# Flowering Synchronization of Sensation Mango Trees by Winter Pruning

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**ABSTRACT**

**To synchronize flowering, all of the terminal shoots on separate sets of Sensation mango trees were pruned on a number dates occurring just prior to and during the flowering period. Pruning was performed 5 cm beneath the site of apical bud or inflorescence attachment or at this site. Only trees in their 'on' year were pruned.**

**Flowering was effectively delayed in accordance with pruning date due to the consequent development of axillary inflorescences beneath the pruning cuts. Flowering was synchronized, and resulted in a reduction in variability of the stage of fruit maturation at harvest. Flowering intensity was increased by winter pruning due to the enhanced number of inflorescences developing per terminal shoot. Fruit drop was also increased. Tree yield was unaffected due to a compensatory increase in fruit size. Stage of fruit maturation at harvest and time of flowering were inversely related. A reduction in fruit retention and tree yield was associated with pruning the terminal shoots 5 cm beneath the site of apical bud or inflorescence attachment, as opposed to at this site.**

**Our results show that winter pruning can be recommended as a measure to synchronize the flowering of Sensation mango trees when the trees are in a positive phase of bearing alternation.**

## INTRODUCTION

In mango, the removal of the apical bud or inflorescence on terminal shoots just prior to or during the flowering period (`winter pruning') results in the development of normally inhibited axillary buds adjacent to the point of cutting (Reece *et al.*, 1946). These buds usually develop as inflorescences, particularly if pruning is performed shortly before or after the start of normal flowering (Issarakraisila and Considine, 1991; Singh *et al.*, 1974). If inflorescences do develop, a delay in flowering of four to eight weeks is effectively caused (Reece *et al.*, 1946; Singh *et al.*, 1974; Gazit, 1975), which may in turn effect a delay in harvest (Issarakraisila and Considine, 1991).

Sensation mango trees growing in the Northern and Mpumalanga Provinces of South Africa flower unevenly. Differences in stage of flowering between trees as well as individual branches on a single tree are encountered. Consequently, the fruit show pronounced variability in time of set, stage of growth and development before harvest, stage of maturation at harvest, and rate of ripening after harvest. As a result, growers find difficulty in adhering to cultural and other management practices whose execution is based on a particular phenological stage. Shippers experience difficulty in choosing a temperature for sea export, in view of the suitability of the storage temperature being dependant on the stage of maturation at harvest (Medlicott *et al.*, 1990; Seymour *et al.*, 1990). Furthermore, foreign and local marketers experience difficulty in marketing fruit that show pronounced variability in rate of ripening.

Uneven flowering has been reported to occur in other mango cultivars (Reece *et al.*, 1949; Lin and Chen, 1981). However, winter pruning or any other measure aimed at reducing flowering variability in mango has not been evaluated previously.

The aim of the present study was to evaluate winter pruning, performed just prior to or during the normal flowering period, as a measure to reduce variability of flowering and of the degree of maturation at harvest. Assessment was also made of the effect of winter pruning on the time and intensity of flowering, on fruit retention, and on tree yield at harvest.

## MATERIALS AND METHODS

In mid-June 1990, 40 Sensation mango trees of uniform size, and which were expected to flower intensely due to them having flushed profusely during the previous summer when they were in their 'off' year, were selected in a commercial orchard at Constantia (latitude: $23^0 40'$S; longitude: $30^0 40'$E; elevation: 457 m) and at Hoedspruit (latitude: $24^0 25'$S; longitude: $30^0 52'$E; elevation: 550 m) in the Northern Province of South Africa. The trees at these sites were six (Constantia) or ten years old (Hoedspruit), and at each site they were treated identically unless stated otherwise.

A factorial treatment arrangement was employed, where the depth and date of pruning were factors. Single trees served as plots in a completely randomized design comprising 10 'unpruned' controls and five replicates of six treatment combinations. In removing the apical buds or inflorescences, every terminal shoot was pruned. Pruning was either performed 5 cm beneath the point of apical bud or inflorescence attachment to approximate the effect of mechanical pruning, or was performed at the base of the apical bud or inflorescence in accordance with `hand pruning' (Factor I). Ten trees were pruned on each of three dates at 14 day intervals (Factor II). Pruning commenced shortly after the general start of flowering as was indicated by visual signs of inflorescence development (July 10 1990 at Hoedspruit; July 18 1990 at Constantia).

The first and last 10 terminal shoots per tree to show inflorescence development were tagged. In the pruned trees, this was done during the reflowering periods. After tagging, inflorescence development and fruit drop occurring on these shoots was monitored weekly. The date on which the most distal inflorescence on each of the first 10 terminal shoots marked per tree was about to enter the rapid phase of primary axis elongation ['pre-shoot' stage as described by Oosthuyse (1991)], and the date on which the most distal inflorescence on each of the last 10 terminal shoots marked per tree had just completed the stage of shedding flowers and panicle axes (`bare panicle' stage), were recorded. The duration of flowering of a tree was determined as the difference between the average date on which the 'first inflorescences' on the tree attained the 'pre-shoot' stage and the average date on which the 'last inflorescences' on the tree attained the 'bare panicle' stage.

To determine the effect of pruning on flowering intensity, the number of inflorescences on each of the tagged shoots and their lengths were recorded once the inflorescences had extended fully. To assess fruit drop from these shoots, the first date on which fruit were seen to be absent on each of them was recorded.

To assess the general differences in stage of fruit maturation and in its variation between the fruits on the control trees and those on each group of trees pruned on a particular date, four fruits were sampled per tree on a number of dates at Constantia. In sampling, one fruit was taken per tree-quadrant on each date. Sampling commenced on Dec. 21 1990, after the rapid phase of fruit growth, and was continued over a period of 12 weeks. On each sampling date, the fruits were individually weighed (for the purpose of yield determination), and after they were cut through transversely, their proportion showing clear signs of pulp colouration was recorded after separately pooling the fruits sampled from each of the tree groups. Fruits dropping to the orchard floor during this period and remaining on the trees afterwards, were individually weighed for the purpose of determining fruit retention, average fruit weight, and tree yield.

On Jan. 23 1991 at Constantia, degree of shoulder development and intensification in pulp colour of the fruits sampled on this date was additionally determined to further ascertain differences in stage of fruit maturation. On Jan. 31 1991 at Hoedspruit, fruits were sampled as at Constantia on Jan. 23 1991, and their degree of shoulder development and pulp colouration was determined. Intensification of pulp colour was assessed on the extent of the transition in colour from white to the deep yellow/orange colour normally seen in a fully ripe fruit. The rating given was either 0, 25, 50, 75 or 100%. Degree of shoulder development was assessed on shoulder height relative to the level of pedicel attachment. The value `0' was assigned when the shoulders had not developed to reach this level. The values '1' and '2' were assigned when the shoulder height equaled and exceeded the level of pedicel attachment, respectively.

Inflorescence diseases, fruit diseases, and insect pests were effectively controlled by regular sprays of fungicides and insecticides. The trees were irrigated regularly either by flood or microjet irrigation, and were fertilized according to commercial recommendations.

Analysis of variance was employed, and appropriate data transformation was performed where necessary.

## RESULTS

### Time and duration of flowering

Flowering of the unpruned trees commenced in July (Tables 1 and 2). Flowering of the pruned trees was generally initiated three to six weeks after pruning. The time taken for flowering to occur after pruning become progressively shorter the later the pruning date. No relationship between pruning depth and the time interval between pruning and flowering was apparent.

Winter pruning was effective in synchronizing flowering as is indicated by the standard deviations for the starting or finishing dates of flowering, and the reduction in tree flowering duration and total flowering duration for the trees pruned on a particular date (Tables 1 and 2). A reduction in flowering duration was apparent the later pruning was performed. A difference in tree flowering duration relating to pruning depth was not apparent.

Flowering intensity, as estimated by the total length of the inflorescences per tagged shoot, was more than double in the pruned trees (Tables 1 and 2). The enhancement was evidently greater when pruning was performed at the site of apical bud or inflorescence attachment than when pruning was performed more deeply. This was apparently due to the presence of the intercalation (clustering of axillary buds at the shoot apex) giving rise to an increase in the number of axillary buds developing in response to pruning (data not shown).

A relationship between flowering intensity and pruning date was apparent at Hoedspruit. Here, the total length of the inflorescences per tagged shoot was greatest when pruning was performed on July 24 (Table 2). This increase corresponded with an increase in the number of inflorescences developing as opposed to an increase in inflorescence length (data not shown).

Flowering was followed by the abscission of the inflorescences not retaining fruit. Consequently, the distal section of the terminal shoots on the pruned trees often became conspicuously 'blind' (devoid of axillary buds).

### Stage and uniformity differences in harvest maturity

In Fig. 1, the proportions of fruit showing clear signs of pulp colouration during January, February and March 1991 are shown for the unpruned trees and each group of pruned trees at Constantia. The general rate at which the proportion increased with time for each group of pruned trees was greater than the general rate shown for the unpruned trees. These differences signify greater uniformity in stage of maturation of the fruit sampled from the pruned trees.

Differences in stage of fruit maturation, as indicated by differences in the intensification of pulp colour and degree of shoulder development of the fruit sampled on Jan. 23 (Constantia) or on Jan. 31 (Hoedspruit) 1991, are shown in Table 3. The stage of maturation of the fruit sampled from the unpruned trees was more advanced than that of the fruit sampled from the pruned trees, and, in considering the fruit sampled from the pruned trees, stage of maturation and pruning date were inversely related. A difference in stage of maturation relating to pruning depth was not apparent.

**Table 1** *Means and contrast significance levels (P) for starting and finishing dates of flowering, days until flowering after pruning, tree flowering duration, and total length of inflorescences per terminal shoot (Constantia).*

| Tree group | Flowering starting date (±SD in days) | Flowering finishing date (±SD in days) | Days to flower after pruning | Tree flowering duration (days) | Total length of inflorescences per shoot (cm) |
|---|---|---|---|---|---|
| Unpruned | July 14 (7) | Sep. 26 (10) | - | 74 (96)[y] | 29 |
| Pruned | Aug. 29 (7) | Oct. 14 (6) | 28 | 46 (66) | 68 |
| Pruning depth: | | | | | |
| 0.5 cm | Aug. 29 (21) | Oct. 14 (12) | 28 | 47 (107) | 78 |
| 5.0 cm | Aug. 29 (22) | Oct. 14 (9) | 28 | 46 (109) | 59 |
| Pruning date: | | | | | |
| July 18 | Aug. 21 (2) | Oct. 8 (2) | 34 | 48 (52) | 70 |
| Aug. 1 | Aug. 29 (3) | Oct. 14 (2) | 28 | 46 (54) | 74 |
| Aug. 15 | Sep. 6 (1) | Oct. 21 (1) | 22 | 45 (49) | 61 |
| ANOVA results - [x]P values | | | | | |
| Interaction (depth x date) | ns | ns | ns | ns | ns |
| Unpruned vs pruned | *** | *** | - | *** | *** |
| Pruning depth | ns | ns | ns | ns | ** |
| Pruning date: | | | | | |
| linear | *** | *** | *** | ns | ns |
| quadratic | ns | ns | ns | ns | ns |

[x]Non-significant (ns) or significant at $P<0.05$ (*), 0.01 (**) or 0.001 (***)
[y]Flowering duration of the tree group

**Table 2** *Means and contrast significance levels (P) for starting and finishing dates of flowering, days until flowering after pruning, tree flowering duration, and total length of inflorescences per terminal shoot (Hoedspruit).*

| Tree group | Flowering starting date (±SD in days) | Flowering finishing date (±SD in days) | Days to flower after pruning | Tree flowering duration (days) | Total length of inflorescences per shoot (cm) |
|---|---|---|---|---|---|
| Unpruned | July 9 (2) | Sep. 25 (9) | - | 78 (101)[y] | 27 |
| Pruned | Aug. 28 (7) | Oct. 13 (5) | 35 | 46 (69) | 64 |
| Pruning depth: | | | | | |
| 0.5 cm | Aug. 27 (24) | Oct. 12 (10) | 34 | 46 (108) | 65 |
| 5.0 cm | Aug. 28 (23) | Oct. 13 (10) | 35 | 46 (104) | 63 |
| Pruning date: | | | | | |
| July 18 | Aug. 19 (5) | Oct. 7 (3) | 40 | 49 (60) | 60 |
| Aug. 1 | Aug. 29 (2) | Oct. 12 (1) | 36 | 45 (50) | 74 |
| Aug. 15 | Sep. 5 (1) | Oct. 19 (1) | 29 | 44 (47) | 58 |
| ANOVA results - [x]P values | | | | | |
| Interaction (depth x date) | ns | ns | ns | ns | ns |
| Unpruned vs pruned | *** | *** | - | *** | *** |
| Pruning depth | ns | ns | ns | ns | ns |
| Pruning date: | | | | | |
| linear | *** | *** | *** | * | ns |
| quadratic | ns | ns | ns | ns | *** |

[x]Non-significant (ns) or significant at $P<0.05$ (*), 0.01 (**) or 0.001 (***)
[y]Flowering duration of the tree group

Fruit drop, and fruit number, average fruit size and yield at harvest

In each tree, the first 10 terminal shoots to show inflorescence development showed a substantially greater capacity to retain fruit than the last 10 terminal shoots to show inflorescence development, irrespective of whether pruning was performed or not (Fig. 2). In considering the first 10 terminal shoots marked per tree, a greater number on the unpruned than on the pruned trees retained fruit. A reversal of this pattern was evident for the last 10 terminal shoots marked per tree, the number retaining fruit generally being greater in the pruned trees.

**Table 3** *Means and contrast significance levels (P) for degree of shoulder development and intensification of pulp colour of the fruit sampled on Jan. 23 (Constantia) and on Jan. 31 (Hoedspruit).*

| | Shoulder development index | | Pulp colouration (%) | |
|---|---|---|---|---|
| Tree group | Constantia | Hoedspruit | Constantia | Hoedspruit |
| Unpruned | 1.54 | 1.57 | 21.3 | 28.7 |
| Pruned | 1.11 | 0.94 | 8.6 | 11.5 |
| Pruning depth: | | | | |
| 0.5 cm | 1.05 | 1.00 | 6.7 | 14.0 |
| 5.0 cm | 1.17 | 0.89 | 10.4 | 9.1 |
| Pruning date: | | | | |
| 1 st | 1.36 | 1.16 | 15.1 | 15.3 |
| 2 nd | 1.09 | 0.81 | 7.3 | 9.3 |
| 3 rd | 0.89 | 0.71 | 3.3 | 4.2 |
| ANOVA results - $^x$P values | | | | |
| Interaction | ns | ns | ns | ns |
| Unpruned vs Pruned | * | ** | *** | * |
| Pruning depth | ns | ns | ns | ns |
| Pruned: | | | | |
| linear | * | * | ** | ns |
| quadratic | ns | ns | ns | ns |

$^x$Non-significant

**Table 4** *Means and contrast significance levels (P) for number of fruit harvested, average fruit weight, and tree yield.*

| Tree group | Number of fruit harvested | Average fruit weight (g) | Tree yield (kg) |
|---|---|---|---|
| Unpruned | 211 | 209 | 44.5 |
| Pruned | 174 | 250 | 42.3 |
| Pruning depth: | | | |
| 0.5 cm | 189 | 248 | 46.0 |
| 5.0 cm | 159 | 252 | 38.9 |
| Pruning date: | | | |
| 1 st | 166 | 245 | 40.2 |
| 2 nd | 185 | 250 | 44.4 |
| 3 rd | 175 | 255 | 43.7 |
| ANOVA results - $^x$P values | | | |
| Interaction | ns | ns | ns |
| Unpruned vs Pruned | * | *** | ns |
| Pruning depth | * | ns | ** |
| Pruned: | | | |
| linear | ns | ns | ns |
| quadratic | ns | ns | ns |

$^x$Non-significant (ns) or significant at $P < 0.05$ (*), 0.01 (**) or 0.001 (***)

At Constantia, a greater number of fruit were harvested from the unpruned than from the pruned trees (Table 4). However, average fruit weight was greater in the pruned than in the unpruned trees. A difference in yield between these tree groups was not apparent. In singly considering the pruned trees, differences in number of fruit harvested, average fruit weight, or tree yield were not evident with respect to pruning date. A reduction in fruit number was associated with deep pruning, however. This reduction was not accompanied by an increase in fruit size, and hence, deep pruning reduced tree yield.

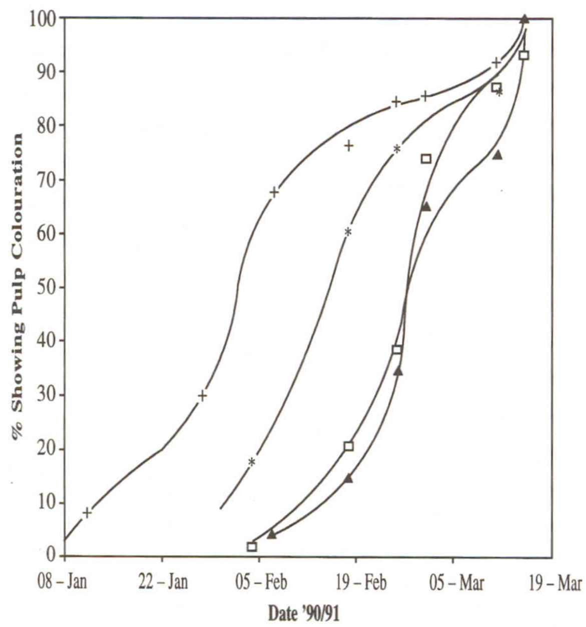


**Fig. 1** *Increases in the proportion of fruit sampled from each tree group showing clear signs of pulp colouration during January, February and March.*

## DISCUSSION AND CONCLUSION

Studies indicating factors determining budbreak in mango are lacking. Flowering synchronization in the present study might be ascribed to the simultaneous wound

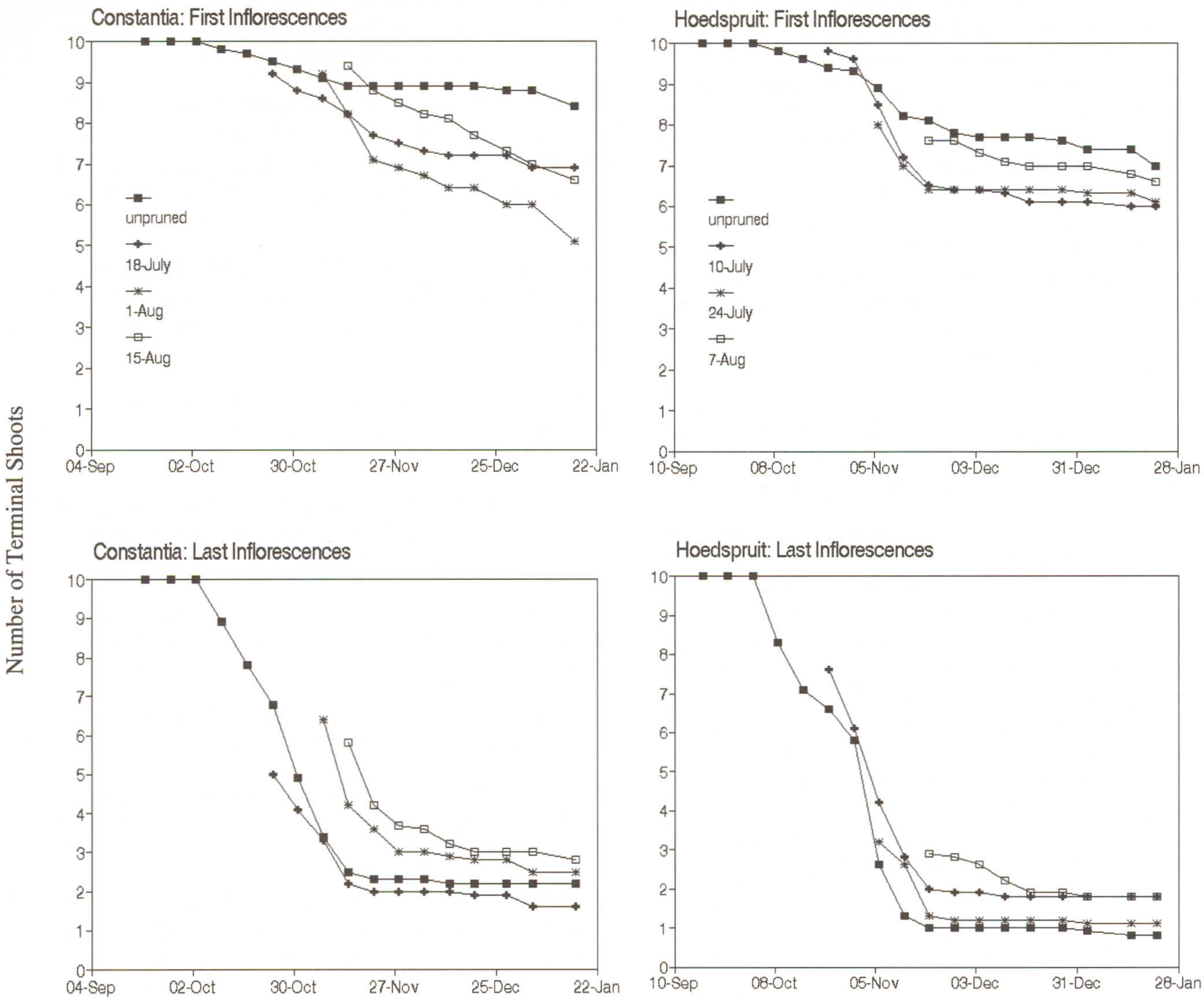


**Fig. 2** *Reductions in the average number of tagged terminal shoots retaining fruit.*

stimulation and release from apical dominance of distally situated axillary buds in similar states of quiescent dormancy at a time when root produced growth substances were not limiting. The reduction in response time with pruning date may have been due to a general increase in ambient temperature, a general decline in the intensity of bud dormancy, and/or an increase in root activity. It might be considered that the absence of an effect relating to pruning depth was due to the absence of pronounced positional differences between the axillary buds in dormancy intensity. Specific studies to elucidate differences in dormancy between axillary buds with respect to their relative position on terminal shoots have not been made in mango.

Winter pruning enhanced the intensity of flowering. At Hoedspruit, the enhancement was greater when pruning was performed on July 24 as opposed to on July 10 or Aug. 7 1990. This was due to increased budbreak. Enhanced budbreak is mainly attributed to increased translocation of root produced cytokinins to shoots and branches due to enhanced root activity (Peel, 1974; Grochowska *et al.*, 1984). This result thus supports the view that root activity was a factor affecting budbreak in the present study.

In the pruned trees, tree flowering duration became shorter the later flowering occurred. This might be expected, since flowering in the pruned trees probably occurred during a period when temperatures were generally increasing. It is noteworthy that a positive effect of increased temperature on the rate of inflorescence development may have contributed to the reduction in flowering variation observed in the pruned trees.

The ability of a fruit to successfully compete for assimilates, and thus be retained, depends on both assimilate availability and the capacity of the fruit itself to act as a sink for assimilates (Chacko *et al.*, 1972; Chacko *et al.*, 1982; Chacko, 1984). Sink strength depends on a fruit's capacity to produce growth promoting hormones, which in turn is commensurate with growth rate, and thus the size of the fruit during the early stages of its development (Chacko *et al.*, 1970; Powell, 1973; Chauhan and Pandey, 1984; Treharne *et al.*, 1985; Chen, 1983; Ram *et al.*, 1983; Prakash and Ram, 1984). In the present study, the pruned trees retained less fruit than the unpruned trees. In each tree, the first 10 terminal shoots to show inflorescence development retained a substantially greater number of fruit than the last 10 terminal shoots to show inflorescence development. Moreover, the magnitude of the difference in fruit retention here was positively correlated with tree flowering duration. Deep pruning (5 cm as opposed to 0.5 cm), which resulted in the removal of the leaves clustered at the shoot apex, was associated with a marked reduction in fruit retention. All of these findings explicitly suggest that assimilate availability during the fruit set period - which would be expected to have been inversely related to the intensity of flowering and depth of pruning - and the relative abilities of the fruit to compete for assimilates during this period - as was determined by the differences in fruit size at this time resulting from the differences in the times of fruit set - determined the observed differences in fruit drop after flowering.

As anticipated, the extent of the delay in flowering caused by pruning was inversely related to the stage of fruit maturation at harvest. This result is in accordance with prior observations made by Issarakraisila and Considine (1991).

The present study shows that winter pruning is effective in synchronizing flowering in Sensation and, consequently, can facilitate production and marketing operations. The results indicate, however, that the performance of trees whose terminal shoots are pruned deeply may be inferior. In large trees, terminal shoot pruning to only remove the inflorescences or apical buds is laborious and time consuming. Mechanical pruning may be undesirable in view of the negative effect of additional leaf removal on fruit retention found in the present study. Inflorescence removal by chemical means may thus be the most practicable alternative. However, it is still to be shown whether chemical inflorescence removal will be effective in synchronizing flowering in Sensation.

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