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# Manipulation of branching and architectural structures of mango trees by shoot pruning

(Manipulasi percabangan dan struktur seni bina pokok mangga dengan pemangkasan pucuk)

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**Abstract**

The present study evaluates the responses of Chokanan mango after subjected to shoot pruning. There are two different pruning cuts namely, i) pruning cuts made 1 cm above the first intercalation unit and, ii) pruning cuts made 1 cm below the intercalation unit were tested. The new lateral axillary shoots started to grow in the second week after pruning. The length and diameter of the new shoots were measured at a weekly interval. Two months following the pruning, the number, final length and size of the shoots produced from both pruning cuts were assessed. It was found that pruning cut that was made below the intercalation unit produced three to four new lateral shoots. In contrast, five to six new lateral shoots were produced from pruning cut that was made above the intercalation unit. No significant differences were found on the final mean length, diameter and shoot cross-sectional area of the lateral shoots. Both pruning cuts can assist synchronise flushing of vegetative shoots and can be used to manipulate branching of mango trees. It is noteworthy that the information generated from this study may contribute to the improvement of physiological understanding, increase farmer's knowledge to a proper tree management and useful for optimising mango production.

Keywords: *Mangifera indica* L., architecture, cultural practices, vegetative growth

## Introduction

Successful tree pruning is based on three basic principles, namely 1) tree physiology, 2) scientific principles of tree growth, and 3) understanding of tree responses to pruning cut and practices (Marini 2001). Pruning is required in mango for several purposes such as to control the size of tree, to remove unproductive and damaged branches that are cause by pests and diseases. In addition, pruning can also be used to improve light penetration and air circulation by creating spaces in the canopy of mango trees, as well as maintaining tree vigour (Tengku Ab. Malik et al. 1996). Besides the application of plant growth regulator such as Paclobutrazol, pruning is important to synchronise flowering in mango (Davenport 2003, 2006). In older orchard, pruning can be used to improve the yield and production of mango trees (Gross 1996; Davenport 2006). It was revealed in previous studies on subtropical mango that apical pruning can stimulate new growth of

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lateral shoots, synchronising the vegetative flushing and restoring back the productivity of pruned trees (Davenport 2006; Oosthuyse 1996; Ramírez and Davenport 2010). It is noteworthy that scarce information is available on the effects of pruning on vegetative growth of tropical mangoes.

The utmost importance knowledge in managing fruit tree crops is the basic physiological knowledge of pruning. Pruning requires a basic understanding of shoot architectural structures and how the tree response to various pruning cut. Furthermore, responses from the fruit trees to shoot branching can be translated to greater vegetative biomass, flowering and production (Yaish et al. 2010). Mango farmers can avoid eliminating the potential shoots for flowering and fruiting by practicing proper pruning technique. However, excessive pruning can present negative effects on mango trees and may cause immature shoots that are not ready for flowering due to insufficient food reserves. Also, this effect may stimulate a new flushing of vegetative shoots instead of flowering shoots (Bally 2006). Moreover, mango trees may not produce any fruit for one to two years after excessive pruning. Pruning is very labour intensive and hence, may increase the cost of field maintenance.

This trial was conducted to evaluate the effects of pruning cut on the shoot architectural structure of mango, cv. Chokanan. It is noteworthy that the effect of pruning cuts on shoot branching of tropical mango trees has not experimentally been tested. The researchers also tested whether different pruning cut may alter the characteristics of branching and shoot architectural of Chokanan mango.

## Materials and methods

### *Study site, plant materials and pruning treatment*

This study was carried out in the year of 2009 at Malaysian Agricultural Research and Development Institute (MARDI) Research Station, Sintok, Kedah. For this pruning trial, uniform three-year-old mango trees, *Mangifera indica* L. cultivar Chokanan were selected. The mango trees were planted at the distance of 6 m x 6 m and managed in accordance to the standard cultural practices of mango orchard in Malaysia (Tengku Ab. Malik et al. 1996). Following the method proposed by Davenport (2006) (*Plate 1*), the pruning treatments were conducted on the first and second intercalary unit of shoots. The architectural structure of mango shoots is characterised by the long internode that close together and form a cluster of buds at the terminal of each flush (*Plate 1*) (Davenport 2006). Each long internode was described as an 'intercalary unit' and the cluster of leaves, including the buds were described as intercalations numbered from stem terminus (Davenport and Núñez-Elisea 1997) (*Plate 1*).

The present study adopted and applied two pruning-cut treatments either on first or the second intercalary unit, i.e. 1) pruning


*Plate 1. Typical architectural structure of mango shoots. Small picture indicates the position of intercalation or ring of bud on mango shoots*

cut above the intercalation or ring of buds, and 2) pruning cut below the intercalation or ring of buds. Sixty mango shoots were subjected to both pruning cuts with a total of 120 shoots.

***Data collection and experimental design***

The timing and duration of emergence of shoots were recorded from the two pruning treatments. Following the emergence of the shoots, three shoots per pruning treatment were selected and tagged. Data on the development of shoots in terms of length (cm) was recorded starting from the base until the shoot tip by using measurement tape. Furthermore, the diameter of the shoots (mm) was measured in weekly interval by means of using digital calliper (Mitotuyo, Japan) and converted to shoot cross-sectional area ($mm^2$). At the end of the study period (after two months), the number of shoots produced (i.e. branching) per pruning treatment was manually counted. The final length and diameter of lateral shoots were recorded again from each pruning treatment. Complete Randomized Design (CRD) with ten single tree replicates was the arrangement of the experiment. Both pruning cuts were applied on the same trees, and a guard tree was positioned at the end of the rows in order to minimise the variation between the trees. Data were compiled using Spread sheet and summarised using Pivot Table (Microsoft Excel). SAS application system was used to analyse and check the normality of data. The differences between mean values were compared using t-test at 0.05.

## Results and discussion

***Effects of pruning cut on shoot growth and development***

*Figure 1* illustrates the lateral shoot growth of 'Chokanan' mango cultivar from both pruning cuts. Similar patterns were exhibited from the shoot development in terms of length (*Figure 1a*) and diameter (*Figure 1b*) from both pruning cuts. The line graph indicates that the elongation of lateral shoots was drastically increased starting from the second week after pruning cut (*Figure 1a*). Subsequently, the elongation of shoots from both pruning treatments was gradually increased until eight weeks (*Figure 1a*). Also, it was observed that the initiation or emergence of new lateral shoots was apparent in the second week regardless of pruning cut. The growth of shoots from pruning cut made below the intercalation (i.e. ring of buds) was slightly slower compared to the growth of shoots from pruning cut above the intercalation (*Figure 1a* and *Figure 1b*). Similar pattern was also observed on the diameter of shoots from both pruning treatments (*Figure 1b*). It is worthy to note that the slower growth

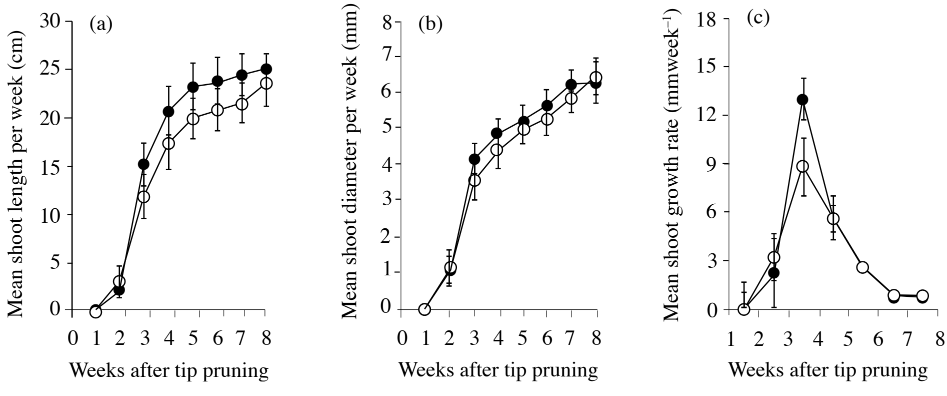


*Figure 1. (a) Weekly mean shoot length; (b) shoot diameter; and (c) shoot growth rate (mm week$^{-1}$) after subjected to tip pruning. Tip pruning above intercalation unit (●), and tip pruning below intercalation unit (○). Bars indicate standard error of mean (±) of raw data. n = 120 shoots*

rate of lateral shoots produced from pruning cut below the intercalation in *Figure 1c* reflected the slower growth in *Figure 1a* and *Figure 1b*. In the first two weeks following pruning, there was a drastic increase on the diameter of the shoots, but after the third week, only small increment on the diameter of shoots was observed (*Figure 1b*). After subjected to both pruning cuts, the growth and development of mango cv. 'Chokanan' shoots were similar and not much different were observed (*Figures 2a, 2b* and *2c*). The final length and diameter were recorded at the end of study period and presented in *Figure 3*. The results indicate that there was no significant differences ($p$ >0.05) on the final shoot characteristics of mango cv. 'Chokanan' (i.e. length, diameter and shoot cross-sectional area) from both pruning cuts (*Figure 3*). Both pruning cuts produced comparable length and diameter, as well as when expressed as shoot cross-sectional area of lateral shoots.

The researchers found that the growth and development of lateral shoots were similar from both pruning treatments (*Figure 1*). Even though the growth rate of lateral shoots was slightly slower from the pruning cut that was made below the intercalation (*Figure 1c*), there were no differences in the final length and diameter after two months following both pruning cuts (*Figure 3*). Therefore, it would be reasonable to suggest that the lateral shoots produced from both pruning cuts are in similar physiological maturity stage and this findings are in agreement with the previous study on mango cv. 'Haden' (Davenport 2006). As regards young mango trees, pruning cut at the apical shoots can force rapid initiation of shoots and may encourage synchronise flushing of new lateral shoots (i.e. vegetative growth) (Davenport 2006; Oosthuyse 1996). It is important to note that synchronise flushing of shoots is really crucial in managing mango trees because new mango leaves are really efficient in producing carbohydrates (Oosthuyse 1996). Apart from that, another vital factor lateral shoots (*Plate 2b*) with an average of three lateral shoots (*Figure 3*). Also, it was observed that the shoots from this pruning cut originated from the axillary buds at the base of leaves nearest to the pruning cut. As reported in the literature, pruning is usually a drastic operation that can directly or indirectly influence the physiological processes of tree (Marini 2001).

Flushing of shoots in the branches of mango was described as intercalary units and the cluster of leaves and buds at terminal of each intercalary unit was described as intercalations numbered from

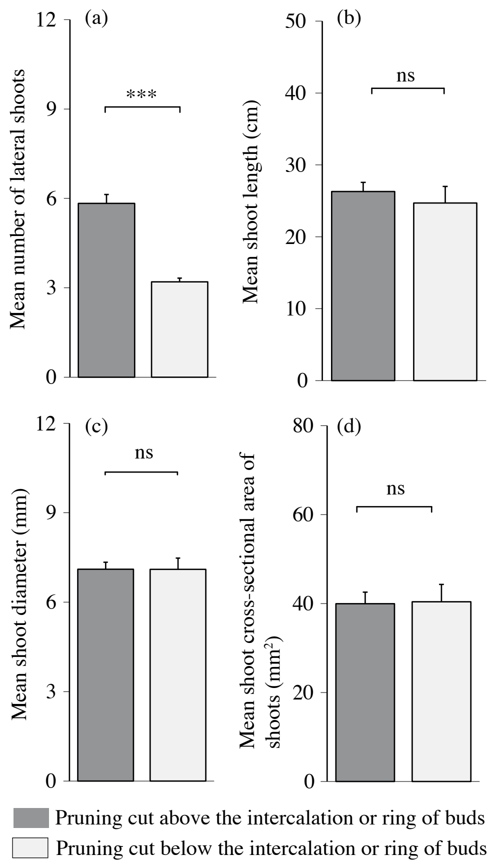


*Figure 2. The shoot care characteristics of 'Chok Anan' mango at the end of experimental period. (A) Final mean number of lateral shoots, (B) final mean shoot length, (C) final mean shoot diameter, and (/d) final mean shoot cross-sectional area of lateral axillary shoots. ns, *, **, ***non significant or significant at p ≤0.05, 0.01 and 0.001, respectively. n = 120 shoots*

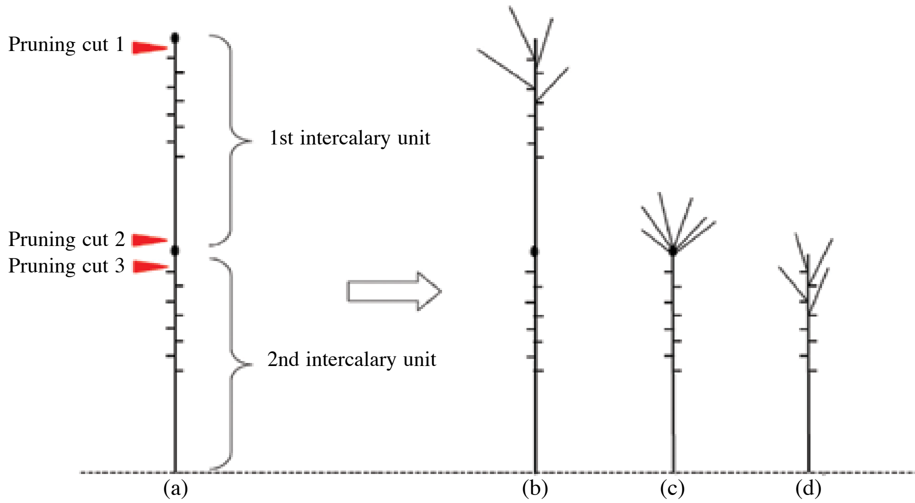


*Figure 3. Schematic representation of shoot architectural structures of mango and the effect of pruning cut on branching of young mango trees. (a) Red solid arrows indicate the position of pruning cut that can be applied, (b and d) pruning cuts made 1 cm above the intercalary unit may produce 3 to 4 lateral shoots; and (c) pruning cuts made 1 cm below the intercalary unit may produce 5 to 6 lateral shoots. Black solid dots (•) indicate the apical shoot and intercalation (refer **Plate 1**)*

that may influence flowering in mango is the age of shoots (Ramírez et al. 2010). Furthermore, synchronise shoot flushing resulted from a proper pruning cut was proven to be really important to produce off-season mango as proven in local mango cv. 'Sala' (Omran et al. 2010). In the present study, no data on flowering and fruiting could be recorded because the growth of new lateral shoots produced from both pruning cuts were only observed for a two months experimental period. Davenport (2006) reported that lateral shoots produced from pruning need to be rested for four to five months before they are ready for flowering. Therefore, further observation on the effects of pruning cut on flowering and fruiting warrants future investigation. With regards to mango, there are close relationship between shoot morphology (i.e. size), age and flowering (Normand et al. 2008, 2009; Ramírez et al. 2010).

Normand et al. (2008) advocated that larger stem or shoot in mango represent a higher capacity for assimilate transport, and a larger local storage capacity for carbohydrates. It was also hypothesised that larger shoots would have higher resources for reproduction compared to small shoots (Normand et al. 2009). Consequently, determination of the carbohydrate level in shoots of pruned tree may also provide new information on the relationship between flowering and carbohydrate status in mango shoots.

***Effect of pruning cut on branching of mango shoots***

The results illustrated in *Figure 3* and *Plate 2* revealed that the number of lateral shoots (i.e. branching) produced was significantly different ($p < 0.0001$) in both pruning cuts. Pruning cut that was made 1 cm above the intercalation or above the ring of buds produced four to nine lateral shoots (*Plate 2a*) with average of five shoots (*Table 1*). The lateral shoots produced from this pruning cut were clustered and close to the intercalation or ring of buds (*Plate 2a*).

In contrast, pruning cut that was made 1 cm below the intercalation or below the ring of buds only produced two to four

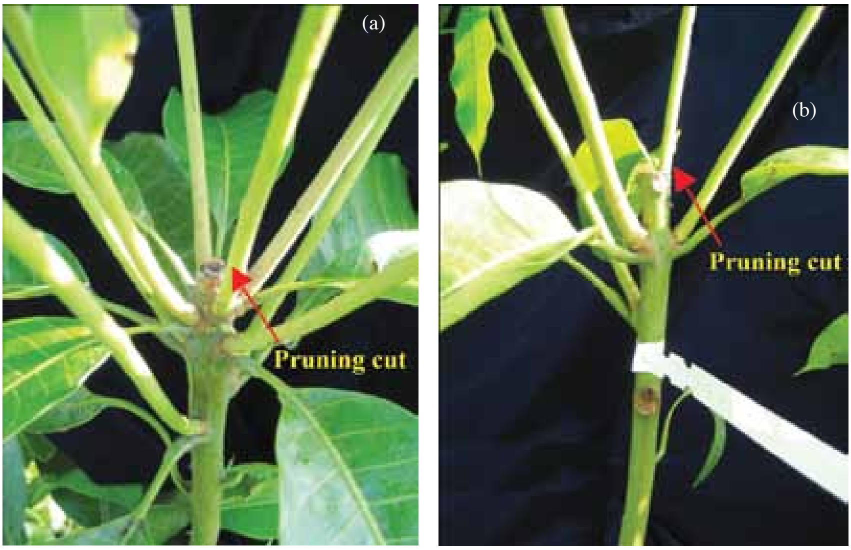


*Plate 2. Lateral axillary shoots (i.e. branching) produced from different pruning cuts. (A) Eight lateral stems resulting from a pruning-cut made above the intercalation or above the ring of buds. (B) Four lateral stems resulting from a pruning-cut made below the intercalation or below the ring of buds*

the stem terminal (*Plate 1*) (Davenport and Núñez-Elisea 1997). If the mango tree is given adequate water and nutrition, pruning cut at apical shoots will force rapid initiation of dormant lateral stem buds to form lateral shoots (Davenport 2006). At the terminal shoot of mango, most of the leaves are clustered at the apex because of the short internodes in this area (Oosthuyse 1996). Performing pruning cut above the intercalation resulted in the new lateral shoots developing from terminal shoot to form branching, and these new shoots are usually close together (*Plate 2a*). This finding is consistent with numerous studies on pruning with other mango cultivars (Davenport 2006; Oosthuyse 1996). The condition and position of the buds on the shoots are other factors that may influence the development of lateral shoots after pruning cut (Mika 1986).

For instance, Mika (1986) observed that the new shoot growth normally occurs on the buds that are located on the top of shoots after the shoot was headed in apple. This indicates that well-developed buds are usually located close to the shoot apex, whereas most of the buds that are not well developed are located at the base of the shoot (Mika 1986).

Similar evidence was found in the present study on Chokanan mango, whereby most of the new lateral shoots were developed from the top part of shoots after tip-pruning (*Figures 3a* and 3*b*). The results in *Plate 2* also supported Mika's (1986) statement that the shoot growth was influenced by the type of pruning cuts because the researchers found that the number of new lateral shoots of Chokanan mango was significantly different from both pruning treatments (*Figure 2*).

The stimulation of the growth of axillary buds (i.e. lateral shoots) is the main effect of pruning on trees. According to Cline (1994), pruning disrupted the natural processes of apical dominance, which is likely to involve the interaction among endogenous plant hormones such as auxin, cytokinins and gibberellins. Removal of the terminal portion of mango shoots will eliminate the source of auxin and consequently, removing the apical dominance. This has stimulated the growth of axillary buds into lateral shoots (Cline 1994). Apical dominance may not only influence the number of shoots (i.e. branching), but it may also affect the branching angle at which the shoots emerge from the main limb (Marini 2001; Mika 1986; Wade and Westerfield 1999). There was a similarity between apical pruning and heading cut (Mika 1986) due to the fact that both pruning types can stimulate the growth of new lateral shoots. Both pruning cuts can be employed for shortening the shoots and strengthen the tree frame structure (Mika 1986). Also, the researchers deemed that pruning on mango trees will change the proportion of tree parts such as the weight of new and old woods, as well as the proportion between above ground and underground parts. Wade and Westerfield (1999) stated that in relation to the root system, pruning could reduce the size of the above ground portion of the plant.

In addition, the flushing of new growth (i.e. vegetative re-growth) will occur due to the relatively higher uptake of nutrients and water by the remaining shoots and buds (Wade and Westerfield 1999). As regards mango, Davenport (2006) pointed out that in order to understand the responses of mango trees to pruning, the relationship between soil water content and leaf nitrogen levels are imperative and need to be considered. One flush of lateral shoot growth will occur after shoot tip pruning when mature mango trees received adequate water and leaf nitrogen levels (range from 1.1% to 1.4%) (Davenport 2003). Furthermore, when the water content of the soil is adequate, leaf nitrogen level will affect the frequency of mango flushes.

## Conclusion

Based on the results of the present study, the branching of mango shoots can be manipulated by pruning and is summarised in *Figure 3*. Pruning cut that was made below the intercalation (Pruning cut 1 and 3, *Figure 3b* and *2d*) produced 3 to 4 new lateral shoots. In contrast, 5 to 6 new lateral shoots were produced with pruning cut made above the intercalation (Pruning cut 2, *Figure 3c*). It can be concluded that the effects of pruning cut on shoot growth of mango trees are dependent on the type and the timing of the pruning cut. The present study has confirmed that both pruning cuts can be employed to synchronise vegetative flushing of tropical mango cv. 'Chokanan'.

The researchers believe that the information generated from this study is of the utmost importance to assist farmers in our country in managing their mango orchard. Moreover, through proper pruning management, mango farmers can get optimum tree growth, good tree frame shape that may produce high quality mango fruits. Therefore, further study is needed to evaluate these pruning techniques on the overall mango tree architecture and other commercial mango cultivars such as Harumanis, Nam Dork Mai and Sala (Ram 1992).

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**Abstrak**
Kajian ini menilai gerak balas pokok mangga Chokanan selepas pemangkasan pucuk. Dua pemangkasan yang berbeza telah diuji seperti: i) pemangkasan pucuk dibuat 1 cm di atas unit interkalasi yang pertama dan, ii) pemangkasan pucuk dibuat 1 cm di bawah unit interkalasi. Pucuk sisi baru telah mula berkembang selepas dua minggu pemangkasan. Panjang dan diameter pucuk baru diukur pada selang setiap minggu. Dua bulan selepas pemangkasan, nombor, panjang dan saiz akhir pucuk yang terhasil daripada pemangkasan telah dinilai. Didapati bahawa pemangkasan yang dibuat di bawah unit interkalasi boleh menghasilkan tiga ke empat pucuk sisi baru. Sebaliknya, lima keenam pucuk sisi baru telah dihasilkan daripada pemangkasan yang dilakukan di atas unit interkalasi tersebut. Tiada perbezaan yang bererti ditemui pada purata akhir panjang, diameter dan luas keratan rentas pucuk sisi. Kedua-dua pemangkasan didapati membantu menyeragamkan pengeluaran pucuk vegetatif, dan boleh digunakan untuk memanipulasi percabangan pucuk mangga. Maklumat yang dijana daripada kajian ini boleh menyumbang kepada peningkatan pemahaman fisiologi dan meningkatkan pengetahuan petani mengenai pengurusan pokok mangga yang betul, selain berguna untuk mengoptimumkan pengeluaran hasil manga.