

Pruning of Sensation Mango Trees to Maintain Their Size and Effect Uniform and Later Flowering

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ABSTRACT

Pruning after harvest was evaluated as a measure to maintain the size of mature Sensation mango trees. Trees growing in the Transvaal were either left, or pruned in late February to remove the branches which developed during the preceding season.

Prolific and synchronous re-growth was initiated within 13 days of pruning. In the unpruned trees, new shoot development was delayed after harvest, and occurred erratically during March, April and May. A greater number of new shoots arose from the pruned than from the unpruned branches. Shoot length was similar, although fewer leaves were produced by the shoots on the pruned branches. Flowering commenced in late June. Pruning gave rise to slightly delayed and more uniform flowering. Starch in the leaves and stem of the new shoots on the pruned trees was higher at flowering. Neither tree yield, number of fruit retained per tree, nor average fruit weight at harvest were adversely affected by pruning. The success of pruning was ascribed to adequate canopy recovery and the general ability of the new shoots produced to initiate inflorescences.

UITTREKSEL

Snoei na oes is geëvalueer as 'n metode om die grootte van volwasse Sensation mango bome te beheer. Bome in die Transvaal is of gelaat of gesnoei gedurende laat Februarie om die takke wat gedurende die vorige seisoen ontwikkel het te verwyder.

Sterk en gesinchroniseerde hergroei is geïnitieer binne 13 dae na snoei. By die ongesnoeide bome, was nuwe loot ontwikkelend vertraag en het baie onderbroke voorgekom. 'n Groter hoeveelheid nuwe lote het by gesnoeide bome voorgekom as by ongesnoeide bome. Loot lengte was dieselfde, terwyl minder blare geproduseer is by lote op gesnoeide takke. Blom het laat in Junie begin. Snoei het 'n geringe vertraging in en meer uniforme blom tot gevolg gehad. Reserwe stysel in die blare en stamme van die nuwe lote was hoër by gesnoeide bome tydens blom. Nie een van opbrengs, aantal vrugte behou per boom of gemiddelde vrug massa is deur snoei geïmpak nie. Die sukses van snoei is toegeskryf aan voldoende blaardak herstel en die algemene vermoë van die nuwe lote om blompluime te initieer.

INTRODUCTION

High density planting provides mango growers with the opportunity of dramatically increasing orchard productivity (Chadha, 1988; Oosthuysen, 1993; Pandey and Singh, 1993). It is well known that mutual shading, caused by continued canopy development, eventually results in a reduction in tree yield due to the failure of the shaded portions of the canopy to produce inflorescences. Canopy size maintenance implies the regular removal of outer branches with a view to indefinitely maintaining the canopy dimensions desired. Hence, size maintenance pruning need not necessarily be severe.

Few studies have been made to evaluate pruning of mature mango trees to maintain their dimensions. Annual or biannual size maintenance pruning is practiced commercially in south Florida (USA), Puerto Rico, and Queensland (Australia) by mechanical hedging directly after harvest (Mitchell, pers. comm.; Segal, pers. comm.; Anon, 1992). Favourable reports of light pruning or hedging have been made (Anon., 1985; Tohill, *et al.* 1989; Pandey and Singh, 1993; Ram, 1993). Iyer and Subramaniam (1973), in performing detailed pruning experiments, found that the annual increase in canopy size could be minimized by heading the previous season's terminal shoots back to 5 cm stumps. Flowering and fruit-set were found to be negatively affected in certain cultivars. Cull (1991) stated that mango is poorly suited to hedgerow prun-

ing, in view of it having a terminal flowering habit, and there being a need for quiescent dormancy of up to three months for flowering to occur. Clarke and Clarke (1987) did not recommend the pruning of mature mango trees unless it was confined to the removal of diseased, pest infested or dead shoots and branches.

It has been recognized that the ideal time to prune is directly after harvest (Anon., 1985; Mullins, 1986; Oosthuysen, 1993; Ram, 1993). The rationale for this inference, is the allowance of maximum time for canopy recovery, shoot maturation and quiescence, to maximize the likelihood of flowering of the new shoots arising after pruning. No direct evidence has been presented in support of this, although it has been demonstrated that older shoots are more likely to produce inflorescences than younger ones (Scholefield, *et al.*, 1986). The need for quiescence might be linked to the reduction of endogenous gibberellin (Chen, 1987; Chacko, 1991) and the accumulation of starch reserves (Singh, 1960; Suryanarayana, 1978; Chacko and Ananthanarayanan, 1982).

Sensation, which tends to retain more fruit than most of the other popular mango cultivars originating in Florida, generally flowers unevenly when grown in the Transvaal. New shoot development after harvest is usually delayed, occurs unevenly, or may only materialize at flowering or soon thereafter. The absence of flushing during February, March and



Fig. 1 Heading of a branch just behind the site of flowering the preceding season to remove the branches that developed subsequently.

April, followed by flushing as opposed to flowering during August and September, results in crop failure, and the initiation or continuation of the phenological growth pattern generally associated with alternate bearing in mango (Thimmaraju, 1966; Chacko, 1984). Narwadkar and Pandey (1982) ascribed the inability of trees to flush after harvest to 'tree exhaustion' due to heavy cropping.

In mango, pruning is reported to stimulate new shoot development shortly after its performance (Reddy, 1983; Khamlert, 1985; Ram and Sirohi, 1991). Size maintenance pruning of Sensation mango trees after harvest may thus be effective in forcing early and uniform flushing, which in turn may lead to more even flowering, assuming the existence of a positive relationship between flushing and flowering uniformity. Furthermore, the alternate bearing habit often shown by this cultivar may be eliminated by annual pruning.

In mango, re-growth was reported to be prolific following size maintenance pruning (Charnvichit and Tongumpai, 1991; Ram, 1993). Gibberellin levels increase in mango shoots during their development, decline during maturation, and attain low levels at the time of flowering (Chen, 1987). Paclobutrazol, which inhibits gibberellin bio-synthesis (Dalziel and Lawrence, 1984), was found to advance flowering in mango (Tongumpai *et al.* 1991; Burondkar and Gunjate, 1993; Nunez-Elisea *et al.*, 1993). In view of these findings, it might be considered that pruning, in causing prolific re-growth, should effect delayed flowering due to the enhancement in gibberellin biosynthesis. A delay in flowering is considered to be advantageous, since inflorescence development when temperatures are higher results in an increase in the proportion of perfect as opposed to male flowers formed (Majumder and Mukherjee 1961; Singh *et al.*, 1965, 1966; Mullins, 1987), and gives rise to more effective pollination (Sharma and Singh, 1970; Robbertse *et al.*, 1986; Shu *et al.*, 1989; Issarakraisila *et al.*, 1993) and fertilization (Sturrock, 1966; Lakshiminarayana and Aguilar, 1975).

The present study was performed to evaluate pruning shortly after harvest as a measure to maintain the size of mature Sensation mango trees, and to specifically determine whether cropping will be negatively affected, and whether later and greater uniformity of flowering can be achieved.

MATERIALS AND METHODS

In early January 1992, ten adjacent mango trees were selected in a twelve-year-old Sensation orchard at Constantia (latitude: 23°40'S; longitude: 30°40'E; elevation: 457 m),



Fig. 2 Appearance of a tree shortly after it had been pruned.

which is considered to be a warm, dry subtropical region. The trees had born a moderate crop the previous season. The orchard was flood-irrigated every 21 days. After harvest in late January 1992, each tree was fertilized with 1 kg of limestone ammonium nitrate, broadcast monthly in three equal applications, and 1 kg of potassium chloride, broadcast monthly in two equal applications. Systemic fungicides were sprayed on the trees during flowering at 14 day intervals to control inflorescence diseases, and copper-oxychloride was sprayed during the fruit development period at 21 day intervals to limit disease infection. Insecticides were applied when required. A Stevenson screen was set-up in the orchard in late January 1992, to record temperature.

A randomized complete blocks design, comprising five blocks of two trees each, was employed. On February 26 1992, 27 days after harvest, one randomly designated tree in each block was pruned. Branches having borne inflorescences during flowering in 1990 (June to September) were headed back just behind the point at which new shoots grew subsequently (February to April, 1991) (Fig. 1). Branches not flowering in 1990, were headed back to remove the flushes produced during or after the flowering period in 1990. Heading of these branches was not performed if flushing did not occur, or if the new growth was weak, i.e., the shoots were short (1 to 6 cm) and possessed relatively few leaves. Fig. 2 shows a tree once pruned.

In the pruned trees, twenty pruned branches, selected so as to be well distributed in the canopy, were tagged per tree. Twenty branches, which produced inflorescences during the flowering period in 1991, were similarly tagged in the unpruned trees.

Flushing behaviour was observed periodically from the time of harvest in late January 1992. In late May 1992, once new shoots were no longer being produced, the number of new shoots that developed per tagged branch, and the length of and number of leaves on the outermost new shoot on these branches, were recorded.

On August 12 1992, once flowering had commenced, ten new shoots were sampled per tree for analysis of reserve starch. These shoots were taken at chest-height whilst walking around each tree, and immediately placed in cooler-boxes containing ice. After ± 4 hours of sampling, they were oven dried at 75°C for 72 hours. The apical buds on the shoots chosen were similar in stage of development, their having been swollen. After separation of the leaves, the stem and leaf samples were milled, and analysis of starch was performed using the method developed by Rasmussen and Henry (1989).

Inflorescence development from the outermost new shoot on the tagged branches was monitored weekly, and the stage of development as described by Oosthuysen (1991) was recorded on each occasion. At harvest on January 21 1993, the fruit on each tree were individually weighed.

Due to the low number of tree replicates, the Kruskal-Wallis one-way analysis of variance by ranks procedure was employed for data analysis (Siegel, 1956).

RESULTS

On March 10 1992, 13 days after pruning, signs of bud swell and new shoot growth were general in the pruned trees, whereas signs of bud development were absent in the unpruned trees. In the pruned trees, the development of buds on inner branches exposed to sunlight by pruning was apparent.

By April 8 1992, the pruned trees showed good canopy recovery. Shoot development had been highly synchronized, and at this stage, the shoots were maturing as indicated by the darkening of the leaves. By contrast, flushing behaviour in the unpruned trees was not synchronized. One of the unpruned trees had not flushed at all, and two had produced new shoots on only a portion of the canopy. The leaves on the new shoots were light green and flaccid. The remaining unpruned tree was similar in appearance to the pruned trees.

New shoot development had ceased by May 27 1993. Each of the unpruned trees had flushed to some extent at this stage. Of the tagged branches, all of those that were pruned had produced new shoots, whereas some of the unpruned branches were devoid of new shoots (Table 1 -A). Only one flush was produced per branch if new shoot growth was indeed initiated. Of the tagged branches producing new shoots, a greater number of shoots were produced by the branches that were pruned (Table 1 -B). The new shoots on the pruned branches were similar in length to those on the unpruned branches, but had fewer leaves (Table 1 -C, D).

Many of the unpruned branches that did not produce new shoots, flowered as a result of floral development of axillary buds situated behind the scar of the previous season's inflorescence (the development of the outermost inflorescence was monitored when such a branch was tagged). The apical bud on some of the new shoots, and the axillary buds on some of the unpruned branches, remained dormant during the flowering period. Of the tagged branches not producing inflorescences, the proportion was greater in the pruned trees (Table 1 -E).

Fig. 3 shows the time and duration of flowering of each tree. In each tree, flowering duration was determined as the

Table 1 Means for comparisons between unpruned and pruned trees.

Comparison	Unpruned	Pruned	P ^x
A. branches failing to produce new shoots (%)	23	0	*
B. no. new shoots/branch	2.3	3.5	*
C. new shoot length (cm)	11.2	10.3	ns
D. no. leaves/new shoot	8.6	6.7	*
E. non-flowering branches (%)	2	14	*
F. tree flowering duration (days)	83	74	*
G. start of flowering	29 June	3 July	*
H. stem starch (%)	2.1	3.3	*
I. leaf starch (%)	1.2	1.8	*
J. no. fruit/tree	277	294	ns
K. average fruit weight (g)	207	224	ns
L. tree yield (kg)	57.4	65.0	ns

^xNon-significant (ns), or significant at P = 0.05 (*)

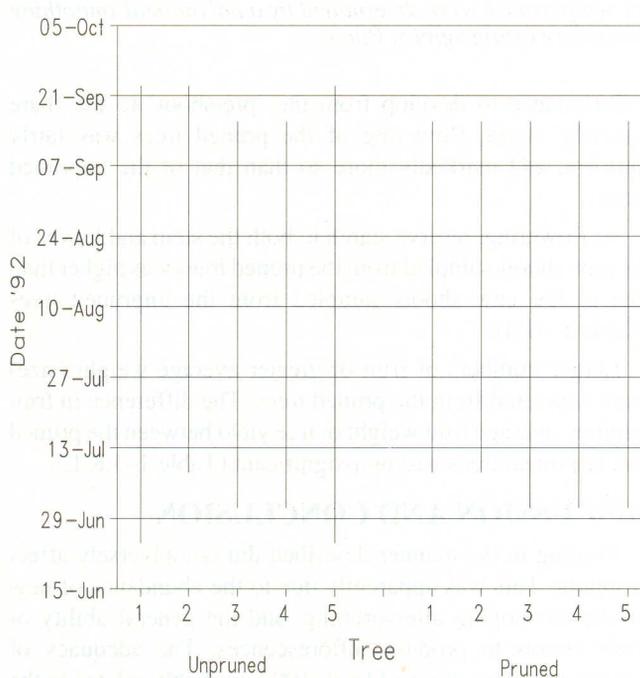


Fig. 3 Time and duration of flowering of each tree.

time taken from the average date on which the apical bud on the outermost shoot on the tagged branches bearing new shoots — or the outermost axillary bud on the tagged branches not bearing new shoots — showed clear signs of swelling ('pre-shoot' stage), to the average date on which the inflorescences developing from these buds had just completed the shedding of flowers ('bare panicle' stage). The unpruned trees were first to show signs of flowering (Fig. 3; Table 1 -G), and collectively, were in flower for a longer period (91 days) than the pruned trees (77 days). On average, the unpruned trees took longer to flower than the pruned trees (Table 1 -F). In view of it having taken an average of 70 days for a single

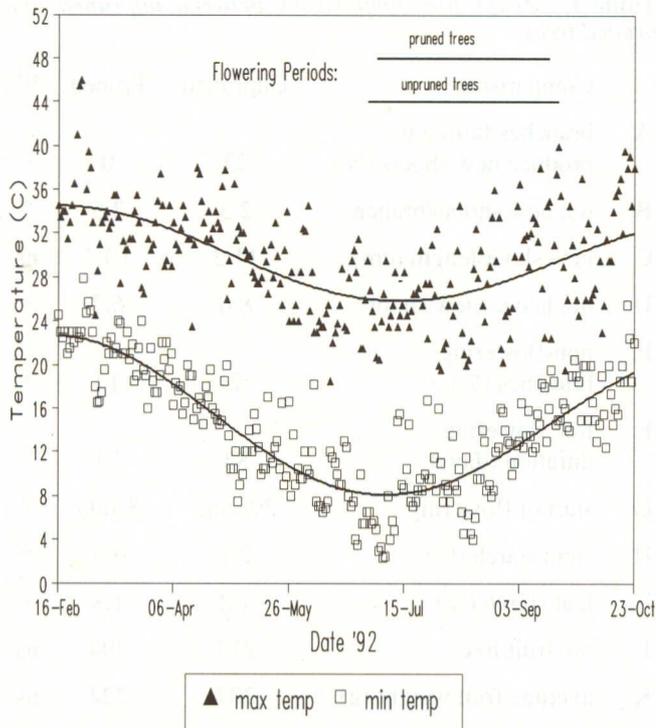


Fig. 4 Daily maximum and minimum temperatures from mid-February (prior to pruning) until late October, 1992 (after the completion of flowering), and the period of flowering of the pruned and unpruned trees (horizontal lines). The regressions for temperature were determined by a polynomial smoothing procedure (Statgraphics Plus).

inflorescence to develop from the 'pre-shoot' to the 'bare pancicle' stage, flowering of the pruned trees was fairly uniform, and markedly more so than that of the unpruned trees.

At flowering, reserve starch in both the stem and leaves of the new shoots sampled from the pruned trees was higher than that in the new shoots sampled from the unpruned trees (Table 1 -H, I).

Larger numbers of fruit of greater average weight (size) were harvested from the pruned trees. The difference in fruit number, average fruit weight or tree yield between the pruned and unpruned trees was non-significant (Table 1 -J,K,L).

DISCUSSION AND CONCLUSION

Pruning in the manner described did not adversely affect cropping. This was apparently due to the abundance of new shoots developing after pruning, and the general ability of these shoots to produce inflorescences. The adequacy of canopy recovery during March 1992, probably relates to the fact that the temperatures were relatively high (Fig. 4), and water and nutrients were not limiting. Whiley (1993) noted that there is sufficient data available to substantiate that low temperature is a powerful floral inductant in mango. Day temperatures of above 20°C are generally found to favour the vegetative development of buds, whereas night temperatures of below 15°C are generally found to promote the emergence of inflorescences (Shu and Sheen, 1987; Whiley *et al.*, 1989; Issarakraisila and Considine, 1991; Nunez-Elisea *et al.*, 1993; Chaikiattiyos *et al.*, 1994). The temperature fell below 15°C on 56 of the 61 days in May and June, the lowest temperature recorded being 3.5°C. It would therefore appear that the temperatures experienced by the trees during May and June were strongly inductive, and of significance to the flowering of the pruned trees.

Reece, *et al.* (1946, 1949) presented strong evidence to support their postulation that floral induction in mango only occurs once bud development has started, and if conditions are in fact inductive when the bud development begins. The results of this study support the view that the vegetative re-growth caused by pruning after harvest, elevates the level of endogenous gibberellin, and thereby effects a delay in bud development — and a delay in flowering if conditions are in fact inductive when the apical buds on the new shoots begin developing. Exogenous gibberellin application prior to or during the flowering period has been found to delay bud development, and give rise to delayed flowering or to the development of new shoots (Kachru, *et al.* 1971; Nunez-Elisea and Davenport, 1991; Oosthuysse, 1992).

The negative effect of size maintenance pruning on the tree productivity found by others (Iyer and Subramaniam, 1973; Charnvichit and Tongumpai, 1991), might be ascribed to inadequate canopy recovery following pruning due to conditions not being favourable for vegetative growth, or to a delay in bud development to a period when environmental conditions were no longer inductive.

A positive association between the likelihood of flowering and the availability of starch reserves has been made in mango (Gazit, 1960; Suryanarayana, 1978; Chacko and Ananthanarayanan, 1982). The depletion of reserves by fruit has been cited as a reason for the failure of trees pruned after harvest to flower, despite there having been strong vegetative re-growth after pruning (Charnvichit and Tongumpai, 1991). In the present study, the concentration of starch was higher in the new shoots on the pruned trees than in the new shoots on the unpruned trees at flowering. It would appear, therefore, that the failure of mango trees to flower following postharvest pruning cannot be ascribed to a lack of starch in the new shoots developing after pruning. The higher starch content of the new shoots on the pruned trees was probably due to these shoots being generally older than the new shoots on the unpruned trees at the time of sampling.

The observation of greater flowering uniformity in the pruned trees supports the view that postharvest pruning, in forcing uniform flushing, effects greater uniformity of flowering. In the unpruned trees, the variation in time of flowering relative to the variation in time of postharvest flushing was small. It would thus appear that the temperatures experienced by the trees were of greater significance in determining bud behaviour than the time of shoot growth cessation. This conclusion is supported by observations made by Issarakraisila and Considine (1991) of the phenology of mango trees grown in a warm temperate region of Western Australia, which led them to deduce that temperature was the dominant influence on the growth cycle.

Inflorescences were observed to develop from unpruned branches that did not initiate new shoots during the post-harvest growth period. It therefore seems that the production of new shoots after harvest is not essential for regular bearing in Sensation. Moreover, the foregoing observation contradicts the general perception that the annual production of new shoots is required for regular flowering (Chacko, 1986), and supports the view that buds will always develop as inflorescences when released from inhibition provided that conditions are sufficiently inductive when the buds begin to develop.

The new shoots on the pruned branches had fewer leaves than those on the unpruned branches. Studies relating bud position or rate of shoot development to shoot length or

number of shoot leaves are lacking in mango. The results of Whiley *et al.* (1989) indicate that Sensation mango trees grown at the day/night temperature regime of 20⁰C/15⁰C produced more leaves per flush than did trees grown at the temperature regimes of 25⁰C/20⁰C or 30⁰C/25⁰C. A negative relationship between the rapidity of shoot development and the number of leaves produced might thus be considered in Sensation.

In South Africa, mango orchard development strategies are now geared toward high density planting with a view to the establishment of hedgerows. This has necessitated the evaluation of pruning to maintain canopy dimensions. The results of the present study indicate that in Sensation, pruning shortly after harvest can be employed as a measure to maintain tree size without there being an adverse effect on cropping. It is further indicated that postharvest pruning will effect prolific and synchronous re-growth shortly after its performance, and will result in slightly delayed and more uniform flowering. It is still to be shown whether success will be achieved following repeated postharvest pruning on an annual basis.

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