Studies on Shoot, Flower and Fruit development in Litchi and Strategies for Production Improvement

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From harvest to fruit production of next season, a chain of interrelated developmental phases are involved.
1. Overview

Each phase requires appropriate management for a good crop.

Shoot elongation → Leaf expansion → Foster high quality bearing shoots

Bud evocation → Leaf maturation → Build up tree C-reserve

Bud break → Bud evocation → Chill → Flower induction → Prevent winter flush

Bud quiescent → Flower induction

Shoot elongation → Leaf expansion → Foster high quality bearing shoots

Bud evocation → Bud quiescent

Harvest → Fruit growth → Blooming → Improve flower quality

Fruit growth

Fruit retention

Promote pollination
2 Growth and Management of Post-harvest Flushes

Post-harvest flushes constitute fruiting shoot of next season

High quality fruiting shoot

↓

High quality flowers (plenty and fertile)

↓

Productive panicle

↓

High quality crop
What are quality fruiting shoots?

Strong and healthy

Abundant reserve

Mature at right time
2 Growth and Management of Post-harvest Flushes

The outer mature leaves on the latest flushes are most functional and are the major feeder for fruit.
The timely growth of flushes

- Pruning time
- Harvest date
- Agro-regulation
- Climate
- Internal growth rhythm

Mature at right time

Flush mature prior to inductive chilly season

- Time window of flowering
- Purity of flowering shoot
2 Growth and Management of Post-harvest Flashes

The Internal growth cycle

- **Shoot elongation**
- **Leaf expansion**
- **Leaf matures after full expansion (delayed greening)**

Graph showing the growth cycle with timelines and measurements.
2 Growth and Management of Post-harvest Flushes

The internal growth cycle can be regulated.

- **New flush killer (300~500ppm eth)**
- **Shoot elongation**
- **Leaf expansion**
- **Leaf maturation**
- **Bud quiescent**
- **Enforced quiescence**
- **Pruning**
- **Girdling**
- **Urea+KH₂PO₄**
- **Paclobutrazole**
- **Chemicals (400-1000ppm eth ± 1000ppm PP333)**
- **Water withholding**
2 Growth and Management of Post-harvest Flushes

The Internal growth cycle can be predicted

Leaf maturity can be indicated by leaf greenness

SPAD meter: a nice tool to measure it

The turning point of logistic SPAD-days curve is regarded as leaf maturation point. And heat units from bud break till flush mature can be calculated.
The Internal growth cycle can be predicted

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Flush time</th>
<th>Theoretical max. SPAD</th>
<th>mature leaf SPAD</th>
<th>Heat unit from bud break to leaf maturation (°D)</th>
<th>Heat unit of growth check period (°D)</th>
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</thead>
<tbody>
<tr>
<td>BL</td>
<td>Jul</td>
<td>34.7±1.1</td>
<td>26.7±1.1</td>
<td>449.3±19.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aug</td>
<td>34.8±0.6</td>
<td>27.2±0.4</td>
<td>588.5±30.4</td>
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<tr>
<td></td>
<td>Oct</td>
<td>35.3±2.0</td>
<td>26.2±0.8</td>
<td>502.9±31.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave</td>
<td>34</td>
<td>27</td>
<td>513.5±40.5</td>
<td>463</td>
</tr>
<tr>
<td>HY</td>
<td>Jul</td>
<td>50.9±0.7</td>
<td>40.2±0.5</td>
<td>383.2±13.3</td>
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<tr>
<td></td>
<td>Aug</td>
<td>51.6±0.6</td>
<td>37.6±1.2</td>
<td>567.4±36.5</td>
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<tr>
<td></td>
<td>Oct</td>
<td>39.5±1.0</td>
<td>31.1±0.82</td>
<td>545.9±34.3</td>
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</tr>
<tr>
<td></td>
<td>Ave</td>
<td>51</td>
<td>36</td>
<td>498.9±58.1</td>
<td>420</td>
</tr>
</tbody>
</table>

Flush growth needs a sum of heat units of around 500 °D, while Growth check (from cessation of shoot elongation to bud break) needs around 440°D

Heat unit=(daily max T+ daily min T)/2-10 (basal growth T)
The flush growth cycle is strongly influenced by weather. Drought and low temperature slows flush growth and elongates growth check period.
C-reserve is built up as flush matures and increases during growth check period. Duration of growth check period is positively related to C-reserve build-up.
2 Growth and Management of Post-harvest Flushes

Measures suppressing flush growth increase tree C-reserve

🌟 Chemicals

🌟 Root pruning

🌟 Drought

🌟 Girdling
3 Flower induction and its promotion

Phases of flowering and corresponding management

Growing autumn shoots $\rightarrow$ Pre-induction phase $\rightarrow$ Floral induction phase $\rightarrow$ Floral initiation & development phase

Requirements

- Moisture stress
- Inductive chill
- Ascending temp.
- Moderate moisture

November $\rightarrow$ December $\rightarrow$ January $\rightarrow$ February $\rightarrow$ March

Enforced growth check
Chemical/drought/girdling
C-reserve
Increase sensitivity to chill

Induced by chill evocating

Irrigation
Panicle elongation
Ethephon (1000ppm) applied in early October enforced growth check and induced flower, which set quite well
4 Panicle growth and management

Make panicle less leafy

- Marginal chill
- Leafy panicle
- Abortion of rudimentary leaves
- Plenty chill

- Hand removal of young leaves
- Ethyrel: 300-600ppm

- Weak or no panicle
- Pure panicle
Some cultivars like Feizixiao produce large panicles but set poorly.

4 Panicle growth and management

Poor pollen fertility

Incomplete embryo sac
4 Panicle growth and management

Abscising male flowers do not return nutrient to tree

<table>
<thead>
<tr>
<th>Items</th>
<th>Cultivar</th>
<th>Unopened male</th>
<th>Fully opened male</th>
<th>Freshly abscised male</th>
<th>Fully opened female</th>
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</thead>
<tbody>
<tr>
<td>Dry mass (mg/flower)</td>
<td>FZX</td>
<td>1.2*</td>
<td>1.8*</td>
<td>2.2*</td>
<td>5.2*</td>
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<tr>
<td></td>
<td>BTY</td>
<td>1.5</td>
<td>2.1</td>
<td>2.5</td>
<td>3.6</td>
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<tr>
<td>N (g kg⁻¹)</td>
<td>FZX</td>
<td>21.3*</td>
<td>20.5</td>
<td>21.9</td>
<td>31.7*</td>
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<tr>
<td></td>
<td>BTY</td>
<td>24.3</td>
<td>22.4</td>
<td>24.2</td>
<td>25.2</td>
</tr>
<tr>
<td>P (g kg⁻¹)</td>
<td>FZX</td>
<td>2.5*</td>
<td>2.4</td>
<td>2.5</td>
<td>4.1*</td>
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<tr>
<td></td>
<td>BTY</td>
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<td>2.6</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>K (g kg⁻¹)</td>
<td>FZX</td>
<td>12.9*</td>
<td>13.7*</td>
<td>15.1</td>
<td>19.7*</td>
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<tr>
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<td>BTY</td>
<td>14.7</td>
<td>14.9</td>
<td>18.4</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Note: * following the data of ‘FZX’ indi
4 Panicle growth and management

Blooming of large-panicled Feizixiao depletes tree C-reserves

Little C-reserve left for subsequent fruit set
Early fruit set depends on tree-C reserve in addition to leaf photosynthesis.

Measures are taken to reduce panicle size to save some C-reserve for fruit from blooming consumption.
4 Panicle growth and management

Measures to reduce panicle size or flowering consumption

- Panicle shortening: Prior to and after initial bloom
- Shortening during panicle elongation may stimulate growth of laterals and less effective in reducing panicle size
- Flower thinning
- Hand thinning
- Ethyrel (~150ppm)
4 Panicle growth and management

Measures to reduce panicle size or flowering consumption

Some farmers thin Wuheli (seedless litchi) panicle like this to produce large and even sized high priced fruit
Reducing panicle size does increase set

4 Panicle growth and management

Fruit set per panicle

Shortening at early anthesis
Shortening during elongation

Early panicle removal
Shortening during elongation
Factors regulating fruit abscission

Factors increasing ethylene supply:
- ABA
- Wounding
- Disease
- Drought
- Ethylene

Factors increasing auxin supply:
- Active growth
- Fertilization
- Seed growth

Factors decreasing auxin supply:
- Ethylene
- Low light
- Wounding
- Senescence

Factors increasing sensitivity to ethylene:
- Water stress
- ABA
- Pollination
- Low light

Factors increasing sensitivity to auxin:
- CTKs
- Calcium
- Fertilization
- High light
- Auxin

Roy Sexton (1997)
5 Fruit development and management

 Strategies to increase fruit set

S1: Enable sufficient initial fruit set

Successful pollination
Introduce pollinators to orchard

Post-pollination auxin application 2,4-D (~5ppm)

Plenty of initial fruit set suppresses summer flush which induces massive drop
5 Fruit development and management

 Strategies to increase fruit set

 S2: Suppression competing growth

 Various girdling treatments
5 Fruit development and management

Strategies to increase fruit set

S3: Control of pests and diseases

S4: Application of counter-ethylene regulators in cases of stresses
  - Auxins (2.4-D, NAA, 3,5,6-TPA) / gibberellins (GA3) / cytokinins (6-BA, CPPU)

S5: Foliar application of organic nutrient in case of long term shading
  - Sugars & amino acids (from fermentation or sugar processing)

Always remember:
Fostering high quality bearing shoot is the fundament for a good crop
5 Fruit development and management

 Practices to enhance fruit growth

 ★ Sufficient irrigation and fertilization

 ★ Foliar application of micro-minerals in deficiency at early stages

 Healthy fruit

 Stunted yellow fruit related low Zn
5 Fruit development and management

 Practices to enhance fruit growth

 ★ Ca important for cell wall construction

 Liming or foliar spray in early fruit stages: for good fruit size and cracking resistance
5 Fruit development and management

Practices to enhance pigmentation

Bagging with white fiber bags produces beautiful and clean fruit free of pests
ABA and glutamic acid promote pigmentation while CPPU inhibits it.
5 Fruit development and management

Protect fruit from pests

Netting the trees protects fruit from mangy pests and saves sprays
谢谢Thank you！