering on guava. a) new shoot appearance after pinching, and b) Flowering after pinching.
Fig. 13. Guava fruit is covered with plastic and white foam bag. a) fruit diameter at bagging, b) plastic and white foam bag, c) covered fruit.