Foliar and soil applications of PBZ also promoted an off-season flowering from August to October in experiment one. The former result probably was due to a drastic reduction of vegetative shoots (Borroto et al., 1986) in favor of floral shoots (Table 1). Borroto et al. found that a high flowering density was associated with a decrease in endogenous content of gibberellic acid on Persian lime leaves (Borroto et al., 1986; Shearling and Voon, 1986). As previously reported, (Monse-lune and Goren, 1981; Shearling and Voon, 1986) the effect of foliar and soil PBZ applications were very similar. However, results on Mexican lime in the tropics indicate that PBZ effects on vegetative and floral shoots had a shorter duration (90 to 120 days) than on other citrus in the subtropics (365 days). Citrus species, climatic conditions and soil type are probably major factors causing these differences.

Trees exhibiting the greatest flowering (observed in August), became severely infected with Gloeosporium limetticolum, which caused anthracnose, so that harvest at winter season (January to March) was low in experiment one.

Foliar and PBZ soil applications between April and August promoted an unexpected flowering between July and October. This result is very important because fruit resulting from August to October blooms are harvested from December to March when fruit prices are higher and will have a tremendous economical impact on Mexican lime growers.

**Literature Cited**


**EFFECT OF PACLOBUTRAZOL AND SEVERE PRUNING ON MANGO TREES CV TOMMY ATKINS AT HIGH DENSITIES**

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Additional index words. Early flowering, early fruit, production, tree size, vegetative growth, shoot length.

Abstract. To evaluate the effect of severe pruning and paclobutrazol (TZ) applications on vegetative growth, flowering and yield of mango trees cv Tommy Atkins, three experiments were conducted over three years at Tecoman, Colima. The orchard was 5 yr-old and planted at a distance of 4 x 4 m. Experiment one was initiated in July 1992 to evaluate foliar and soil drench applications of TZ on pruned trees and compared with only pruned and control trees. Trees 3.8 m height were severely pruned at 2.0, 2.5 and 3.0 m height to control tree size. Experiment two was conducted to evaluate different dates of TZ foliar and soil applications on severely pruned trees in September 1993. Experiment three was carried out to evaluate mainly different dates of soil TZ applications. Results of experiment one showed that TZ soil applications alone or plus pruning increased 2.5 to 3.3 times total yield in comparison with control trees. Fruit yield on TZ soil applications was measured 30 days earlier (April) than on other treatments including control trees. Yield was strongly reduced by severe pruning (branches of 3.7 to 4.7 cm of diameter) applied in September 1993 in all treatments of experiment two. Less severe pruning of trees was more productive (20.0 T/ha) than control pruned trees (3.0 T/ha). Experiment three showed that soil TZ application made in February increased yield 12.6 ton/ha in relation to control trees. Results of the three experiments showed, that with TZ soil applications, mango tree size was reduced 30 to 40% in relation to control trees.

Thirty five thousand ha of mango (Mangifera indica L.) trees are cultivated at the Pacific Central West region of Mexico. This acreage is about 30% of total mango growing area in Mexico (Medina-Urrutia, 1993). Fifty percent of the total fruit volume exported to U.S.A and Canada comes from this region. The chief exported varieties are 'Tommy Atkins' and 'Haden'. Trees are established at 10 x 10 m distance and when they are 9 years-old, because of favorable soil and climatic conditions, they reach 8-10 m height. However such vigorous trees are difficult to harvest, and difficult to spray. The vigorous size of the tree also reduces the potential to increase...
yield by having a higher number of trees/ha, as had been reported for other fruit crops; but a major disadvantage in high density plantings is the control of canopy size (Charnvichit et al., 1994).

Mango tree size had been controlled using rootstocks and interstocks with dwarf characteristics, less vigorous varieties, pruning and growth retardants (Kohne and Kremer-Kohne, 1990; Medina-Urrutia, 1993; Salazar-G. and Perez-R., 1991; Whiley, 1984). However, most of these alternatives requires long term studies, except those regarded with pruning and growth regulators.

Pruning reports to control tree size are scarce (Charnvichit et al., 1994; Kohne and Kremer-Kohne, 1990), but there are not reports of the effect of both practices on yield.

The objective of present work was to determine the effectiveness of TZ on vegetative growth, flowering and yield on rarely pruned mango trees cv Tommy Atkins planted in a high density system.

**Materials and Methods**

For the study five yr-old mango cv Tommy Atkins, an orchard planted at 4 x 4 m distance established on a sandy-clay loam at Tecoman, Colima, Mexico was selected. The present work consisted of three experiments initiated in July 1992.

**Experiment one.** In July 1992, trees 3.8 m height and 3.8 m canopy diameter were subjected to the following treatments: Control; severe pruning at 2.0, 2.5 or 3.0 m height respectively; pruning at 2.5 or 3.0 m plus addition of the growth retardant Triazol (TZ) sprayed to foliage at 2000 ppm; pruning at 2.5 or 3.0m plus TZ soil drench applications; or a TZ soil drench. Pruning was done in July at the same time of TZ applications. Diameter of pruned branches were 0.6 to 3.5 cm. Sprays were made on new tender leaves that emerged in August. Ten ml of TZ a.i. per tree was added to soil in a collar drench around the tree trunk. A one way completely randomized experimental design was used; each treatment was replicated eight times; one tree was used as an experimental unit. Tested variables are shown on Tables 1 and 2.

**Experiment two.** A severe pruning was done on trees of all treatments in September 1993 in order to reduce tree size from 3.8 m to 1.8 m height and reduce excessive tree shadow. Treatments evaluated were as follow: 1) Control; TZ foliar sprays in November 1993 (N/93), December 1993 (D/93) or

**Table 1.** Height, canopy diameter, yield and early season fruit production of mango trees cv Tommy Atkins treated with pruning and growth retardants (1992).

<table>
<thead>
<tr>
<th>Treatments'</th>
<th>Height (m)</th>
<th>Canopy diameter (m)</th>
<th>Yield T/Ha</th>
<th>Early season fruit production T/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Control</td>
<td>3.6 a</td>
<td>4.1 a</td>
<td>3.7 a</td>
<td>3.7 a</td>
</tr>
<tr>
<td>2 P-2.0 m</td>
<td>3.8 a</td>
<td>3.1 cd</td>
<td>3.9 a</td>
<td>2.8 c</td>
</tr>
<tr>
<td>3 P-2.5 m</td>
<td>3.7 a</td>
<td>3.8 ab</td>
<td>3.9 a</td>
<td>3.6 ab</td>
</tr>
<tr>
<td>4 P-3.0 m</td>
<td>3.9 a</td>
<td>3.9 a</td>
<td>3.8 a</td>
<td>3.6 ab</td>
</tr>
<tr>
<td>5 P-2.5 + TZ/FS</td>
<td>3.8 a</td>
<td>3.8 ab</td>
<td>3.9 a</td>
<td>3.6 ab</td>
</tr>
<tr>
<td>6 P-3.0 + TZ/FS</td>
<td>3.7 a</td>
<td>3.8 ab</td>
<td>3.9 a</td>
<td>3.6 ab</td>
</tr>
<tr>
<td>7 P-2.5+TZ/S</td>
<td>4.0 a</td>
<td>2.9 d</td>
<td>3.9 a</td>
<td>3.0 bc</td>
</tr>
<tr>
<td>8 P-3.0+TZ/S</td>
<td>3.9 a</td>
<td>3.5 bc</td>
<td>3.9 a</td>
<td>3.1 bc</td>
</tr>
<tr>
<td>9 TZ/S</td>
<td>3.8 a</td>
<td>3.5 abcd</td>
<td>3.8 a</td>
<td>3.8 a</td>
</tr>
</tbody>
</table>

*P = pruning; TZ = Triazol; FS = Foliar spray; S = Soil applications.
'April-May, 30 days before the normal harvest.

**Table 2.** Vegetative and flowering response of mango trees cv Tommy Atkins to pruning and TZ applications (1992).

<table>
<thead>
<tr>
<th>Treatments'</th>
<th>VEGETATIVE SHOOTS (%)</th>
<th>SHOOT NO.</th>
<th>SHOOT LENGTH (cm)</th>
<th>FLOWERING (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEPT</td>
<td>JAN</td>
<td>MAR</td>
<td>SEPT</td>
</tr>
<tr>
<td>1 Control</td>
<td>36 b</td>
<td>53 bcd</td>
<td>21 cd</td>
<td>0.7 c</td>
</tr>
<tr>
<td>2 P-2.0 m</td>
<td>94 a</td>
<td>87 a</td>
<td>72 a</td>
<td>4.7 a</td>
</tr>
<tr>
<td>3 P-2.5 m</td>
<td>87 a</td>
<td>88 a</td>
<td>59 a</td>
<td>3.3 a</td>
</tr>
<tr>
<td>4 P-3.0 m</td>
<td>87 a</td>
<td>81 ab</td>
<td>44 abc</td>
<td>3.1 ab</td>
</tr>
<tr>
<td>5 P-2.5 + TZ/FS</td>
<td>93 a</td>
<td>81 ab</td>
<td>67 a</td>
<td>3.4 b</td>
</tr>
<tr>
<td>6 P-3.0 + TZ/FS</td>
<td>93 a</td>
<td>73 abc</td>
<td>47 ab</td>
<td>3.6 a</td>
</tr>
<tr>
<td>7 P-2.5+TZ/S</td>
<td>87 a</td>
<td>46 cd</td>
<td>28 bcd</td>
<td>3.6 ab</td>
</tr>
<tr>
<td>8 P-3.0+TZ/S</td>
<td>85 a</td>
<td>41 de</td>
<td>29 bcd</td>
<td>3.2 b</td>
</tr>
<tr>
<td>9 TZ/S</td>
<td>5 c</td>
<td>14 e</td>
<td>14 d</td>
<td>0.1 c</td>
</tr>
</tbody>
</table>

*P = pruning; TZ = Triazol; FS = Foliar spray; S = Soil applications.
Shoot number registered 10 cm below the apical position of the branch.
Flowering and shoot growth was registered on new shoots emerged after pruning treatment, except on control and TZ/S treated trees.

N + D 93 respectively; TZ soil drench in N/93, D/93, February 1994 (F/94) or May 1994 (M/94); pruning + TZ soil drench applied in July 1992; or a TZ soil drench in July 1992. Foliar sprays were the same as those of the former experiment. Diameter of pruned tree branches were 3.7 to 4.7 cm on average. Tested variables are shown in Tables 3 and 4.

**Experiment three.** This year, most of the trees remained unpruned. Since pruning and foliar sprays of TZ did not have a beneficial effect in the former two experiments, selected treatments consisted mainly of TZ soil applications. By this year, 50% of trees were removed from the orchard and the remaining trees were adjusted to 8 x 4 m distance. Treatments applied this year were similar to former year and appear in Tables 5 and 6. Differences were only on treatments 8 and 9 that were pruned in July 1994, but only trees of treatment number 8 received TZ soil applications of 7.5 ml a.i per tree. Besides, trees with treatment 7 received half (4.0 ml) of the TZ soil dosage applied in July 1992.

**Results**

**Experiment one - 1992**

**Tree growth.** Pruned trees, or pruned + TZ sprayed and control trees, were more vigorous than those trees receiving pruning + TZ soil applications (Table 1).

**Yield and early season fruit production.** Triazol soil application, on both pruned and unpruned tree showed the highest yield. Control unpruned trees produced one-third the fruit as those treated with TZ soil applications. Pruning alone decreased yield in relation to control trees. TZ sprays had little beneficial effect on yield. (Table 1).

**Vegetative and flowering response.** Severe tree pruning showed a strong effect on vegetative growth, shoot number and shoot growth as compared with control and TZ soil applications treatments (Table 2). Vegetative shoot percentage and shoot number in the first flushing measured two months after tree pruning was higher and similar on all pruned trees. However, flushings that occurred in January and March showed a decrease in vegetative shoot percentage on pruned and TZ soil applied trees. Shoot number on a second vegetative flush measured in October was reduced only at 3.0 + TZ/S treatment. Trees receiving only TZ soil application showed the lowest vegetative shoot percentage and shoot number. It was observed that lowering the pruning resulted on a higher shoot number.

In the first flush measured in September shoot growth was similar on trees subjected to pruning with or with out TZ and the control trees. Trees treated only with TZ soil applications showed the shortest shoot length. During the second flush (October) shoot growth was decreased by TZ soil application treatment. Similar results were observed for the following three flushing until March, but data are no presented here.

Two important flowering seasons were observed, one in late-December/early-January and the second in March. Normal flowering season is in late-January early-February, when mean minimum temperature is below 15°C. The early flowering was higher on trees treated with TZ soil application in re-
Treatments’ TZ was applied complete 1992 (10.0 ml TZ a.i/tree) and half dosage at 1994 (4.0 ml TZ a.i/tree).

Table 5. Tree size, yield and early season fruit production of mango cv Tommy Atkins subjected to TZ soil drench applications (1994).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Height (m)</th>
<th>Canopy diameter (m)</th>
<th>Trunk circumference (cm)</th>
<th>Early Apr-May</th>
<th>Normal Jun-Jul</th>
<th>Total Yield T/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Control</td>
<td>4.4 a</td>
<td>4.3 a</td>
<td>48 a</td>
<td>30.0 a</td>
<td>35.0 a</td>
<td>65.0 a</td>
</tr>
<tr>
<td>2 TZ/FS NOV+DIC 93</td>
<td>4.3 a</td>
<td>4.2 ab</td>
<td>45 ab</td>
<td>29.2 a</td>
<td>32.3 a</td>
<td>61.5 a</td>
</tr>
<tr>
<td>3 TZ/S JULY 93</td>
<td>4.0 a</td>
<td>3.7 ab</td>
<td>42 ab</td>
<td>29.2 a</td>
<td>32.3 a</td>
<td>61.5 a</td>
</tr>
<tr>
<td>4 TZ/S NOV 93</td>
<td>3.8 a</td>
<td>3.5 ab</td>
<td>40 ab</td>
<td>28.2 a</td>
<td>31.3 a</td>
<td>59.5 a</td>
</tr>
<tr>
<td>5 TZ/S DEC 93</td>
<td>4.1 a</td>
<td>4.2 ab</td>
<td>47 a</td>
<td>27.2 a</td>
<td>30.3 a</td>
<td>57.5 a</td>
</tr>
<tr>
<td>6 TZ/S FEB 94</td>
<td>4.0 a</td>
<td>4.1 ab</td>
<td>46 a</td>
<td>26.2 a</td>
<td>29.3 a</td>
<td>55.5 a</td>
</tr>
<tr>
<td>7 TZ/S JULY 92+94</td>
<td>2.5 b</td>
<td>2.7 c</td>
<td>42 ab</td>
<td>14.6 bc</td>
<td>16.4 bc</td>
<td>31.0 bc</td>
</tr>
<tr>
<td>8 TZ/S+ P JULY 94</td>
<td>2.9 b</td>
<td>3.2 bc</td>
<td>40 b</td>
<td>24.1 a</td>
<td>15.4 bc</td>
<td>39.6 ab</td>
</tr>
<tr>
<td>9 P JUL 94</td>
<td>4.2 a</td>
<td>4.1 ab</td>
<td>44 ab</td>
<td>3.9 c</td>
<td>26.1 ab</td>
<td>30.0 bc</td>
</tr>
</tbody>
</table>

P = Pruning; TZ = Triazol; FS = Foliar Spray; S = Soil application.
TZ was applied complete 1992 (10.0 ml TZ a.i/tree) and half dosage at 1994 (4.0 ml TZ a.i/tree).

Experiment three - 1993

Vegetative and flowering responses. New shoot number per terminal twig was promoted by severe pruning in all treatments. Trees sprayed with TZ in November, December or both months did not reduce shoot number on flushings observed in December, February and April. But, trees treated with TZ soil drench applications in July 1992 showed the lowest shoot number per terminal shoot in December and February (Table 4).

Flowering was strongly reduced by pruning. TZ soil drench applications made in early July 1992 showed the highest percentage of floral shoots. Also TZ soil applications in May showed good flowering percentage, but was more due to the slight pruning applied to trees than to the effect of growth retardant applied after the season of flowering. All treatments showed a very late flowering season because by that time low temperatures started and very few mature shoots were on the trees (Table 4).

Vegetative flushing number and shoot expansion was reduced only by TZ soil drench applications. Foliar sprays of the growth retardant did not have an effect on either variable. Fewer number of vegetative flushes and shorter length of shoots probably promoted early shoot maturation and a higher percentage of flowering that in the other treatments (Table 4).

Experiment three

Tree size. The smallest tree size was obtained on trees treated with TZ soil applications made in July 1992 and again in 1994 (Table 5).

Yield and early season fruit production. Total yield was higher on trees treated with TZ soil application in February 1994. This treatment produced 12.6 T/ha more fruit than control trees. Trees that were treated with soil application in February...
and July 1994 produced more early season fruit than the other treatments (Table 5).

Vegetative and flowering responses. The higher percentage of new vegetative shoots were observed on trees pruned in July 1994 followed by trees treated with TZ soil drench in July 1992. Percentage of vegetative shoots were low in most treatments due to TZ soil drench applications (Table 6).

Flowering percentage increased during early January due to treatments in which TZ soil drench application were made more recently in relation to control or pruned trees (Table 6). More, but later, flowering in control trees was measured mid-February. Pruned trees in July 1994 and 1992 TZ soil drench applications showed the lowest percentage of flowering in all the treatments during the whole season.

Discussion

Experiment one. After severe pruning applied in July 1992, new shoots developed quickly. Flushing number (data not presented) and shoot number per terminal were increased. New shoots were longer than in control trees. Trees subjected to pruning treatment showed late flowering and low yield. Tree size after one year of pruning was the same as control. Foliar sprays of TZ growth retardant on pruned trees had no beneficial effects. But TZ soil drench treatments on pruned or unpruned trees controlled tree size as a consequence of a reduction on shoot number and shoot length. Also an early flowering of 30 days and early-yield was observed on TZ soil treated trees. Final yield was also increased by TZ soil applications. This report was in agreement with several evidences that have observed similar results (Charnvichit et al., 1994; Kohne and Kremer-Kohne, 1990; Rowley, 1990; Salazar-G. and Perez-R, 1991; Voon et al., 1991).

Experiment two. Tree pruning in September 1993 was more severe than that applied in July 1992. Tree size was reduced to 1.8 m height with pruning in all treatments, except one that was only slightly pruned (2.8 m). Tree size control was tried with TZ foliar or soil drench applied at different times. Similar results than that of 1992 were observed in 1993 on trees subjected to pruning. Foliar spray again had no effect on tree size neither on vegetative and floral shoots. TZ soil drench dosages applied to the tree were reduced in several treatments. Flushing number, shoot number and length of shoots were reduced by TZ soil applications, but pruning was so severe that no differences in tree size were noted after one year between control and TZ soil treated trees. Smaller trees were observed only with TZ soil treated trees applied one year before (July 1992) and with high TZ dosage. Yield was strongly reduced by the time of pruning in mid-September 1993 closer to the period of flowering induction (late-November-December).

Experiment three. For this year only trees of one treatment were hard pruned. Reapplication of complete TZ (7.5 ml a.i.) and half dosage (4.0 ml a.i.) soil treatments two years after first high dosage (10.0 ml a.i.) maintained trees of smaller size than other treatments.

Early addition of soil TZ to trees in November and December of 1993 produced higher yields of fruit in 1995 than in 1994 because the growth retardant was applied closer to flowering time in 1993 and had little effect this year. But TZ soil application in February improved total yield and produced a higher percentage of early fruit production than other treatments in 1995.

Yield was decreased by 1995 in treatments when TZ soil applications were made in July 1992; this was probably due to lower number of flushes observed on those trees. This response was improved by pruning at the same time of TZ applications. Repeated TZ soil applications, if not done at the same as pruning, did not improve yield.

Literature Cited


