PREVENTION OF ALTERNATE BEARING IN LITCHIS

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ABSTRACT
Alternate bearing is a major problem in litchi production and research aimed at stabilising production is of primary importance. One of the reasons for poor flowering is that premature development of buds in late autumn results in buds that are no longer responsive to cold-induced flower induction. This results in inconsistent flowering and yield. The manipulation of bud development during autumn to ensure bud growth during the cold winter period is therefore crucial. In this trial, the late autumn vegetative flush of ‘HLH Mauritius’ was chemically inhibited by the application of different growth inhibitors. These included Sunny®, Ethephon®, CycoCeCe® and a combination of CycoCeCe® and Ethephon®. Field observations indicated that the development of a vegetative flush could be inhibited during autumn by the application of growth inhibitors. The application of growth inhibitors resulted in a significant reduction in alternate bearing and ultimately higher and more stable yields.

INTRODUCTION

Even if environmental conditions allow it, a litchi tree does not grow continuously (Zimmerman et al., 1971; Batten and Lahav, 1994). New reddish coloured leaves need to harden off before another flush can occur. In South Africa ‘HLH Mauritius’ displays two distinct postharvest vegetative flushes. The first of these is at the end of January or the beginning of February and the second during April/May. If the second flush occurs too close to winter, the buds will remain dormant during the cold and flower initiation will be negatively affected. This is because cool temperatures only affect the growing bud’s fate from the time the buds start to swell, until they are a few millimetres in length (Olesen et al., 1996). Cold weather after this stage of bud development will not induce flowers. It only takes a couple of days of low temperature to trigger flowering if the buds are in the correct stage of development. However, at any one time, the buds on a tree are in various stages of development. Buds on the upper branches of a tree start to develop before buds on the lower branches. The result of this is that for an entire tree to flower well, a cold spell lasting for at least two weeks is required. The timing of bud break is vitally important to ensure good flowering in the litchi.

Manipulation of the mid-late autumn vegetative flush traditionally is achieved by applying water stress before the onset of winter. In addition to this, the application of fertiliser, growth inhibitors and girdling are important manipulation techniques used in major producing countries such as China.

This paper deals with the chemical inhibition of vegetative growth which takes place by one of three basic methods: a) by destroying the apical buds of branches or the inhibition of meristematic activity in these buds; b) by shortening the internodes without changing the apical meristematic functions; c) by reducing apical control (Sachs and Hackett, 1972). In the present trial the effect of the growth inhibitors Ethephon®, Sunny® and CeCeCe® on yield and flowering were evaluated.

Ethephon (an ethylene-releasing compound) acts by killing the terminal bud and causes severe disruption in apical meristematic function, inhibits stem elongation by limiting auxin transport (Morgan and Gausman, 1966), causes axillary budbreak, induces early leaf abscission (Sachs and Hackett, 1972), stimulates an increase in stem diameter, causes fruit and leaf abscission, senescence, wilting, fruit ripening and may even cause flowering in certain plants. Li and Chang (1987) found that high concentrations of Ethephon and or might promote flowering in the litchi but this treatment was found to seriously inhibit nutrient levels and to cause leaf drop. It was further found that ethylene in combination with kinetin is more efficient at reducing shoot length and causes flowers to appear a month earlier (Chen and Ku, 1988).

Pineapple and Plumbago flowering is promoted by ethylene and stem elongation is inhibited in pineapples when a low concentration of ethylene is used. Ethylene can also alter the
ratio of male to female flowers. The effect of ethephon on fruit-set depends on the concentration and stage of bud development (Rahemi et al., 1997).

The mode of action of both Sunny® and CCC® involves interference with the synthesis of cytokinins (Rademacher, 1989) and gibberellins (Sachs and Hackett, 1972) and also the metabolising of abscisic acids (Rademacher, 1989). Growth inhibitors may also reduce sucrose transport to shoot tips, change CO₂ assimilation rates, interfere with metabolic reactions and reduce auxin synthesis (Sachs and Hackett, 1972). In the litchi, ringing and exogenous auxins reduce vegetative flushing and increase flowering (Menzel, 1983).

**MATERIALS AND METHODS**

**Initial trial carried out during 1998 – an “on year”**

The initial trial was carried out during 1998 and was conducted at the Burgershall research farm. A single foliar application of five different concentrations and mixtures of Sunny® (uniconazole), CCC® (chlormequat chloride; CeCeCe) and Ethephon® (Table 1) was applied to five-year-old litchi trees. At the time of spraying the growing buds of the second flush were developing (early April). The effect that these applications had on the percentage flowering, time of flowering and yield efficiency was subsequently determined.

**Trial carried out during 1999 – an “off year”**

During the second week of April 1999 a single foliar application of six different concentrations and mixtures of Sunny®, CCC® and Ethephon® (Table 2) were applied to eight-year-old litchi trees in the Onderberg area. The effect of these applications on yield was measured.

**Table 2 Different chemicals and their concentrations used in the growth inhibitor trial during 1999**

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Concentration</th>
<th>No of applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC and Ethephon</td>
<td>0.2%</td>
<td>1</td>
</tr>
<tr>
<td>CCC and Ethephon</td>
<td>0.4%</td>
<td>2</td>
</tr>
<tr>
<td>Sunny</td>
<td>0.5%</td>
<td>1</td>
</tr>
<tr>
<td>Sunny</td>
<td>0.2%</td>
<td>2</td>
</tr>
<tr>
<td>CCC</td>
<td>0.4%</td>
<td>1</td>
</tr>
<tr>
<td>CCC</td>
<td>0.5%</td>
<td>2</td>
</tr>
<tr>
<td>Control</td>
<td>No application</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 3 The different growth inhibitors and their concentrations as applied during the 2000 trial in the Onderberg area**

<table>
<thead>
<tr>
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</tr>
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<td>Sunny</td>
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<td>1</td>
</tr>
<tr>
<td>Sunny</td>
<td>0.5%</td>
<td>2</td>
</tr>
<tr>
<td>Ethephon</td>
<td>0.05%</td>
<td>1</td>
</tr>
<tr>
<td>Ethephon</td>
<td>0.2%</td>
<td>2</td>
</tr>
<tr>
<td>Control</td>
<td>No application</td>
<td>0</td>
</tr>
</tbody>
</table>

**RESULTS**

During the 1998 trial, the yields of all the treatments except for the 0.1% Ethephon® treatment were found to be higher than the control (Figure 3). However, the differences were not statistically significant. The 1999 season was an “off year” and the yields obtained with the CCC plus Ethephon®, Sunny® and Ethephon® treatments were significantly higher than that of the control (Figure 4). CCC® on its own did not affect yield significantly. The increase obtained with 0.4% CCC® plus 0.1% Ethephon® and 0.2% CCC® plus 0.1% Ethephon® treatments were an amazing 84.11% and 83.6% respectively.

**Trial carried out during 2000**

The different treatments evaluated during the 2000 season are presented in Table 3. The first foliar application of growth inhibitors was applied during the third week of April and a follow-up application was done during the beginning of May. The trees were seven years old and the trial was conducted in the Onderberg area. Yield and fruit size data will be collected at harvest.
DISCUSSION

The results clearly indicate that manipulation of the mid to late autumn vegetative flush with growth inhibitors significantly increases the number of flowering branches in 'HLH Mauritius' trees (Figure 1). Ethephon on its own and in combination with CCC® promotes flowering. Pineapple and Plumbago flowering is also promoted by ethylene.

All the young leaves on the trees treated with Ethephon® and a combination of CCC® plus Ethephon® were found to abscise (Figure 2). In addition to improved flowering, a 0.1% Ethephon® treatment brings about earlier flowering (Klitt, 1999) but not earlier fruit ripening. The reason for this is an interesting area of research. Klitt (1999) discussed the possible effect of the drop of young leaves on gibberellic acid levels and flowering.

Figure 2 Ethephon treatment causes the drop of young leaves and reduces shoot length.

Ethephon® at a concentration of 0.1% reduced yield during an "on year" (Figure 3). Extremely cold winds were experienced during the early parts of 1999. When this cold spell appeared, the Ethephon® treated trees had female flowers that were open while most of the female flowers were still closed on the other trees. Cold damage to female flowers, poor pollination, poor pollen tube growth or abscission of young fruit as a result of higher ethylene concentrations are possible reasons for the reduced yield. On the other hand, the 0.5% Ethephon® treatment significantly increased yield during 1999 (Figure 4).

CCC® on its own does not increase yield and this treatment is not recommended (Figure 4). On the other hand, CCC® plus Ethephon® have the best yield results (Figure 4). However, increasing the CCC® concentration from 0.2% to 0.4% while keeping the Ethephon® concentration at 0.1% did not increase the yield significantly. A concentration of 0.2 CCC® is thus recommended in combination with 0.1% Ethephon®.

Sunny® improved litchi yield during an "on" as well as during an "off year" (Figure 3; Figure 4). The increase in yield is not significant during the "off year". Although fruit size data was not taken it would appear that the improved production attained with Sunny® was due to the production of bigger fruit rather than an increase in flowering (Figure 1). In addition to fruit size, better fruit retention can also increase yield and it is possible that treatment with Sunny® improved both fruit size and fruit retention.

If we consider the costs of the products (Table 4), then the increase in yield justifies the application of growth inhibitors.

CONCLUSION

Growth inhibitors can be successfully used to reduce alternate bearing and the best results were obtained with a combination of CCC® (0.2%) and Ethephon® (0.1%). Increasing the concentration of CCC® to 0.4% did not increase yield significantly. Sunny® is a more expensive product but also gave good results. No residue tests have been done and none of these products are registered for litchi. The results are very promising but the long-term effect of growth inhibitors on trees are not known at this stage. Further research on this aspect is thus essential.
REFERENCES


