CHAPTER 5

THE IMPACT OF PANICLE AND SHOOT PRUNING ON INFLORESCENCE AND FRUIT RELATED DEVELOPMENTS IN TWO MANGO CULTIVARS.

5.1 ABSTRACT

The effects of different pruning treatments were studied in Keitt and Tommy Atkins mango cultivars over two seasons (2001-2003). The trial was conducted at Bavaria Estate, in the Hoedspruit region of the Northern Province of South Africa. Uniform trees were selected for a randomised complete block design experiment with the two cultivars and seven pruning treatments in factorial combinations. There were three blocks and three trees per plot. Trees that received the panicle pruning (during full bloom) treatment at the point of apical bud attachment were observed to be induced for synchronised re-flowering. These trees also attained early fruit set and more fruit per panicle than the other panicle pruning treatments. Trees on which renewal pruning (early in the season when the fruit were on the tree) as well as post-harvest pruning (especially for early cultivars) treatments were applied, developed an adequate number of inflorescences per season. Post-harvest pruning treatments also resulted in more vigorous vegetative growth on both cultivars. Promising increment in yield could be expected in the long run, especially from panicle pruning at apical bud attachment and shoot pruning (time of pruning is crucial) treatments in 'Tommy Atkins' with vigilant management of the trees. The fruit quality, especially the TSS content, was greatly improved by renewal and post-harvest pruning treatments. 'Keitt', being a late cultivar, was found to be non responsive to the pruning treatments especially for quantitative fruit parameters. Inflorescence removal together with apical

whorl of leaves subtending the inflorescence, had an adverse effects on the various parameters studied in both cultivars.

Key words: apical bud, apical whorl of leaves, renewal pruning, post-harvest pruning

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5.2 INTRODUCTION

It has been recorded that the average number of flowers per inflorescence in mango (*Mangifera indica L.*) varies from 200-4000 depending on the cultivar, the cultural practices adopted and the climatic conditions (Chadha & Pal, 1986). The mango is andromonoecious, which means that each inflorescence bears both hermaphrodite and staminate flowers (Coetzer *et al.*, 1995). The removal of the apical bud or inflorescence on terminal shoots of mango just prior to or during the flowering period results in the development of normally inhibited axillary buds adjacent to the point of pruning (Reece *et al.*, 1946). These buds usually develop as inflorescences, particularly if pruning is performed shortly before or after the start of normal floral bud development (Issarakraisila *et al.*, 1991). If inflorescences do develop from these buds, a delay in flowering of four to eight weeks is effected (Reece *et al.*, 1946; Singh *et al.*, 1974; Gazit, 1975), resulting in a delay in harvest (Issarakraisila *et al.*, 1991; Oosthuyse, 1995).

'Sensation' mango trees grown in the Northern and Mpumalanga province of South Africa are known to flower unevenly and consequently differences in stage of flowering between trees as well as individual branches in the same tree are encountered (Oosthuyse & Jacobs, 1996). Uneven flowering has also been reported to occur in other mango cultivars (Reece *et al.*, 1946; Lin & Chen, 1981). 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 (Oosthuyse & Jacobs, 1996). Growers then find it difficult in adhering to cultural and other management practices based on a particular phenological stage.

Clearly, relative light flowering can limit yield in most fruit and nut species (Stover, 1999). This commonly occurs before mature bearing commences and in 'off' years for varieties that display alternate bearing. During mature bearing, many species will bear fruit numbers that exceed commercially desirable levels, resulting in excessively small fruit and accentuating alternate bearing.

In general, tree height exceeding more than 80% of the distance between rows is not advantageous in the orchard situation, as it has some disadvantages like shading, decreasing leaf water potential with height, delayed bearing and poor resource allocation to fruiting (Wolstenholme, 1990). Fivas & Stassen (1995) indicated that fruit trees are pruned to create a sturdy tree framework and to facilitate the adoption of high density planting. Bearing mango trees should also be pruned to maintain their size (Oosthuyse, 1993b) and reduce excessive tree vigour. Timing is however one of the most important factors determining the success of pruning (Fivas & Stassen, 1996).

Many farmers are still afraid to apply panicle pruning since they consider it to be a loss of the whole crop. Farmers are also reserved about pruning their trees since they consider it to be loss of vital vegetative parts. The lack of a synchronised approach to evaluate the pros and cons of the different pruning methods validated the current experiment that tested the farmers' hypothesis about the negative effects of both vegetative parts and inflorescence pruning on mango trees. Hence, this report supplies information about the effects of different pruning methods that were applied in Keitt ('KT') and Tommy Atkins ('TA') mango cultivars, on various inflorescence and fruit development aspects over a period of two seasons.

5.3 MATERIALS AND METHODS

5.3.1 Area description and season

The varying types of pruning trials were conducted in 'KT' and 'TA' mango cultivars at Bavaria Estate around Hoedspruit area, Northern Province of South Africa (latitude: 24^0 25'S; longitude: 30^0 54'E; elevation: 600 m.a.s.l.) during 2001/2002 as well as 2002/2003 seasons.

5.3.2 Selecting and tagging of experimental trees

Inflorescence development stages of the treatment trees were studied during early July 2002 before applying the treatments and tagging branches. For this purpose, numbers (1-8) were assigned during data gathering to describe the different stages of inflorescence development (Fig. 5.1) (Oosthuyse, 1991). This was to select uniform trees from both cultivars based on the developmental stages of the majority of the inflorescences. Trees with visible inflorescence buds in early June 2002 were studied to select uniform trees for applying treatment 6.

During that observation period (July 2002), 'KT' inflorescence development was in an advanced stage (stages 4-5 in Fig. 5.1) while those of 'TA' were still in the inflorescence elongation stage (stages 1-3 in Fig. 5.1). This was not in line with the normal trend in the inflorescence development of the two cultivars since 'TA' is supposed to be an early and 'KT' a late cultivar.

Trees with shoots having similar stages of inflorescence development were selected from both cultivars.

Figure 5.1 Stages of inflorescence development in Mango.

Key: 1: quiescent bud stage, 2: swollen bud, 3: on set of inflorescence axis elongation, 4: apical inflorescence about to sprout, 5-6: opening of individual flowers and branching of the inflorescence, 7: well developed inflorescence, 8: inflorescence about to set fruit

After selecting trees, twenty randomly selected shoots per tree (five from each of the four wind directions) were tagged on all the treatment trees to study flowering dynamics. Twenty panicles (from the re-flowers for treatments 1, 2, 3 and 6) were also tagged from all treatment trees to study fruit set. Another twenty randomly selected branches per tree from each of the four directions (other than used for observations of flowering) were tagged for all treatment trees to observe the effects of panicle and shoot pruning on the vegetative growth parameters.

For analysing fruit quality parameters, twenty sample fruits per tree were taken. All treatment trees were subjected to the standard orchard management practices as applied at the Fruit Estate.

5.3.3 Treatments, their periods of application and experimental design

The following seven treatments were applied on whole of the trees' in both cultivars and for convenience; only the treatment numbers designated for each treatment below are used in the results and discussion.

(1) Inflorescence removal (when the inflorescences were at stage 7 in Fig. 5.1) at the point of apical bud attachment during full bloom (early August 2002 for both cultivars)

(2) Inflorescence removal (when the inflorescences were at stage 7 in Fig. 5.1) together with apical whorl of leaves subtending the inflorescence (about 5 cm deep from the attachment) during full bloom (early August 2002 for both cultivars)

(3) Inflorescences on every alternate shoots of the tagged branches (50% of inflorescences on the tagged branches) were removed (when the inflorescences are at stage 7 in Fig. 5.1) together with apical whorl of leaves subtending the inflorescence during full bloom (early August 2002 for both cultivars). Therefore trees that received this treatment had half of their inflorescences on the tagged branches unpruned and on the other half, pruned together with apical whorl of leaves

(4) Renewal pruning where 20-30% of terminal shoots with weak, misshaped and small fruit were cut back to a suitable node (October 2002 for 'TA' and November 2002 for 'KT')

(5) Post-harvest pruning where terminal shoots that had been bearing fruit the previous season were cut back to a suitable node (January 2002 for 'TA' and March 2002 for 'KT')

(6) Terminal buds removed (when the inflorescence was at stage 1 in Fig. 5.1) just before bud break (mid June 2002 for both cultivars)

(7) No pruning (control trees).

A randomised complete block design with two cultivars ('KT' and 'TA') and seven pruning treatments in factorial combinations was used. There were three blocks and three trees per plot.

5.3.4 Observations on flowering and fruit set

The tagged shoots were used to follow up the impact of the treatments on the average number of inflorescences developed (NID) in September and October 2002. The percentage tagged shoots with panicles (PTSP), were also recorded during September and October 2002.

In addition, for applying the three panicle pruning treatments (treatments 1, 2 & 3) and bud pruning treatment (treatment 6), only shoots bearing a single inflorescence per terminal branch were tagged before treatment application. This was done to study the extent of re-flowering from the axillary buds (which is the same observation as number of panicles developed). Extent of re-flowering was determined only for panicle and bud pruning treatments where the number of panicles developed per tagged shoots after inflorescence removal was recorded and compared with the single panicle per tagged shoot before inflorescence removal.

Tagged panicles from the treatment trees were used to determine percent tagged panicles setting fruit (PTPF) during September, October and November 2002 observation periods. The fruit may have been of different sizes or at different stages of development, but a panicle that set a visible fruit was grouped into panicles that started fruit bearing.

5.3.5 Observations on vegetative growth

The following vegetative parameters were recorded per tagged shoots, once the development of new vegetative flush had hardened off: average number of new vegetative flushes developed, average length of new flushes developed, average number of new leaves developed on the new flushes as well as average leaf area of forty newly developed leaves randomly selected from the newly developed flushes. The leaf area of each of the forty leaves tagged was calculated using the formula:

$$Y= -0.146+0.706X \ (r^2=0.995)$$

where Y= leaf area (cm^2) and X = leaf length (cm) $\times$ leaf width (cm) (Nii *et al.*, 1995).

5.3.6 Yield and fruit quality observations

Quantitative parameters like fruit number and weight per tree were recorded during harvesting. Fruit harvested from trees and sampled for quality analysis were treated according to commercial pack house procedures. The quality analysis was done after

shipping simulation (storing the fruit in a cold store for 28 days at 10 ^{0}C and then ripening them at room temperature for three days).

The total soluble solids (TSS) from the sample fruit's pulp was measured using a EUROMEX handheld digital Refractometer and expressed as ^{o}Brix. The pulp of the sampled fruit was also used to determine the titratable acids (Ta) after mixing the pulp with a juice blender and centrifuging it for ten minutes at 1000-rpm. A METTLER TOLEDO DL 25 (Mettler-Toledo Inc., USA) Titrator was used to determine the titratable acids, and it is expressed in m eq. L^{-1}. The fruit firmness was measured using a Penetrometer probe after peeling a portion of the exocarp and expressed as Kg cm^{-2}.

5.3.7 Statistical analysis

Logarithmic transformations were done where necessary, to normalise a highly variable data set before accomplishing data analysis. The final data was acceptably normal with homogeneous treatment variances. Differences between treatments were determined with Analysis of Variance (ANOVA) using MSTATC statistical package (MSTATC, 1989) for each season separately and combined. Whenever significant differences were detected, means were separated using Least Significant Difference (LSD) test at the 5% level of significance.

5.4 RESULTS

Data for yield and quality parameters are presented for two seasons (2001-2003). Since there was no significant difference between the seasons for all parameters

considered, data were pooled together. Data for the inflorescence as well as vegetative growth is only presented for the 2002-2003 season due to technical problems that resulted in incomplete data.

5.4.1 Effect of treatments on inflorescence development

Flowering and fruit set in September, October and November 2002

The various treatments produced significantly different results on the trees during the September observation. Averaged across cultivars, trees from treatments where inflorescence pruning was not involved (treatments 4, 5 and control) had a significantly larger number of inflorescences (Table 5.1). Among the inflorescence pruning treatments, treatment 2 did not produce any inflorescences at all compared to treatments 1, 3 and 6 during this period. Lateral buds on decapitated branches of trees that received treatments 1, 3 and 6 in both cultivars started producing lateral inflorescences and there were no significant differences among them on the number of inflorescences developed during the September observation (Table 5.1). The numbers of panicles developed is an expression of the extent of re-flowering for panicle and bud pruning treatments. Accordingly, significantly larger re-flowering percentages were recorded for treatments 1, 3 and 6 as compared to treatment 2 during the September observations (Table 5.1).

In September, there was a significant difference for the interaction effects between cultivars and treatments regarding to a response on percent tagged shoots with panicles (Table 5.2). The highest result from 'TA' was by trees that received treatments 4, 5 and the control where 93.05, 84.72 and 94.44% of their tagged branches had panicles respectively, while trees that received treatment 2 did not have

any panicles on their tagged shoots. 'KT' trees followed the same trend where trees that received treatments 4, 5 and the control had 50, 54.17 and 75% of their tagged branches with panicles respectively. The lowest result obtained for 'KT' was by the trees that received treatment 2 (0%).

Table 5.1 Effects of pruning treatments on the development of lateral inflorescences (Figures pooled over cultivars)

Pruning treatments	Av. number of inflorescences developed per tagged branch in September 2002	Av. number of inflorescences developed per tagged branch in October 2002	Percent tagged shoots with panicles in October 2002
1	0.62b	1.14a	75.00a
2	0.00c	0.38c	34.72c
3	0.64b	0.80b	59.03b
4	1.36a	--------	--------
5	1.18a	--------	--------
6	0.54b	1.24a	72.92a
7 (control)	1.44a	--------	--------

Means followed by different letters in the same column are significantly different by LSD test at $P<0.05$

There was also a significant difference between the interaction effects of cultivars and treatments with respect to percent tagged panicles that started to bear fruit in September (Table 5.2). 'TA' trees that received treatments 4, 5 and control had larger percentages of panicles that started setting fruit (90.28, 75 and 93.06% respectively). 'KT' trees where treatment 5 was applied and the control had a larger percentage of panicles that started to bear fruit (45.83% and 62.50% respectively). Trees in both cultivars that received treatment 2 did not produce inflorescences. In addition, treatment 6 in 'TA' did not produce inflorescences during this period of observation.

Among inflorescence pruning treatments, it was observed that some of the lateral buds of treatment 1 in 'TA' trees had given rise to an inflorescence (re-flowered) and some of these inflorescences produced marble-sized fruit (with an approximate fruit diameter of 1 cm). Hence treatment 1 had a larger percentage of panicles fruiting than treatments 2 and 6 (Table 5.2). Trees that received treatment 3 produced a lot of inflorescences from the unpruned tagged shoots (on both cultivars), and some of these inflorescences were at different stages of fruit development (Table 5.2). Trees on which either inflorescence or bud pruning treatments were not applied, showed fruit development on most of their inflorescences, where in most cases, were golf ball-sized fruit (with an approximate fruit diameter of 3 cm) on both cultivars.

Table 5.2 Interaction between cultivars and pruning treatments on flowering and fruit set in September 2002

Cultivars	Treatments	Percent tagged shoots with panicles	Percent tagged panicles with fruits
Tommy Atkins	1	45.83c	43.06cde
	2	0.00d	0.00g
	3	52.78bc	47.22cd
	4	93.05a	90.28a
	5	84.72a	75.00ab
	6	0.00d	0.00g
	7 (Control)	94.44a	93.06a
Keitt	1	29.17c	13.89fg
	2	0.00d	0.00g
	3	34.72c	22.22efg
	4	50.00bc	36.11def
	5	54.17bc	45.83cde
	6	38.89c	29.17def
	7 (Control)	75.00ab	62.50bc

Means followed by different letters in the same column are significantly different by LSD test at $P<0.05$

The parameters measured in September were considered during the October 2002 observation period. During this observation period, there was a clear developmental variability amongst trees that received the inflorescence/bud removal treatments (treatments 1, 2, 3 and 6), and the rest of the treatments. Therefore, only the inflorescence/bud removal treatments were compared amongst each other. Main effects, viz., cultivars and treatments affected the number of inflorescences developed on the tagged shoots during October observations. 'KT' trees had a significantly higher number of inflorescences developed on their tagged shoots as compared to 'TA' (Table 5.4).

There was a significant difference amongst the treatments considered, where treatments 1 and 6 on average had a 213% increment on the number of panicles developed as compared to treatment 2 (Table 5.1). A significantly higher re-flowering percentage was observed for treatments 1 and 6 as compared to treatments 2 and 3 (Table 5.1). Averaged across cultivars, treatments 1 and 6 had significantly higher percentages of shoots with panicles (75 and 72.9% respectively) during October, as compared to treatments 2 and 3 (34.7 and 59% respectively) (Table 5.1).

There was also a significant difference between the interaction effects of cultivars and treatments with respect to percent tagged panicles that started to fruit in October (Table 5.3). Amongst the considered treatments, significantly higher percentages of panicles bearing fruit (56.95 and 51.39) in 'TA' were recorded by trees that received treatment 1 and 3 respectively. The lowest percentage of fruit bearing panicles was recorded for trees that received treatment 2 (9.72%). In 'KT' trees, treatments 1 and 6 had significantly higher percentages (50.00 and 52.78 respectively) of panicles

bearing fruit and the lowest of them was for treatment 2 (22.2%). It was observed during this time that, the fruit development process of some of the control tree's panicles was weak and fruit drop occurred.

Table 5.3 Effect of the interaction between cultivars and pruning treatments on fruit set in October and November 2002

Cultivars	Treatments	Percent tagged panicles with fruits in October	Percent tagged panicles with fruits in November
Tommy Atkins	1	56.95a	80.56a
	2	9.72c	20.83c
	3	51.39a	54.17b
	6	25.00b	47.22b
Keitt	1	50.00a	69.45a
	2	22.22bc	43.05b
	3	33.34b	54.17b
	6	52.78a	73.61a

Means followed by different letters in the same column are significantly different by LSD test at P<0.05

Table 5.4. The response of 'Tommy Atkins' and 'Keitt' on flowering, yield and vegetative growth parameters

Cultivars	Av. number of inflorescences developed per tagged branch in October	No. of new vegetative flushes developed per tree	Av. Leaf area per new flushes (cm^{-2})	Fruit number per tree	Fruit weight per tree (kg)	Av. Weight of fruit (g)	Yield (ton ha^{-1})
Tommy Atkins	0.78a	168a	31.32a	63.23a	26.01a	0.41a	23.94a
Keitt	1.01b	64.40b	14.99b	40.84b	22.28b	0.56b	15.91b

Means followed by different letters in the same column are significantly different by LSD test at P<0.05

As in the October observation period, the inflorescence and bud removal treatments (treatments 1, 2, 3 and 6) were compared amongst each other to observe fruit setting during November 2002. There was also a significant difference between the interaction effects of cultivars and treatments with respect to panicles bearing fruit in November (Table 5.3). Treatment 1 in 'TA' trees and treatment 1 as well as 6 in 'KT' trees had significantly higher percentages (80.56, 69.45 and 73.61 respectively) of tagged panicles that set fruit. In both cultivars trees that received treatment 2 had the lowest percentage of panicles bearing fruit (20.8% in 'TA' and 43.1 in 'KT'). A significant amount of the fruit produced by 'TA' trees that received treatment 1 were larger than a golf ball-size. The size of the majority of the fruit produced from the tagged panicles of 'KT' trees that had received treatment 6, during this observation period, was between marble and a golf ball-size.

5.4.2 Effect of treatments on vegetative growth

In general, all pruning treatments, except treatment 2, enhanced new vegetative growth than the controls. The main effects of cultivars and treatments affected the number of new flush development. 'TA' trees had a significantly larger average number of new flush development per tagged shoot as compared to 'KT' (Table 5.4). Treatments 4 and 5 had a significantly higher average number of new flush development, on average 21% higher as compared to the control (Fig. 5.2). There was also a significant difference between the interaction effects of cultivars and treatments with respect to the length of new flush developed (Table 5.5). In 'TA' trees, significantly longer flushes (20.78 and 21.11cm) were recorded on trees that received treatments 4 and 5 respectively as compared to the controls (15.78 cm). 'KT' trees

that received treatments 4 and 5 had significantly longer flushes (21.78 and 26.56cm respectively) as compared to the control trees (13cm) and all the remaining treatments.

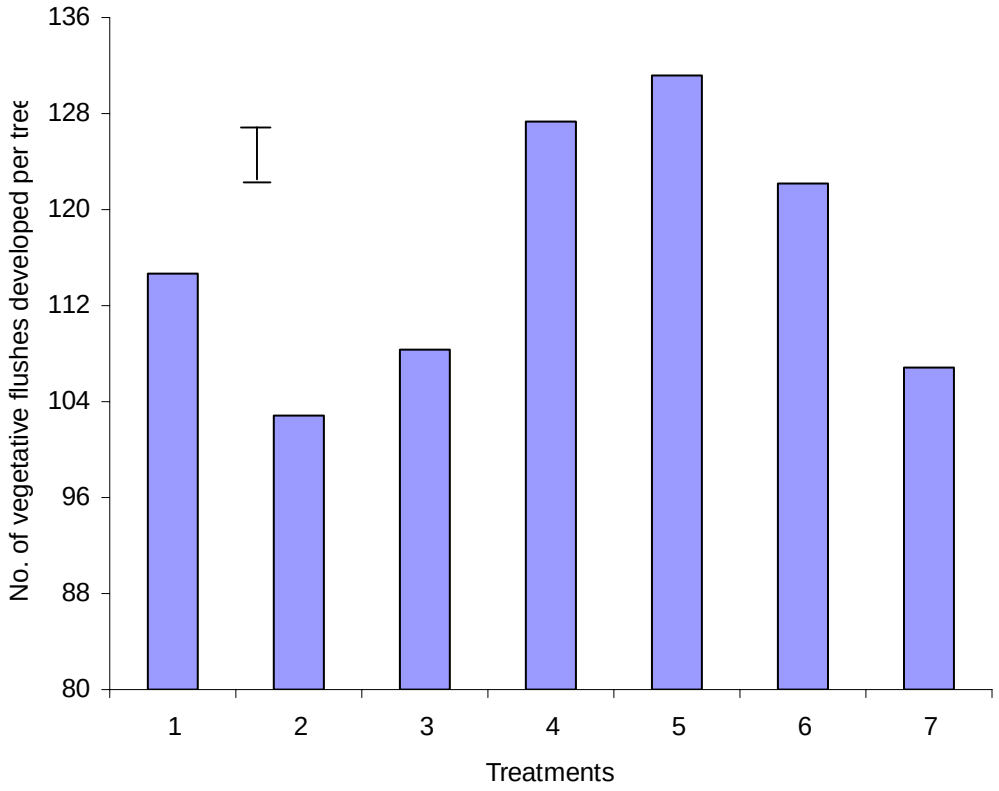

Figure 5.2 **Effect of pruning treatments on the number of new vegetative flushes developed per tree. The line bar is LSD between means at P<0.05 level.**

The number of leaves developed per new flush was also affected by the interaction between cultivars and treatments (Table 5.5). 'TA' trees that received treatment 5 had higher number of new leaves developed, by 106.7% higher as compared to the control. In 'KT' trees, higher number of leaves were recorded for treatment 5, however, the results were not significantly different to the results obtained for the control trees.

Table 5.5 Interaction between cultivars and pruning treatments on number of leaves per flush and length of new flushes

Cultivars	Treatments	Length of new flushes (cm)	Number of leaves per flush
Tommy Atkins	1	16.89e	10.89efg
	2	16.00ef	17.00b
	3	19.11b-e	14.44cd
	4	20.78bcd	17.56b
	5	21.11bc	20.44a
	6	18.11cde	16.44bc
	7 (Control)	15.78ef	9.89fg
Keitt	1	18.11cde	9.56g
	2	10.00g	9.89fg
	3	13.00fg	10.67efg
	4	21.78b	12.56de
	5	26.56a	14.00d
	6	17.67de	12.11def
	7 (Control)	13.00fg	12.11def

Means followed by different letters in the same column are significantly different by LSD test at $P<0.05$

The main effects viz., cultivars and treatments affected the average leaf area of the newly developed leaves. The average surface area of the newly developed leaves in 'TA' trees was significantly higher as compared to 'KT' (Table 5.4). Treatment 5 produced a significantly higher average leaf area (32.80 cm^2) as compared to the control trees (19.58 cm^2) (Fig. 5.3).

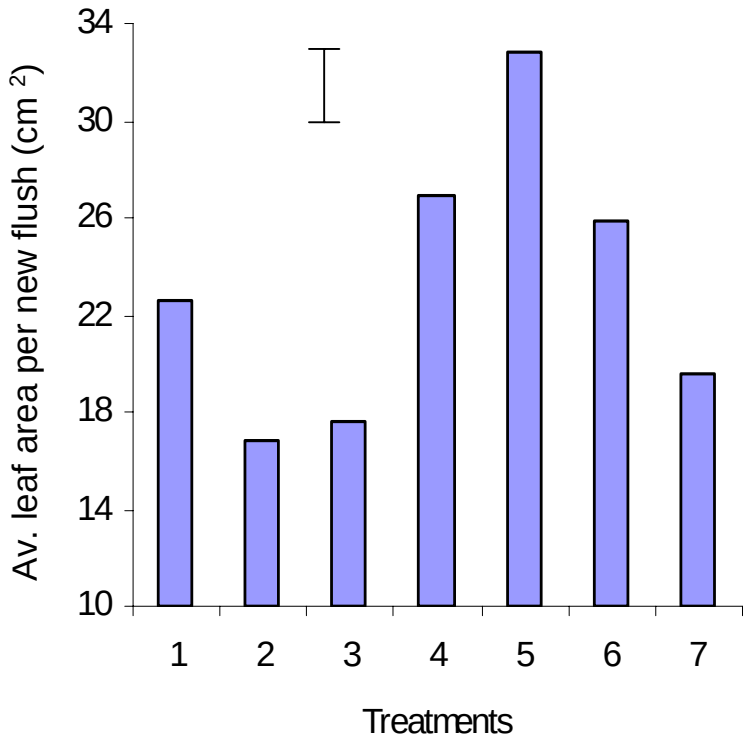

Figure 5.3 **Effect of pruning treatments on the average leaf area per new flushes. The line bar is LSD between means at P<0.05 level.**

5.4.3 Fruit yield related observations

The main factors influenced the number of fruits produced on the trees independently. 'TA' trees produced significantly higher numbers of fruits as compared to 'KT' trees (Table 5.4). Trees that received treatment 1 produced significantly higher number of fruit (by 14.6% higher) as compared to the control trees (Table 5.6). The lowest fruit number was recorded for trees that received treatment 2.

The same trend was observed for total fruit weight per tree, where the main effects (cultivars and treatments) were the factors, which determined the parameter results. Fruit in 'TA' trees were significantly heavier than the fruit from 'KT' trees (Table

5.4). Treatments 1, 4 and 5 produced significantly higher total fruit weight per tree (on average by about 19.1% higher) as compared to the control trees (Table 5.6). **N**o significant difference was observed amongst the treatments, with respect to the total yield ha^{-1} and average weight of fruit harvested per tree for both cultivars. However, there was a significant difference between the two cultivars and consequently, the average weight of fruit from 'KT' trees was significantly higher than 'TA' while the total yield ha^{-1} in 'TA' trees was significantly higher than 'KT" (Table 5.4).

Table 5.6 Effect of pruning treatments on yield

Pruning treatments	Fruit number per tree	Fruit weight per tree (kg)	Av. Weight of fruit (g)	Yield (ton ha^{-1})
1	56.30a	26.23a	0.48a	20.14a
2	47.60c	21.36d	0.48a	19.57a
3	53.94ab	22.97cd	0.43a	19.57a
4	53.46ab	26.21abc	0.51a	21.11a
5	53.51ab	26.45ab	0.52a	21.15a
6	50.31bc	23.21bcd	0.48a	18.94a
7 (control)	49.12bc	22.20d	0.48a	18.99a

Means followed by different letters in the same column are significantly different by LSD test at $P<0.05$

Although there was no significant difference amongst the treatments effect on the average weight of fruit in both cultivars, an apparent fruit size difference within the treatments was noticed, and they fall down in different size counts. An increase in occurrence of 'jelly seed' and delay of ripening for over sized fruit ($\geq$ 700 g) than medium (400-600 g) and small sized fruit (< 400 g) was noted as can be seen in Fig. 5.4 below.

This delay in ripening causes variability in ripening and complicates marketing of the fruit at a given period of time.

Figure 5.4 Delayed fruit ripening (A) and development of Jelly seed (B) among over sized 'KT' fruit.

5.4.3 Fruit quality parameters

After the shipping storage simulation procedure, a significant interaction was observed between cultivars and treatments with respect to TSS, titratable acids, ratio of TSS to acids and firmness of the fruit. 'TA' trees that received treatments 4 and 5 produced fruit with significantly higher TSS (15.18 and 15.24 ^{0}Brix respectively) as compared to the fruit from the control trees that had only 13.95 ^{0}Brix (Table 5.7). Fruit from 'KT' trees that received treatment 2 had the highest TSS even if the results were not significantly different to that of the control and rest of the treatments (Table 5.7). 'TA' trees that received treatment 6 had significantly lower titratable acids (about 46%) in their fruit as compared to fruit on the control trees (Table 5.7). In 'KT'

trees, the lowest titratable acids in the fruit was recorded by trees that received treatment 2, even if the results were not significantly different to the remaining treatments including the control (Table 5.7). Fruit from 'KT' trees that received treatments 2 and 5 had significantly higher TSS to acid ratio as compared to the control and the other treatments (Table 5.7). In 'TA' trees, even if the highest value was obtained for fruit from treatment 6 and the lowest on the control trees, there was no significant difference (Table 5.7). 'TA' trees that received treatment 1 had significantly softer fruit as compared to fruit from the control trees (Table 5.7). Fruit from 'KT' trees that received treatments 2, 4, 5 and 6 had softer fruit as compared to the control (Table 5.7).

Table 5.7 Interaction between cultivars and pruning treatments on fruit qualitative parameters

Cultivars	Treatments	Total soluble solids (^{o}Brix)	Titratable acids (%)	TSS:acid	Firmness (Kg cm^{-2})
Tommy Atkins	1	14.26cd	0.38bc	37.97d	1.74cd
	2	13.95d	0.53a	38.51d	2.11ab
	3	14.19cd	0.40bc	38.80d	2.05ab
	4	15.18a	0.41bc	39.35d	2.26a
	5	15.24a	0.36bc	42.82d	1.97bc
	6	14.60bc	0.31c	48.46cd	2.04ab
	7 (control)	13.95d	0.45ab	31.13d	2.06ab
Keitt	1	15.19a	0.13d	123.00b	1.47ef
	2	15.44a	0.08d	252.40a	1.25f
	3	15.09ab	0.13d	123.10b	1.47ef
	4	15.17a	0.13d	121.40b	1.36f
	5	15.28a	0.09d	207.60a	1.32f
	6	15.10ab	0.14d	115.30b	1.41f
	7 (control)	14.95ab	0.15d	103.40bc	1.69de

Means followed by different letters in the same column are significantly different by LSD test at P<0.05

5.5 DISCUSSION

Growth of lateral buds is normally inhibited by the presence of terminal buds due to apical dominance. When the apical bud was removed, the inhibited but induced axillary buds adjacent to the point of cuttings were released and started developing lateral inflorescences corresponding to the observations of Reece *et al*. (1946). Similar to what was observed in the current study, Singh *et al.* (1974); Issarakraisila *et al*. (1991) indicated that these buds usually develop as inflorescences, particularly if pruning is performed shortly before or after the start of normal terminal bud development. Nunez-Elisea & Davenport (1995) indicated that growth of induced buds in the presence of cool temperature was found to be essential for floral initiation. In both cultivars, up to 3-4 inflorescences were produced from below the pruning cut, especially for treatments 1 and 6 of this experiment.

Most buds from trees where treatment 2 and 3 were applied, did not sprout since they had not yet reached the minimal developmental stages. Oosthuyse & Jacobs (1996) also found a higher rate of re-flowering in 'Sensation' when the inflorescence was removed at the site of apical bud or inflorescence attachment as compared to when pruning included the leaves clustered around the shoot apex. They explained this to be due to the presence of intercalation (clustering of axillary buds at the shoot apex) giving rise to an increased number of axillary buds developing in response to pruning. In the current experiment, even if inflorescence development was earlier in 'KT' trees, fruit development did not proceed accordingly.

It is clear from this experiment that, either inflorescence or bud pruning treatments did not cause a failure in re-flowering and fruiting, however, there was a delay in harvesting. According to Reece *et al.* (1946); Gazit (1975), if inflorescences do develop after inflorescence pruning, a delay in flowering of four to eight weeks is effected, resulting in a delay in harvest (Issarakraisila *et al*., 1991; Oosthuyse, 1995).

Terminal bud pruning when temperature is high (post-harvest and renewal pruning), on the other hand, led to sprouting of lateral buds into vegetative growth. The direct relationship between flush length and leaf number implies a direct relationship between flush length and number of axillary buds per flush, thus increasing the scope for subsequent pruning. Fruiting appears to 'exhaust' the shoot, and it may not even flush post-harvest unless stimulated by pruning and this is even more so in relatively cooler climates or after late harvest (Wolstenholme & Whiley, 1995). Lateral buds from the other trees, especially those of treatments 1 and 6, which did not sprout into inflorescence during the winter, grew into vegetative flushes. The control trees were not encouraged to stimulate new shoot development by pruning and the old flower stalks that remained on the shoots inhibited sufficient vegetative growth. Limited new shoot development and flowering on these shoots, therefore, was due to sprouting of apical buds that didn't sprout the previous season. Issarakraisila *et al*. (1991) found that only 4% of shoots that matured a fruit flushed after harvest in cool subtropical Australia. Shoot development and flowering on the control shoots can also be due to random development from previous harvest and inflorescence development scars that might have activated axillary buds as also been stated by Oosthuyse (1994) in 'Sensation' mango. The total average leaf area of the newly developed leaves,

together with the existing foliage of the tree, will determine the amount of carbohydrate to be produced.

The assimilate produced could be used for reserve demanding processes like flowering and fruiting and any surplus, for replenishing the reserve of the tree. This will ultimately have an impact on regular bearing and quality of fruits to be produced. Immediate post-harvest pruning proved to produce better results for all the vegetative parameters observed in both cultivars. That was because pruning trees immediately after harvest encouraged the trees to produce enough new vegetative growth that matured early in the season especially for an early cultivar. Therefore, pruning immediately after harvest may be extrapolated to any early cultivar. Like what is observed in this study for 'TA', it has been generally recognised that the ideal time to apply terminal shoot pruning is directly after harvest (Mullins, 1986; Ram, 1993). The rationale for early pruning is the allowance of maximum time for canopy recovery, shoot maturation and quiescence to maximise the likelihood of flowering of the new shoots. The need for quiescence might be linked to the reduction of endogenous gibberellins (Chen, 1987) and accumulation of starch reserves (Suryanarayana, 1987). Consequently, pruning by hastening post-harvest flushing to occur uniformly, may effect earlier and more complete reserve replenishment (Oosthuyse, 1994; Davie *et al*., 1995). Flushing is important because new mango leaves are efficient producers of carbohydrates, the tree's building materials (Oosthuyse, 1995) and sources of energy. The results for number of new shoot development after post-harvest pruning were in line while that of new shoot length and number of leaves per new shoots contrary to the observations of Oosthuyse (1994) in 'Sensation' mango.

Flowering and fruiting from trees that received post-harvest pruning was delayed as compared to the control (on average by about 2-3 weeks). Oosthuyse (1994) also indicated that post-harvest pruning would result in slightly delayed flowering. He explained that vegetative re-growth caused by pruning after harvest, elevates the level of endogenous gibberellins, and thereby effects a delay in bud development and a delay in flowering. This connotation is contradictory to the fact that gibberellins normally encourage sprouting of buds. A delay in flowering is generally considered advantageous, since inflorescence development when temperatures are higher, results in an increase in the proportion of perfect as opposed to male flowers formed (Mullins, 1986), and gives rise to more effective pollination (Robbertse *et al*., 1986; Shu *et al*., 1989; Issarakraisila & Considine, 1994).

Practicing post-harvest pruning on late cultivars like 'KT' may have a negative effect, especially with a very late harvest, on the development and maturation of vegetative growth required for bearing the coming season's crop. This phenomenon may lead to the occurrence of biennial bearing. Renewal pruning, consequently, was primarily developed for late cultivars where 30% of the shoots were pruned before harvest when the fruit are still small. Stassen *et al*. (1999) promoted the applicability of renewal pruning for late cultivars. Fivas *et al*. (1997) and Fivas & Stassen (1996) also advocated the merits of renewal pruning on different mango cultivars. In general, pruning is essential for a timely development of vegetative flush. The absence of flushing during February, March and April may be followed by flushing instead of flowering during August and September that could result in a crop failure.

Pruning treatments, especially renewal and post-harvest pruning, involve removal of vegetative plant parts. However, not all pruning treatments had a negative effect on yield, more particularly in 'TA'. That was because pruning encouraged the development of new vegetative shoots. Those shoots can replenish the tree's carbohydrate reserve and also mature, flower and bear the coming season's crop. This advantage of pruning was also observed by Oosthuyse (1994) in 'Sensation' mango. If the tree stores a good carbohydrate reserve due to sufficient vegetative growth (as obtained by treatments 4 and 5 in this experiment) a larger total fruit weight per tree can be expected. The larger fruit weight obtained in this experiment due to post-harvest pruning was contrary to the results for the first year observations of Fivas & Stassen (1996) in 'TA'. Fivas & Stassen (1996) explained that the lower fruit weight result for the first season could be due to pruning the trees two months after harvest (late) and the time available for new shoot development was limited. This indicated that post-harvest pruning should be done directly after harvest as has been done in the current experiment. Their second season result on pruning of 'TA' was perspective to the results of the current experiment. Stassen *et al.* (1999) observed that fruit weight was always better with pruning while yield was lower during the first year but not for the consequent years.

The higher fruit numbers from for treatment 1, which is indicated in Table 5.6, may be due to increased fruit setting and fruit retention after re-flowering. The larger fruit setting in turn may be due to a favourable higher temperature during the growth of the different parts of the flowers. Mean monthly maximum and minimum temperatures were 22/10, 26/12 and 30/12 ^{o}C for September, October and November 2002 respectively (data recorded but not included in the thesis). In line with the

current observations, several practical advantages in the induction of axillary panicles after panicle pruning of mango (as in the case of treatment 1) have been reported in previous experiments. The primary advantage is to assure a good crop by escaping from or by making up the damages to the panicles caused by prevailing low temperature, frost and incessant rain (Singh *et al*., 1974). Another benefit of inducing axillary panicles is to provide a remedy for trees render unproductive by malformation (Majumder *et al*., 1976; Pal & Chadha, 1982). Moreover, orchard owners in the central part of Taiwan have used this technique to produce off-season mango fruits (Shu & Sheen, 1987). Chang & Leon (1987) also indicated that deblossoming of the terminal inflorescence could lead to inflorescence development from axillary buds but a 20-30 day later harvest. The result for the increase in fruit number and weight due to some of the pruning treatments in the current study is in contrary to the results of Oosthuyse & Jacobs (1996) in 'Sensation' mango. It is worthy to note, however, that fruit quantitative factors may vary based on different cultivars, weather variations in different seasons and tree physiological conditions.

The lowest fruit number and weight per tree by trees that received treatment 2 could be due to additional leaf removal. This in turn may affect inflorescence and fruit development as well as fruit retention as also observed by Oosthuyse & Jacobs (1996). They noted that a reduction in fruit number, 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 this site. Hence, especially 'TA' trees that received treatments 1, 4 and 5 produced larger fruit weight as compared to trees that received treatments 2, 3 and the control because of the above-mentioned reasons.

The treatments, however, did not have any impact on the total yield ha^{-1} for both cultivars as also been observed by Oosthuyse (1994); Oosthuyse & Jacobs (1996); Stassen *et al*. (1999) in 'TA' and other cultivars. The result was perspective to the observations of Fivas & Stassen (1996) while contradictory to that of Oosthuyse (1997), where reduced yield due to pruning was obtained. Chang & Leon (1987), on the contrary, obtained a larger yield by deblossoming the terminal inflorescence.

There was a trend towards synchronised flowering and ultimately fruiting after applying treatment 1 compared to the control trees. About 90% of the fruit from trees that received treatment 1 were ready for harvest (physiologically matured) on average with in two week period as compared to about a month required to complete harvesting of the fruit from the control trees. Oosthuyse & Jacobs (1996) indicated that flowering synchronisation in their studies might be ascribed to the simultaneous wound 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.

Higher fruit TSS of 'TA' by renewal and post-harvest pruning treatments can be ascribed to trees getting enough time to produce a new flush and those flushes mature early in the season especially for early cultivars. As compared to old flushes, new and matured leaves can efficiently manufacture more photsynthate and consequently attain higher reserve levels. The implication with sufficient reserve and fruit number not exceeding the tree's capacity is that all the developing fruit would receive an adequate supply of carbohydrates. Regarding renewal pruning, by removing dead and dying plant parts, which are with reduced photosynthesis efficiency, as well as poorly

developed and excess fruit, the plant reserve is conserved for the developing fruit. Wolstenholme & Whiley (1995) indicated that by practising renewal pruning, firstly it removes 'carbon starved, exhausted' fruiting shoots which will not fruit the next season. Secondly, old leaves with reduced efficiency are replaced with young and active leaves that make a better chance to build up carbohydrate reserves (even with winter photo inhibition).

In general, there was a trend that fruit with higher TSS would normally have lower titratable acids, which ultimately affects the TSS to acid ratio. Lakshminarayana (1980) explained that the titratable acids of fruit decrease during ripening. The reduction of acidity during ripening, he explained, plays a great part in the acid: sugar balance and consequently, in influencing the taste and flavour of the fruit. The predominant acid in common mango cultivar's pulp is citric acid and the secondary acids are malic and tartaric acid in varying proportions depending on the cultivars and ripening stage (Lakshminarayana 1980).

5.6 CONCLUSION

The hypothesis of some researchers and growers on the adverse effects of pruning treatments especially on the quantitative fruit parameters was not observed in the current study. Panicle pruning at the point of attachment, renewal and post-harvest pruning treatments were found to be promising for attaining higher results on vegetative growth, fruit number, TSS as well as synchronisation of flowering and fruit development. Time of applying post-harvest pruning is very crucial in that delayed pruning of the trees after harvest may lower or cause failure of cropping especially for

late cultivars. Renewal pruning should be practiced on late cultivars rather than post-harvest pruning. Panicle pruning together with apical whorl of leaves showed adverse effects on flowering and fruit harvested. It should be noted that, an increase in the parameters mentioned might not occur over seasons and a combination of pruning treatments should be applied than a single treatment. Adequate management as to the standard requirements of each mango cultivars is also mandatory to attain the desired response out of pruning treatments.