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FRUIT SET AND OIL PALM BUNCH COMPONENTS

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ABSTRACT

Hand pollination was carried out using different amounts of pollen to produce different levels of fruit set in fruit bunches of 12-year-old DxP oil palms planted at Bangi, Selangor. Seventy ripe bunches were sampled and their fruit set ascertained. The fruit set ranged from 2% to 96%. Open pollinated bunches had a mean fruit set of about 80%. This indicates that the weevils were more efficient pollinators than hand pollination. There was an expected increase in fruit set with increasing amount of pollen from 0.0001 g to 0.01 g used in the hand pollination. The bunch weight increased with fruit set to a maximum of about 24 kg at 90% fruit set. Bunch development was affected by the increasing number of fertilized flowers, which increased the sink for carbohydrates. The increased sink under a limited carbohydrate supply led to a reduction in the mean fruit weight and an increase in parthenocarpic fruits in the inner bunch. The kernels had a higher priority for carbohydrate supply for their development than the mesocarp or shell.

Keywords: fruit set, fruit bunch, pollination, hand-assisted pollination, oil palm.

INTRODUCTION

The production of fruit bunches in the oil palm is influenced by several factors, such as nutrients, water, carbohydrate supply and pollination. The latter depends on the pollen supply and pollinator activity. Changes to any of these may decrease or increase the level of fruit bunch production. Among these factors, pollination has the greatest influence on fruit bunch production. Nutrient deficiencies, poor pollination or inefficient pollinator activity, either separately or combined, will lead to low bunch production.

Inefficient pollination can cause poor fruit set, and result in bunch failure and a loss in yield. This was a problem in the early days of oil palm cultivation, especially in young palms that produce insufficient male inflorescences. Assisted pollination had to be practiced to overcome the poor fruit set (Gray, 1969; Hardon, 1973; Lawton, 1981).

The introduction of the pollinating weevil, *Elaeidobius kamerunicus,* in 1981 succeeded in alleviating the problem of poor pollination (Syed *et al.,* 1982; Basri *et al*., 1983; 1987). The weevil pollination increased fruit set over hand pollination by about 20%, *i.e.* from 50% to 70%. An increased yield resulted from an increased bunch weight from a higher fruit-to-bunch ratio.

There was, however, a reduction in fruit size although compensated for by increases in the mesocarp-to-bunch and kernel-to-bunch ratios, and a reduction in the number of parthenocarpic fruits (Chan *et al*., 1982; Syed *et al*., 1982). Some of the changes have been permanent – fewer but bigger bunches and higher kernel-to-bunch ratio. The increase in kernel production has reduced the mesocarp-to-fruit and mesocarp oil-to-fruit ratios, although the mesocarp-to-bunch may not be lower because of the increased fruit set (Wood *et al*., 1984; Donough and Law, 1988; Chan *et al*., 1989). The changes in the bunch characteristics wrought by the weevil are attributed to increased fertilization of the inner flowers. Fruits from the inner bunch are smaller with a lower mesocarp-to-fruit ratio than the outer fruits (Yee *et al*., 1984). Tan *et al.* (1995) reported that the larger bunches produce a lower oil-to-bunch ratio because they contain more of the densely packed inner fruits that have a lower mesocarp-to-fruit ratio

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and higher moisture content. It is still unknown whether the poor growth of the inner fruits is caused by the spatial limitation for development of the mesocarp or a lack of assimilates.

This study investigated the effects of different fruit set levels on the fruit bunch components from mature oil palm.

MATERIALS AND METHODS

Assisted pollination using various amounts of pollen were carried out on 12-year-old DxP palms planted in 1988 at the MPOB Research Station, Bangi. The amounts of pollen used were 0.0001, 0.001, 0.01, 0.1, 1.0 and 5.0 g per anthesising inflorescence. The aim was to produce different levels of fruit set in the bunches. Each pollen treatment was randomly applied to 15 female inflorescences. The young inflorescences were bagged at least a week before anthesis and hand pollinated at the first sign of anthesis. Pollen was injected through a small hole in the bag which was then re-closed.

Pollen was collected from anthesising male inflorescences of commercial DxP palms and its viability tested by incubation in a 10% sucrose solution containing 15 drops of 5% boric acid solution. Hand pollination was carried out using only pollen with more than 60% viability. The pollen for each treatment was mixed with 2 g talcum powder before puffing on the anthesising female inflorescences. Each inflorescence received only one application of pollen, in order to induce low fruit set levels.

The ripe bunches were harvested about five months after pollination and fruit spikelet samples taken for bunch analysis (Blaak *et al.*, 1963) and fruit set count. For the bunch analysis, the spikelets were divided into the inner and outer bunch regions. Nineteen open pollinated bunches were also sampled for comparison. Fruits with no kernels were considered parthenocarpic.

RESULTS

Seventy bunches were selected for analysis out of 109 bunches. Thirty-nine bunches were discarded because of poor development or contaminated by weevils. The bunch fruit set obtained ranged from 2% to 96%. *Table 1* shows the increase in fruit set level with increasing amount of pollen from 0.0001 g to 0.01 g. The fruit set of hand pollinated bunches was not significantly different from open pollinated bunches when pollen used was greater than 0.01 g.

The bunch weight increased with fruit set to a maximum of about 24 kg at about 90% fruit set (*Figure 1*). The fruit-to-bunch (F/B) ratio increased with fruit set to a maximum value of about 67% at 75% fruit set (*Figure 2*), then decreased with higher fruit set. The kernel-to-bunch (K/B) ratio in the outer bunch also increased with fruit set to about 2.4% at 70% fruit set (*Figure 3*), and then decreased at higher fruit set level. K/B in the inner bunch increased with fruit set and reached a value of 3% at 85% fruit set. The total K/B ratio of the whole bunch reached a peak of about 5% at 70% fruit set.

TABLE 1. MEAN FRUIT SET IN HAND AND OPEN POLLINATED BUNCHES

Pollen amount (g)	No. bunches	Fruit set (%)
0.0001	8	13.2 ± 4.0a
0.001	7	46.6 ± 9.0b
0.01	7	73.4 ± 5.9bc
0.1	9	73.3 ± 7.4bc
1.0	9	64.1 ± 7.9bc
5.0	11	61.3 ± 8.9bc
Open pollinated	19	79.4 ± 2.3c

Notes: Mean ± SE. Values with the same letter are not significantly different at $p < 0.05$.

The mesocarp oil-to-bunch (O/B) ratio increased with fruit set to a maximum of 25% at about 75% fruit set (*Figure 4*), and then decreased. To maintain O/B >20% required at least 40% fruit set. The mesocarp oil content in the outer bunch reached a maximum value of 16% at 70% fruit set, while the inner bunch mesocarp reached at peak of 9.6% at 86% fruit set (*Figure 5*). Subsequently, both the contents decreased with higher fruit set. The inner bunch mesocarp contained less oil than the outer bunch mesocarp.

The mesocarp-to-fruit (M/F) ratio from the inner bunch showed a non-significant ($p<0.05$) negative linear relationship with fruit set (*Figure 6*). Similarly with the outer bunch M/F ratio although it remained >80. This indicates that the inner fruits had less mesocarp than the outer fruits.

The mean fruit weights from the outer and inner bunch showed significant ($p<0.05$) negative linear relationships with the fruit set (*Figure 7*). The inner fruits were smaller than the outer fruits.

The parthenocarpic-to-total fruit (P/F) ratio of the inner bunch region showed a significant ($p<0.05$) positive relationship with fruit set (*Figure 8*), while the ratio of the outer bunch was non-significant ($p<0.05$) and negative with fruit set. The parthenocarpic fruits in the inner bunch increased with fruit set.

The oil-to-dry mesocarp (O/DM) ratios of the inner and outer bunch were not significantly ($p<0.05$) affected by the fruit set (*Figure 9*). This implied that the mesocarp capacity to produce oil was not affected by the level of fruit set.

The mean nut dry weight of the inner bunch showed a significant ($p<0.05$) negative linear relationship with fruit set (*Figure 10*), while the mean nut dry weight of the outer bunch showed a non-significant ($p<0.05$) negative linear relationship with fruit set.

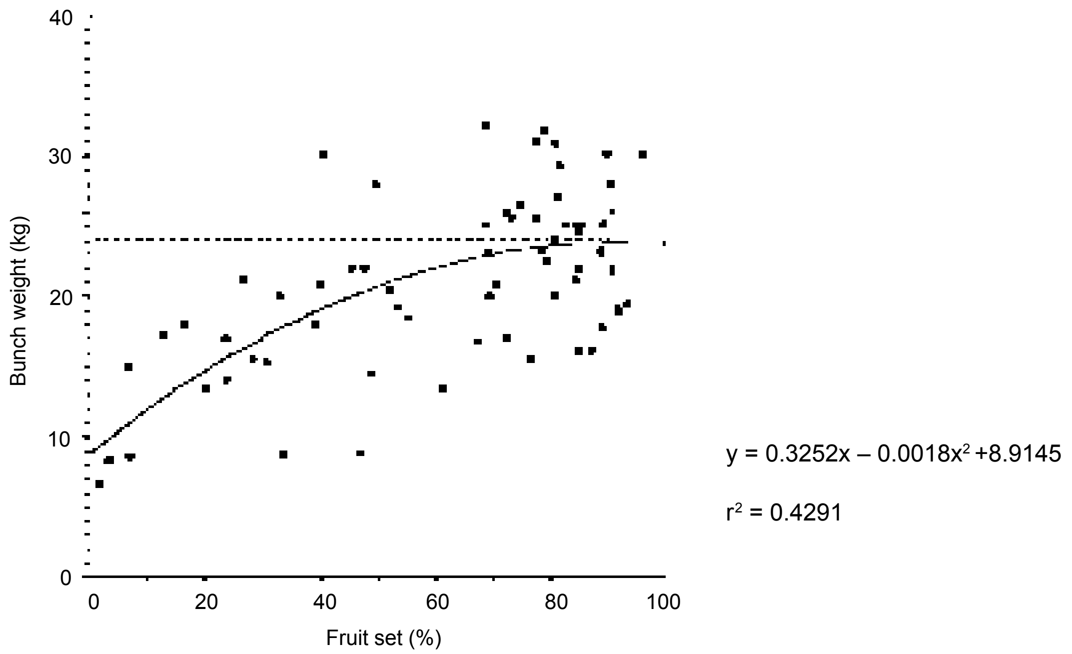

Figure 1. Mean bunch weight vs. fruit set. The quadratic relationship is significant at p<0.001.

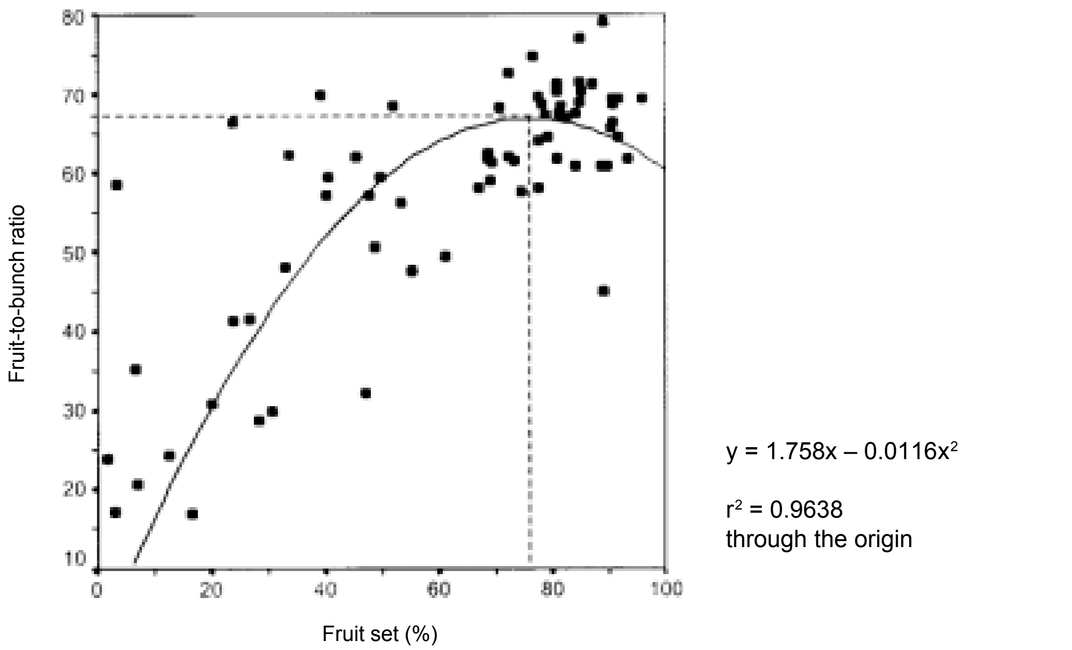

Figure 2. Fruit-to-bunch ratio vs. fruit set. The quadratic relationship is significant at p<0.001.

The mean kernel dry weight of both the inner and outer bunch showed non-significant ($p<0.05$) negative linear relationships with fruit set (*Figure 11*). The kernels of the inner fruits were slightly larger than those from the outer fruits.

The mean shell dry weight of the inner and outer bunch showed non-significant ($p<0.05$) negative linear relationships with fruit set (*Figure 12*). The shell dry weight of the inner fruits was slightly lower than that of the outer fruits. The mean bunch frame (stalk and spikelets) fresh weight showed a significant ($p<0.05$) positive linear relationship with fruit set (*Figure 13*).

DISCUSSION

The fruit set of hand pollinated bunches was lower compared with open pollination and this could be due to the limited number of receptive flowers during the hand pollination and/or the difficulty for the hand-applied pollen to reach the inner flowers. The open pollinated female inflorescences had a mean fruit set of about 80%. This indicated that the weevils were more efficient pollinators through their foraging in the inflorescences whereas in the hand pollination pollen was only applied once to the inflorescences.

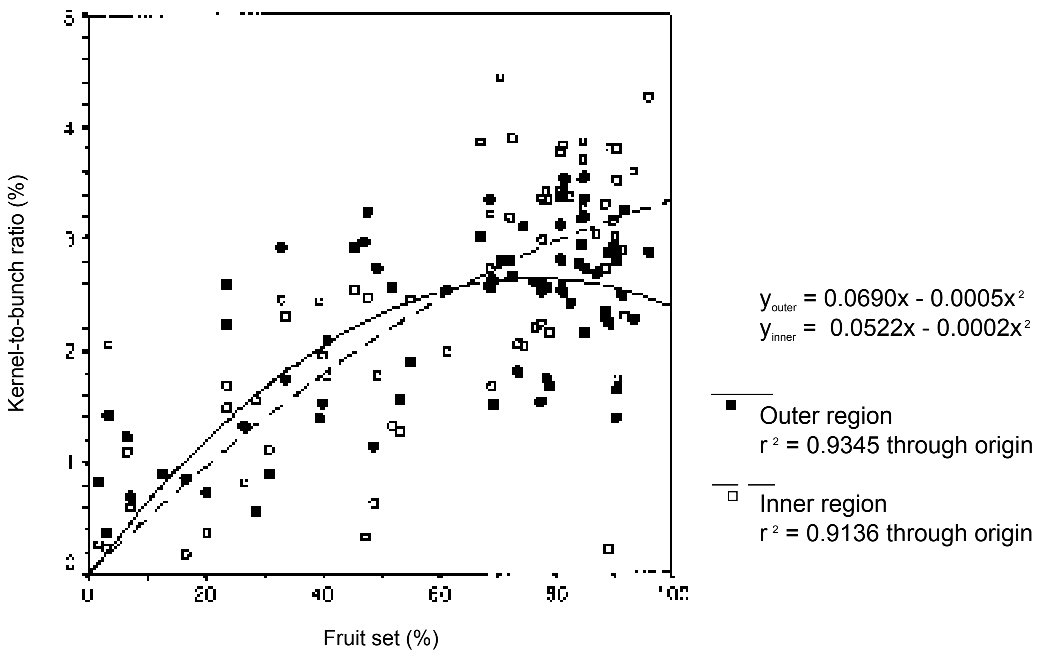

Figure 3. Kernel-to-bunch ratio vs. fruit set (inner and outer bunch). The quadratic relationships are significant at p<0.05.

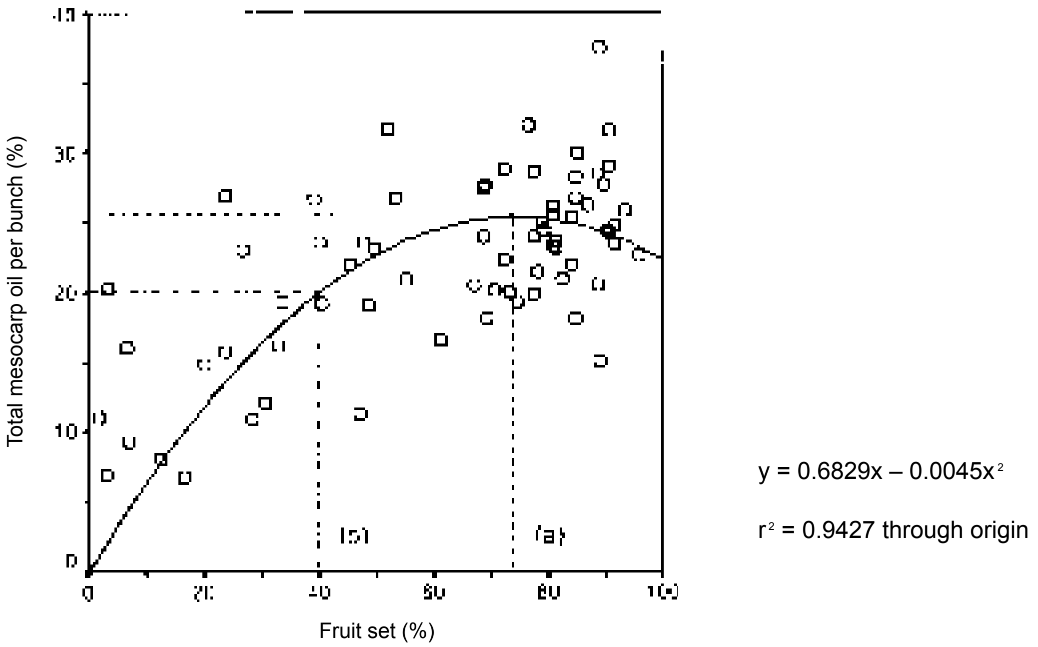

Figure 4. Total mesocarp oil-to-bunch ratio vs. fruit set. The quadratic relationship is significant at p<0.05. Indicated on the graph are the (a) maximum and (b) minimum fruit set for O/B >20%.

An average maximum bunch weight of about 24 kg was attained at a fruit set of about 90%. A bunch comprises the oil-bearing fruits and supporting structures, such as spikelets and stalk. The bunch frame increased linearly with fruit set to support the higher number of fruits. Therefore, a greater supply of assimilates is needed for bunch development at high fruit set levels.

A decrease in the average fruit weight can result in a lower bunch weight even with a very high fruit set. This, in fact, occurred when a low F/B ratio was obtained with a fruit set of <75%. The F/B ratio is dependent on the number and weight of fertilized female flowers that develop into fruits.

The mean fruit weight is dependent on several components such as mesocarp, kernel and shell weights. The mean fruit weight from the outer bunch was slightly higher than from the inner bunch. The poor fruit growth in the inner bunch could either be due to their dense packing and lack of space for

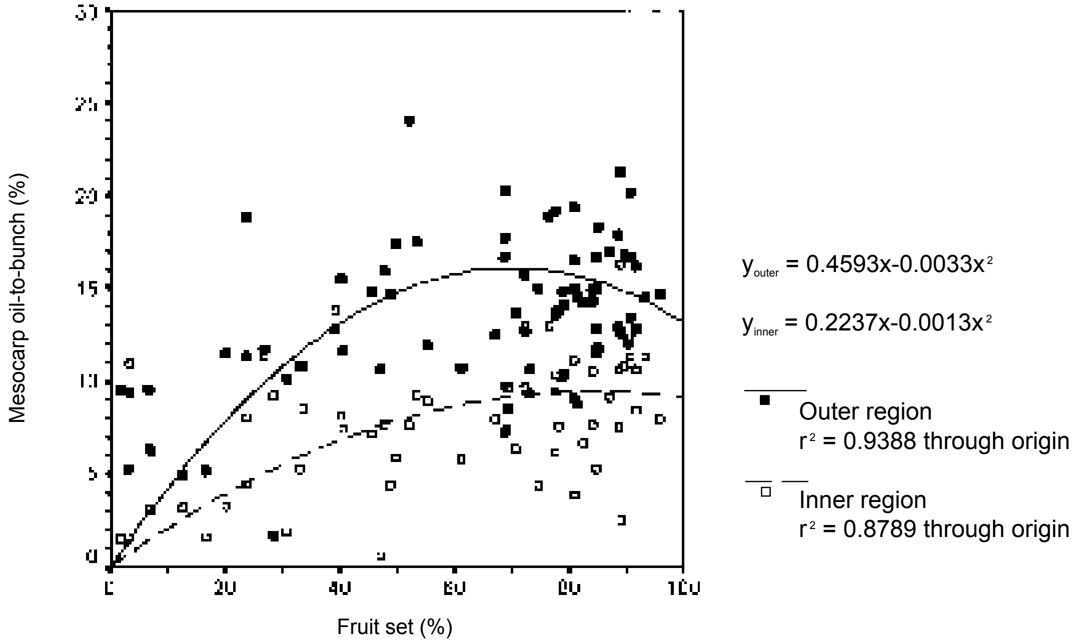

Figure 5. Mesocarp oil-to-bunch ratio vs. fruit set (inner and outer bunch). The quadratic relationships are significant at p<0.05.

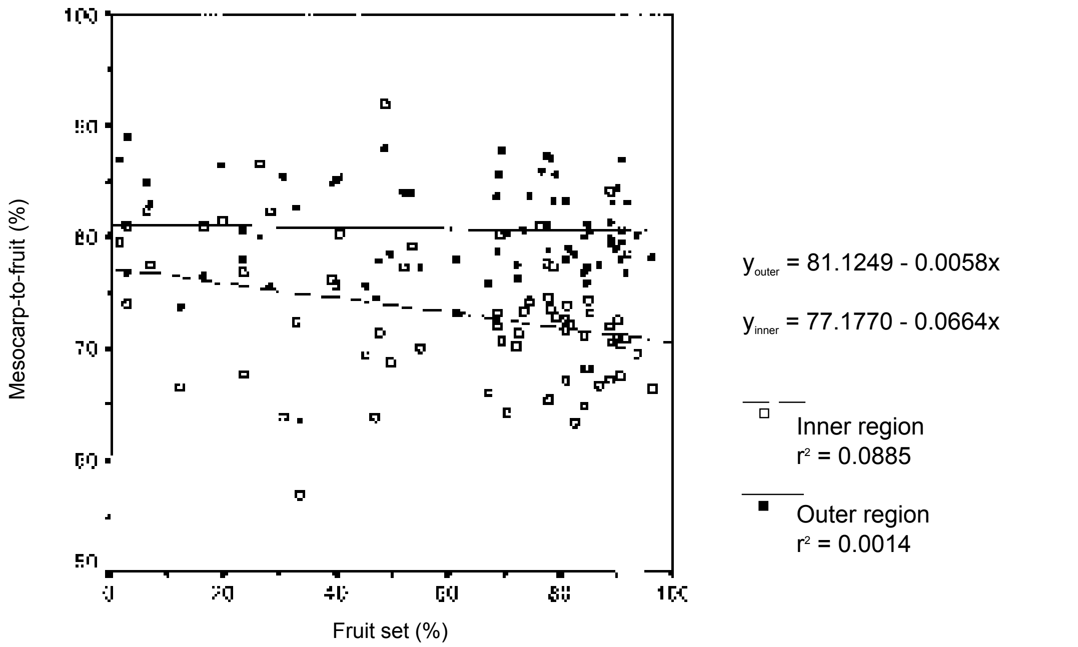

Figure 6. Mesocarp-to-fruit ratio vs. fruit set (inner and outer bunch). The inner relationship is inverse and significant at p<0.05. The outer relationship is not significant.

expansion or to a lower partitioning of assimilates to them.

There was a significant increase in parthenocarpic fruits in the inner bunch with fruit set. Parthenocarpic fruits contain very little oil. Increasing the fruit set increased the P/F ratio in the inner bunch. Therefore, the high P/F ratio in the inner bunch indicated that fertilization of the flowers was not overly successful due to the dense packing of flowers obstructing ingress of the pollen.

A maximum mesocarp O/B ratio of about 25% was obtained at a fruit set of about 75% but it thereafter decreased with higher fruit set (*Figure 4*). The total mesocarp O/B ratio is dependent on the component ratios of O/DM, M/F and F/B. However, increasing fruit set did not affect the O/DM ratio. Although M/F from the outer region was not affected by fruit set, the ratio from the inner region declined when fruit set increased. The F/B reached a maximum at about 75% fruit set. The inner bunch

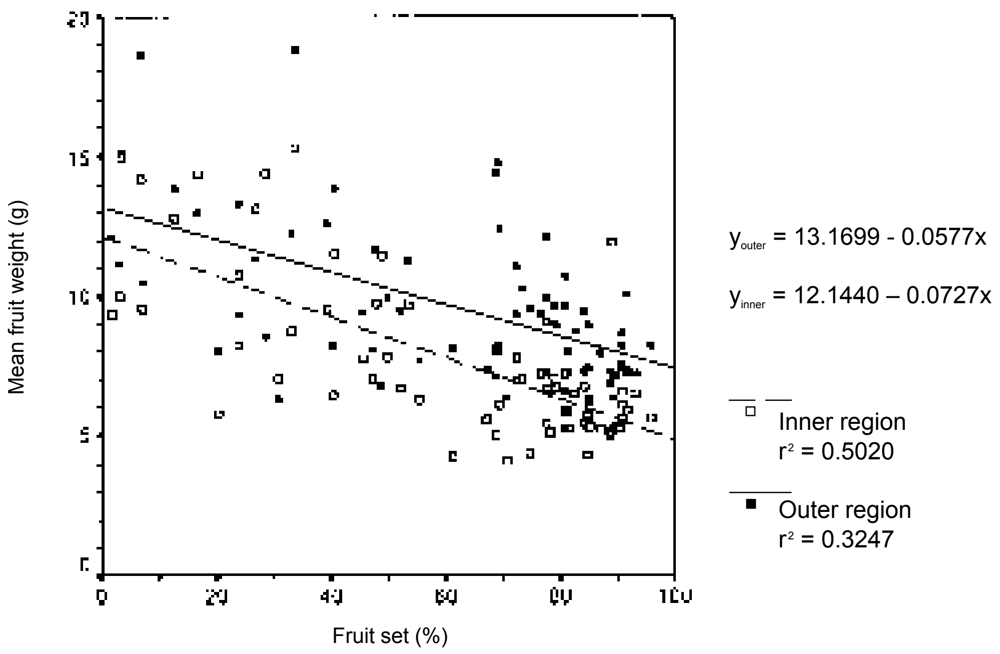

Figure 7. Mean fruit weight vs. fruit set (inner and outer bunch). The linear relationships are negative and significant at p<0.001.

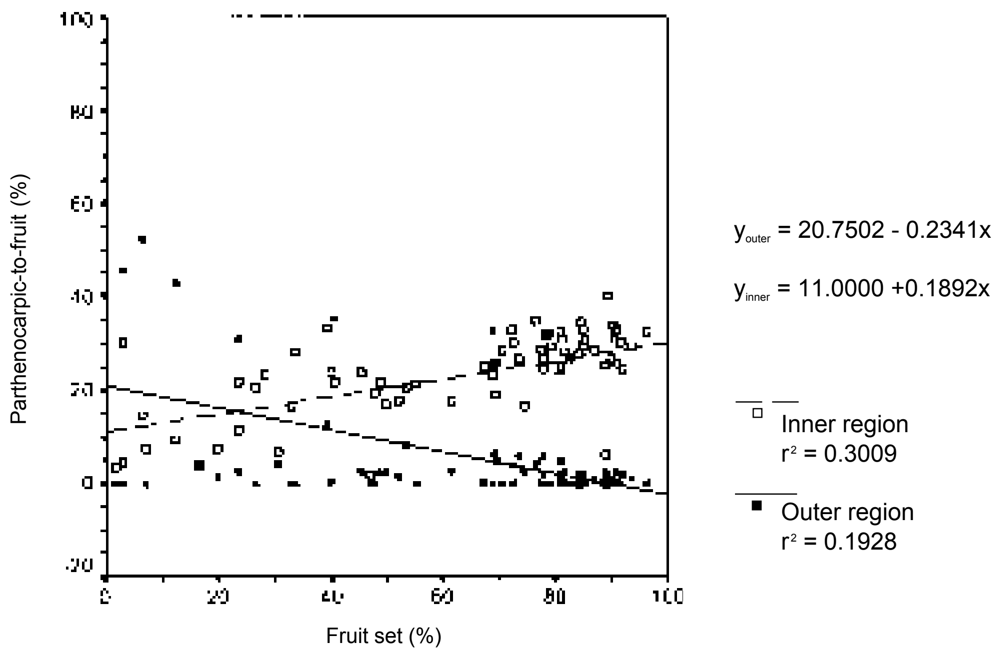

Figure 8. Parthenocarpic-to-fruit ratio vs. fruit set (inner and outer bunch). The inner linear relationship is positive and significant at p<0.05. The outer linear relationship is negative and non-significant at p<0.05.

produced less mesocarp oil in total compared to the outer bunch, because of its lower M/F and fruit weight. Both the inner and outer bunch regions had about the same O/DM. This showed that the capacity of the mesocarp tissue to synthesize oil was not affected by the bunch region.

The mean fruit weight declined with fruit set. The average fruit weight in the outer bunch was higher than in the inner bunch. The mean nut dry weights also decreased with fruit set. However, the mean nut dry weight from the inner bunch was higher than that from the outer bunch because of its slightly higher kernel dry weight and lower shell dry weight. The kernel, which develops earlier than the mesocarp, has priority for the assimilate supply compared to the mesocarp which develops later and which therefore may suffer from a lack of assimilates and space for expansion, particularly in the inner bunch. Kernel development has the priority since the physiological need to propagate the next generation of palms (development of fertilized kernels) must be paramount to the plant.

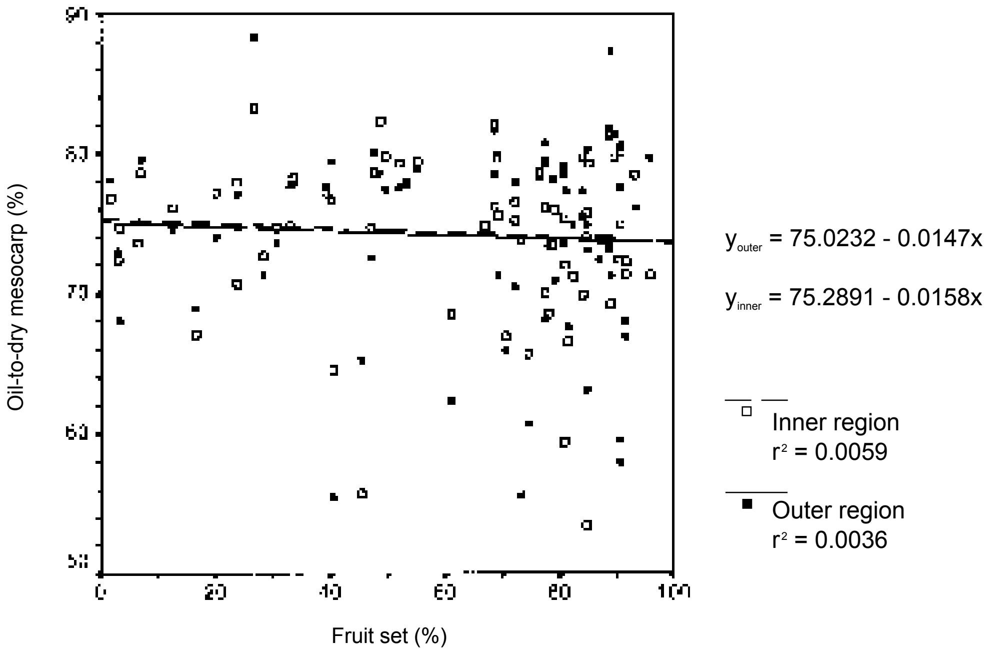

Figure 9. Oil-to-dry mesocarp ratio vs. fruit set (inner and outer bunch). The negative linear relationships are non-significant at p < 0.05.

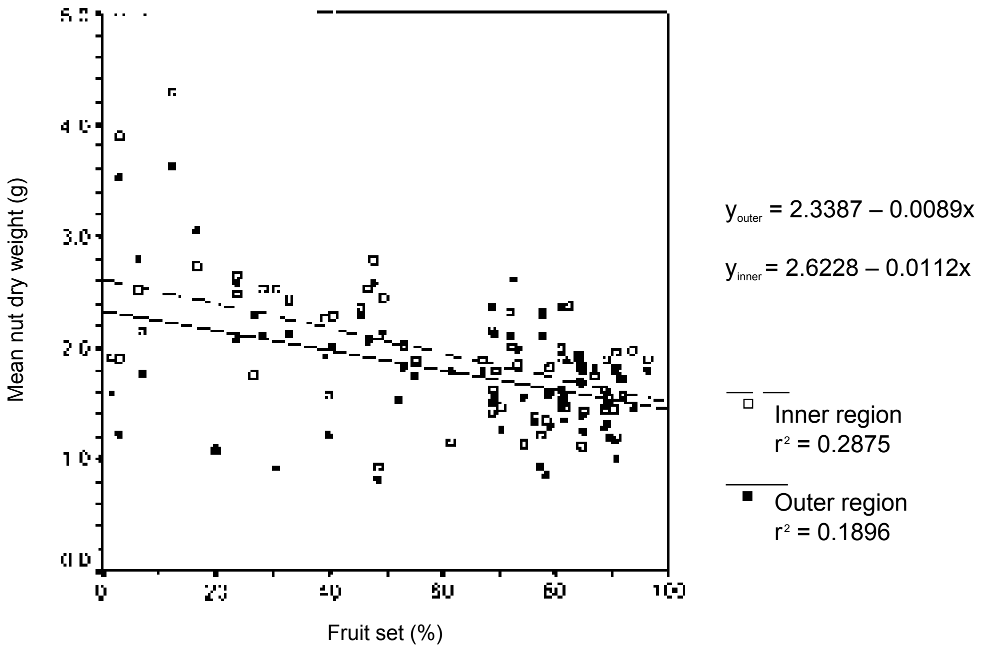

Figure 10. Mean nut dry weight vs. fruit set (inner and outer bunch). The negative linear relationships are significant at p < 0.001.

CONCLUSION

A maximum bunch weight of 24 kg and mesocarp oil content of 25% were obtained at a fruit set of 90% and 75% respectively. A minimum fruit set of about 40% sufficed to maintain the total mesocarp O/B ratio >20%.

The fruit set affected bunch development by firstly increasing the number of fertilized fruits (or F/B) and subsequently increasing the sink demand for carbohydrate. The increased sink demand under a limited supply was compensated for by a reduction in the individual fruit weight and an increase in underdeveloped fruits in the inner bunch.

The nut had priority for the carbohydrate supply and its development was not affected by the limited space in the inner bunch. Within the

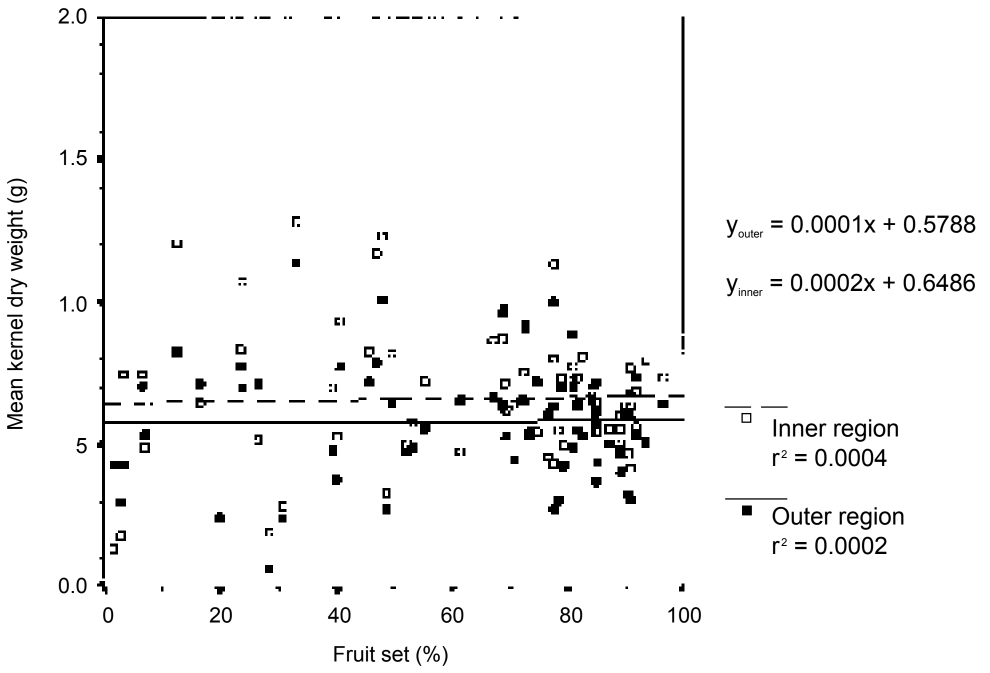

Figure 11. Mean kernel dry weight vs. fruit set (inner and outer bunch). The positive linear relationships are non-significant at $p < 0.05$.

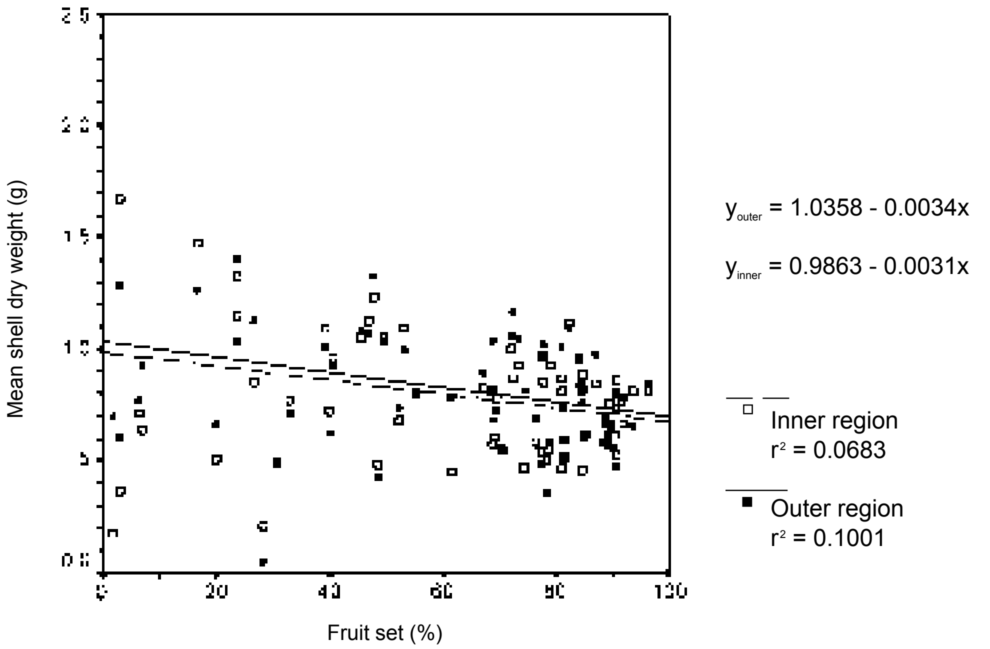

Figure 12. Mean shell dry weight vs. fruit set (inner and outer bunch). The negative linear relationships are non-significant at $p < 0.05$.

nut, the kernel had a higher priority, as the shell was thinner in the inner fruits. The mesocarp was the most affected by the limited carbohydrate supply and by the lack of space for expansion, which was most evident in the inner bunch. The capacity of the mesocarp to synthesize oil, as shown by the O/DM ratio, was the same in both the inner and outer bunch and not affected by level of fruit set.

This study shows the effects of modifying the bunch components on the palm oil yield. Controlling the bunch size and number is the primary means for regulating the assimilate supply of the palm to the sink demands of its bunches. Therefore, it is recommended that 12-year-old oil palm planting materials should have an average bunch weight of - 25 kg. A minimum fruit set of about 40% is sufficient to maintain an O/B ratio • 20%.

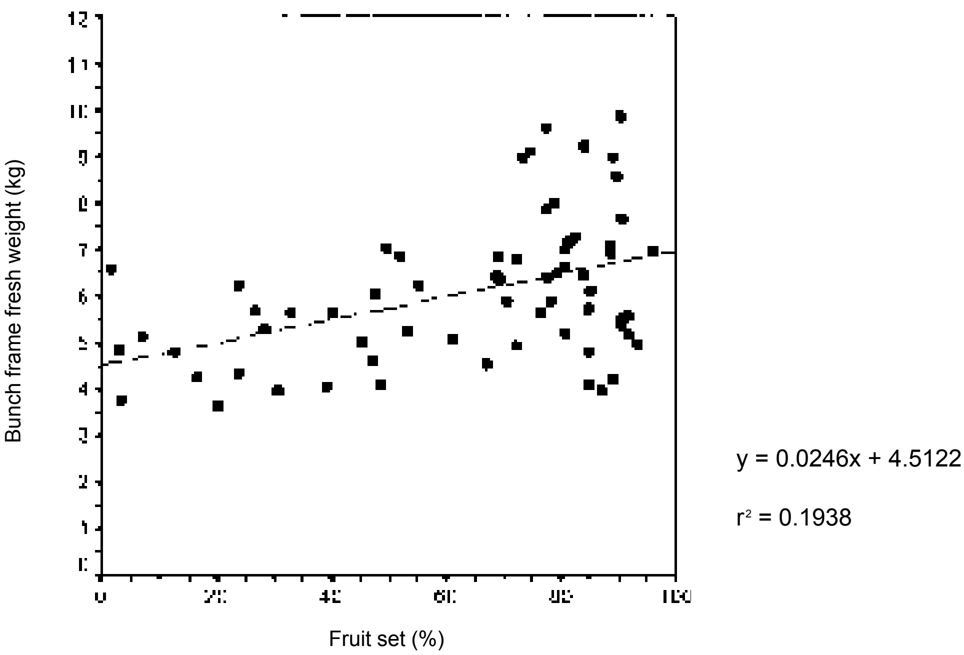

Figure 13. Bunch frame fresh weight vs. fruit set.
The linear relationship is positive and significant at $p < 0.05$.

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