Application of Micro-fertigation in Orchards in South China

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South China area includes Guangdong, Guangxi, Hainan provinces and south part of Fujian province. This area is characterized with tropical and subtropical climate and is the major production area of tropical and subtropical fruit trees.
Banana, citrus, orange, pineapple, mango, litchi, longan, papaya, carambola and so on are grown with large areas in South China.

Table 1. Major fruit production in 2002 in four provinces of South China

<table>
<thead>
<tr>
<th>Location</th>
<th>Citrus and orange (ton × 10^3)</th>
<th>Banana (ton)</th>
<th>Pineapple (ton)</th>
<th>Litchi (ton)</th>
<th>Longan (ton)</th>
<th>Citrus and orange (ton × 10^3)</th>
<th>Banana (ton)</th>
<th>Pineapple (ton)</th>
<th>Litchi (ton)</th>
<th>cultivation area (ha × 10^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujian</td>
<td>1910</td>
<td>764</td>
<td>38</td>
<td>147</td>
<td>192</td>
<td>163</td>
<td>29</td>
<td>3.8</td>
<td>40</td>
<td>52</td>
</tr>
<tr>
<td>Guangdong</td>
<td>232</td>
<td>2717</td>
<td>462</td>
<td>977</td>
<td>382</td>
<td>105</td>
<td>110</td>
<td>29</td>
<td>256</td>
<td>218</td>
</tr>
<tr>
<td>Guangxi</td>
<td>1372</td>
<td>1073</td>
<td>70</td>
<td>361</td>
<td>355</td>
<td>118</td>
<td>54</td>
<td>5.1</td>
<td>218</td>
<td>32</td>
</tr>
<tr>
<td>Hainan</td>
<td>16.5</td>
<td>853</td>
<td>227</td>
<td>29</td>
<td>6.4</td>
<td>2.6</td>
<td>34</td>
<td>14</td>
<td>32</td>
<td>546</td>
</tr>
<tr>
<td>Total</td>
<td>4530</td>
<td>5407</td>
<td>797</td>
<td>1514</td>
<td>935</td>
<td>388</td>
<td>227</td>
<td>52</td>
<td>546</td>
<td></td>
</tr>
</tbody>
</table>


Total cultivation area reaches **1.21 million ha.**
1. Why should micro-fertigation be used in orchards in South China?

Drip irrigation + micro sprinkler irrigation = micro-irrigation

(1) Drought Seasonal drought (like in autumn and winter) and local drought (like in Leizhou peninsula in Guangdong and eastern region in Hainan) take place frequently. Good irrigation facilities are crucial for big and stable harvest in fruit production.
(2). Most fruit plantations are located on hilly land. Traditional irrigation methods like flooding and furrow irrigation are not suitable in this case. Towline irrigation is a widely used method. However, this method is labor intensive and requires physical efforts.
(3). A large quantity of labors are needed in orchards to manage irrigation and fertilization work. As the labor cost is getting higher and higher in this area, labor cost-effective irrigation and fertilization methods are urgent need for growers.

Banana is regarded as a crop requiring frequent irrigation and fertilization.

Compound fertilizer granules were broadcast on soil surface in a banana orchard (Xuwen county, Guangdong). Fertilizers were applied under citrus canopy (Yingde county, Guangdong).
(4) Other incentives for micro-fertigation use in South China

A. Fruit yield and quality will be improved and fruit yield of higher commercial grades will be increased.

B. Water and nutrient management will be easily operated in orchards with large areas. Micro-fertigation is a key part in fruit standard cultivation.

C. Irrigation and fertilization can be completed more rapidly than conventional practices. This is of practical implication for fruit tree management. Equal and balanced water and nutrient management will result in uniform flushing, flowering and fruiting. Uniform growth is beneficial to practices like chemical application and pruning and even harvesting.
D. To decrease “year-on” and ”year-off” fruiting phenomenon and realize more stable fruit production during growth seasons (esp. litchi and longan).

E. To get early fruiting for young fruit trees.

F. To decrease fruit cracking due to keeping soil moisture stable.

G. To get Early mature fruits and consequently a good price.

H. To reclaim marginal land or soil to grow fruits (such as sandy land, volcanic ash soil in Hainan).

2. Main equipped irrigation methods in South China

pump-driven drip irrigation, gravity drip irrigation, sub-surface drip irrigation, micro-sprinkler irrigation, drip tape, mini-sprinkler tape and so on.
Pump-driven drip irrigation system in Xili litchi orchard

Gravity drip irrigation system on hilly orchards
Gravity drip irrigation in a Huan Pai orchard in Guangdong province

Gravity drip irrigation system in a longan orchard in Guangdong
Mini-sprinkler irrigation on mango and papaya orchards in Hainan

Micro-sprinkler irrigation in tea plantations in Guangdong
香蕉园应用喷水带(海南东方县)
Micro-sprinkler tape irrigation in banana orchards (Hainan)

香蕉园应用喷水带灌溉
Micro-sprinkler tape at working
3. Main micro-fertigation methods in South China
(1) By-pass fertilizer tank

Schematic of by-pass tank

Different types of fertilizer tanks used in orchards in South China
(2) Venturi injector

Water flow direction

High pressure zone
Low pressure zone
Fertilizer container

Venturi injector used in a citrus nursery in Guangdong

广东省四会市砂糖橘育苗基地

Venturi injector used in a citrus nursery in Guangdong
(3) Gravity fertilization method

Water

Fertilizer mixing container

Cistern

Zhang; IPI International Symposium on Fertigation; Optimizing the utilization of water and nutrients; Beijing, September 20-24, 2005
(4) Pump sucking fertilization

Water source

One-way valve

Fertilizer container

Pump
Pump sucking fertilization in a watermelon field (Hainan).

Preparation of stock fertilizer solution on spot

Diesel engine

Pump sucking fertilization on a banana orchard

Fertilizer mixing container
4. Commonly used fertilizers in fertigation in South China

- N: urea, KNO₃, NH₄NO₃, NH₄HCO₃
- P: KH₂PO₄, H₃PO₄, NH₄H₂PO₄
- K: KCl, KNO₃
- Compound fertilizer (water soluble)
- Mg: MgSO₄
- Steeped and composted liquid manure (chicken manure, night soils)
- Light industry waste (monosodium glutamate waste, alcohol waste)
5. Favorable conditions for micro-fertigation use in South China

A. Most orchards are situated on hilly lands. Conventional irrigation and fertilization are labor-consumptive. Growers long for all kinds of labor-saving irrigation and fertilization methods.
B. Many plantations in this region cover relatively large area (more than several dozens of hectares) and many managers or investors are also businessmen from Taiwan, Hong Kong, Singapore and Pearl River Delta area in Guangdong province. They can afford to invest on irrigation equipment. Actually, many of them, esp. some from overseas, seek local technical assistance spontaneously at the start of orchard establishment.

C. As compared with North China, South China receives abundant rainfall that can wash accumulated salts away from wetting zones down into deeper soil layer. There is almost no salt hazard to crops in this area.

D. Irrigation water contains less calcium and magnesium content than that in North China. The dripper and pipe clogging problem caused by chemical precipitation is not serious.
E. Pipes are buried in shallower ditches due to no serious freeze. This may save the cost of system installation. At the meantime, there is no worry about pipe explosion or cracking during winter time due to extra water inside pipes.

F. In many cases, gravity drip or mini-sprinkler irrigation system can be used. This system is easy to operate and manage.
6. Limitations for micro-fertigation use in South China

A. Understanding of micro-fertigation

The annual rainfall in South China averages 1800-2000 mm. This is the main reason that many people think it is not necessary to apply equipped irrigation (or water-saving agriculture) in South China. Micro-irrigation is not only a solution of irrigation, but it also has a lot of advantages. As the labor and fertilizer prices are getting higher and higher, micro-fertigation is becoming an urgent need for growers.

B. Shortage of comprehensive technicians

Even if the growers realize the importance of micro-fertigation, where to get technical assistance is still a question. In present South China, there are few researchers or technicians who know fertigation well. Training technicians or extensionists is a task of top priority. At present, only few people are doing fertigation research and demonstration work in this area.
Self-designed fertigation system in a watermelon field in Hainan

Self-constructed fertilization unit
Self-designed drip irrigation system at a date orchard in Hainan

Same pipe diameter from the head unit to the farthest point in the field and no mulch for the PVC pipes.
C. Imperfect extension system

Due to no perfect extension system or professional associations to organize or spread technology and information of fertigation, the extension speed of this technology in this region is very slow. Sporadic demonstrations show limited effects on extension due to few visitors.

D. No local enterprises involved in fertigation extension

Involvement of enterprises gives impetus to fertigation extension. Unfortunately, at present, there is no one local enterprise in South China providing overall services and equipments. Because equipped irrigation is not widely used in this area, the research and development of fertilizers used in irrigation system is still a question mark.
E. No involvement of technical service companies in extension

Soil and plant analysis, monitoring of soil moisture and nutrients, fertilizers formula and distribution, system maintenance and repair.
Drip irrigation system was established to use the water efficiently

G. Higher initial investment for equipped irrigation

According to the prices of irrigation and fertilization equipment in recent years, the investment of fertigation equipment per hectare is estimated from 550~1800 US$ for field crops.
Field fertigation demonstration work done by South China Agricultural University after 2000

<table>
<thead>
<tr>
<th>Crops</th>
<th>Irrigation methods</th>
<th>Fertilization methods</th>
<th>Automation</th>
<th>Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litchi</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>Yes</td>
<td>52</td>
</tr>
<tr>
<td>Tea</td>
<td>Drip and mini-sprinkler</td>
<td>By-pass tank</td>
<td>No</td>
<td>7</td>
</tr>
<tr>
<td>Longan</td>
<td>Gravity drip system</td>
<td>Gravity fertilization</td>
<td>No</td>
<td>25</td>
</tr>
<tr>
<td>Huan Pai</td>
<td>Gravity drip system</td>
<td>Gravity fertilization</td>
<td>No</td>
<td>20</td>
</tr>
<tr>
<td>Carambola</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Banana</td>
<td>Gravity drip system</td>
<td>Gravity fertilization</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Green date</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Guava</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>No</td>
<td>1.5</td>
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<tr>
<td>Citrus nursery</td>
<td>Mini-sprinkler</td>
<td>Venturi injector</td>
<td>Yes</td>
<td>0.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>mini-sprinkler</td>
<td>By-pass tank</td>
<td>No</td>
<td>12</td>
</tr>
<tr>
<td>Mango</td>
<td>mini-sprinkler</td>
<td>By-pass tank</td>
<td>No</td>
<td>5</td>
</tr>
<tr>
<td>Black pepper</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>No</td>
<td>15</td>
</tr>
<tr>
<td>Asparagus</td>
<td>P-compensated drip</td>
<td>By-pass tank</td>
<td>Yes</td>
<td>5</td>
</tr>
</tbody>
</table>
An example

Drip fertigation demonstration in Xili litchi plantation

Area: 52 ha    Location: Shenzhen, Guangdong

Equipment: P-compensated drip system, by-pass tank, automation control

Litchi cultivars: Feizixiao, Nuomici, Guiwei, Heiye, Huaizhi
Soil moisture monitoring
3 tensiometers: 30cm, 45cm, 60cm depth in soil
Start irrigation: when reading of 30cm tensiometer reaches 15~20 KPa
Stop irrigation: when reading of 60cm tensiometer reaches 0 KPa
Major irrigation stages: at shooting, pre- and post-flowering, fruit development
Making the fertilization plan

1. Soil analysis
   Main items: pH, EC, OM, available N, P, K and Mg

2. Leaf analysis   N, P, K and Mg
Fertilizers applied in fertigation

Laterite soil: 30% clay, 70% sand and gravel
Table 1. A comparison of yield per single tree between fertigation and non-fertigation (kg) in 2001 (off-year)

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Fertigation</th>
<th>Non-fertigation</th>
<th>Increased (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heiye</td>
<td>37.9</td>
<td>0</td>
<td>net 37.9 kg</td>
</tr>
<tr>
<td>Feizixiao</td>
<td>11.5</td>
<td>3.1</td>
<td>266</td>
</tr>
<tr>
<td>Nuomici</td>
<td>6.5</td>
<td>2.4</td>
<td>163</td>
</tr>
<tr>
<td>Guiwei</td>
<td>12.9</td>
<td>2.9</td>
<td>345</td>
</tr>
<tr>
<td>Huaizhi</td>
<td>14.3</td>
<td>4.9</td>
<td>193</td>
</tr>
</tbody>
</table>

2001 was off-year and 2002 was on-year for litchi.
Fertigation could save annual fertilizer input by 73%, labor cost by 96%, electricity cost by 44% and water by 45%.

Table 3. Fertilizer input, water consumption, labor and electricity cost during the 2000/01 through 2001/02 seasons

<table>
<thead>
<tr>
<th>Item</th>
<th>2000/01 Fertigation</th>
<th>2000/01 Non-fertigation</th>
<th>2001/02 Fertigation</th>
<th>2001/02 Non-fertigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer cost (US$/ha)</td>
<td>59.2</td>
<td>229.6</td>
<td>64.2</td>
<td>229.6</td>
</tr>
<tr>
<td>Water used (m3/ha)</td>
<td>1780</td>
<td>3260</td>
<td>1950</td>
<td>3120</td>
</tr>
<tr>
<td>Labor cost (US$/ha)</td>
<td>1.40</td>
<td>44.86</td>
<td>1.48</td>
<td>45.47</td>
</tr>
<tr>
<td>Electricity (US$/ha)</td>
<td>8.17</td>
<td>14.87</td>
<td>9.11</td>
<td>14.08</td>
</tr>
</tbody>
</table>

THANK YOU!