ORIGINAL ARTICLE

Assessment of fruit density and leaf number: fruit to optimize crop load of mangosteen

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Abstract

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To optimize crop load of mangosteen, fruit density and leaf number: fruit were assessed using a framework of quadrat cube (0.5 x 0.5 x 0.5 m) in 2 consecutive years (2004-2005). Twenty-four 14-year-old uniform trees, field grown at Songkhla province, were selected to arrange 4 levels of crop loads: 1) Extremely low crop load (T1) = 264±5 fruit pt^{-1}, 2) Low crop load (T2) = 826±36 fruit pt^{-1}, 3) Medium crop load (T3) = 1190±27 fruit pt^{-1} and 4) High crop load (T4) = 1719±36 fruit pt^{-1}. By placing the quadrat cube on the tree canopy, leaves quadrat^{-1} and fruits quadrat^{-1} were counted. Relationship between fruits quadrat^{-1} and fruit number pt^{-1} was found, and leaf number: fruit was also related to fruit yield pt^{-1}. These results indicate that the assessment of fruit density and leaf number: fruit is of benefit for crop load management. Thus, 9 fruits quadrat^{-1} and 18 leaves: fruit are recommended to optimize crop load of mangosteen.

Key words : crop load, fruit density, leaf number: fruit, mangosteen, quadrat cube

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บทคัดย่อ

สายัณห์ สดุดี และ คชาธาร พลรงค์
การประเมินความหนาแน่นผลและจำนวนใบต่อผลเพื่อการไว้ผลมังคุดอย่างเหมาะสม
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เพื่อการไว้ผลมังคุดอย่างเหมาะสมจึงได้ทำการประเมินความหนาแน่นผล และสัดส่วนจำนวนใบต่อผล โดยใช้กรอบลูกบาศก์ (0.5 x 0.5 x 0.5 ม.) ในช่วง 2 ปีต่อเนื่อง (2547-2548) โดยคัดเลือกต้นมังคุดอายุ 14 ปีที่มีขนาดสม่ำเสมอ จำนวน 24 ต้น ภายใต้สภาพแปลงปลูกที่จังหวัดสงขลา โดยมีระดับการไว้ผล 4 ระดับ คือ 1) ไว้ผลต่ำมาก (T1) = 264±5 ผล/ต้น 2) ไว้ผลต่ำ (T2) = 826±36 ผล/ต้น 3) ไว้ผลปานกลาง (T3) = 1190±27 ผล/ต้น และ (4) ไว้ผลมาก (T4) = 1719±36 ผล/ต้น โดยการวางกรอบลูกบาศก์บนทรงพุ่มของต้นพืชเพื่อนับจำนวนใบและจำนวนผล พบว่าจำนวนผล/กรอบลูกบาศก์และจำนวนผล/ต้นมีความสัมพันธ์กัน และจำนวนใบ/ผลมีความสัมพันธ์ต่อผลผลิตต่อต้นด้วย ผลดังกล่าวแสดงให้เห็นว่า การประเมินความหนาแน่นผลและจำนวนใบ/ผลมีประโยชน์ต่อการจัดการไว้ผล ดังนั้นจึงแนะนำว่าการไว้ผลที่เหมาะสมคือไว้จำนวน 9 ผล/ลูกบาศก์ และมีสัดส่วน 18 ใบ/ผล

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Mangosteen (*Garcinia mangostana* L.) is a high potential fruit for export of Thailand, and acceptable fruit size for export is large fruit size or >70 g (Department of Agriculture, 2003). Phonrong (2005) found that an excessive crop load caused adverse effect on fruit size of mangosteen, this led to a marked decrease of the yield of large fruit size. In peach and nectarine, fruit size decreases with increasing crop load (Berman and De Jong, 1996; Blanco *et al*., 1995; Rowe and Johnson, 1992), probably because of the limited availability of assimilates. Naor *et al*. (1999) reported that decreasing crop level of nectarine trees with increasing irrigation level, caused fruit size distribution to be shifted towards larger fruit. The reduction in fruit size is not only adverse effect of an excessive crop load. Trees that produce a very heavy crop usually have a high bloom and a light crop in the following year (Forshey, 1986). This often initiates a continuing cycle of alternate light and heavy crop that is known as alternate bearing. To overcome these problems, optimizing crop load has been investigated. However, it is difficult to estimate the crop load by eye where fruit is small. Vock *et al*. (1997) suggested that a way of determining the need for thinning is to count the fruit in a relatively small defined volume of the tree canopy. The volume is defined by a framework in form of a cube, called a quadrat, with sides of 0.5 m long. In citrus, counting fruitlets inside the cube, it is suggested that optimum fruitlets per cube is 15 fruitlets. Thinning is required when there is an average of more than 15 fruitlets per cube. Besides, leaf number: fruits is also used for optimizing crop load, because the amounts of leaf photosynthate influence fruit yield and fruit quality (Lechaudel *et al*., 2002). Hence, the objective of this study is to assess fruit density and leaf number: fruit in mangosteen to optimize crop load using a quadrat-cube framework.

Materials and Methods

An experiment was established in Songkhla province, southern Thailand. The experimental plot consisted of 14-year-old mangosteen trees, spaced at 8 x 8 m apart. In January 2004, 24 uniform trees were selected for 4 levels of crop load with 6 replicates. The levels of crop load were 1) Extremely low crop load (T1) = 264±5 fruit pt^{-1} (or fruit per plant), 2) Low crop load (T2) = 826±36 fruit pt^{-1}, 3) Medium crop load (T3) = 1190±27 fruit pt^{-1} and 4) High crop load (T4) = 1719±36 fruit pt^{-1}. The total number of fruit in each tree was counted by tagging each fruit at 6 weeks after flowering or near the end of the natural fruit drop. This is the stage of crop load estimation recommended by Department of Agriculture (2003). In 2005, the numbers of total fruits of the trees in each treatment were also counted. All trees were well irrigated by a sprinkler system, and they were also under identical cultural practice. Fertilizers were applied in a wide band around the margin of the tree canopy. Two kilograms of NPK 15:15:15 formulation and 50 kg of well decayed cow-manure were applied each tree at pre-flowering. Then, 2 kilograms of NPK Mg mixture of 12:12:12:17:2 was applied to each tree during fruit development. Therefore, in both years the cultural practices were done in the same way.

Fruit density and leaf number: fruit assessment

To evaluate fruit density and leaf number: fruit, a framework of quadrat cube was used for counting. The quadrat was 0.5 m cube (0.5 m x 0.5 m x 0.5 m), each side (0.5 m) was made of PVC pipe (0.5 inches diameter) with prongs at each corner. The counting quadrat was randomly placed in 4 parts (in the North, East, South and West) of the tree canopy (Figure 1). Numbers of leaves and fruits in the area of the square was counted and recorded throughout the experimental trees. The counts in each tree were then averaged as leaves quadrat^{-1}, fruits quadrat^{-1} and leaf number: fruit. Then, relationship between fruits quadrat^{-1} and fruit number pt^{-1}, and relationship between leaf number: fruit and fruit yield were assessed. Around 14 weeks after bloom, fruits were harvested. The yield of large fruit size (>70 g) in each treatment was determined as the percentage of total yield pt^{-1}.

The data of weather condition during the experimental period was derived form Koh Hong Meteorological Station where is 5 km from the experimental plot.

Results and Discussion

The weather conditions at the experimental site from January 2004 - September 2005 are presented in Figure 2. Average monthly maximum temperature in both year was around 30-35ºC, while the minimum temperature was around 25ºC. During the experimental period, drying period (January-April) in 2005 was more severe than that in 2004. This led to an induction of flowering with higher yield in 2005 compared with 2004 (Figure 3 a and b), because water stress during summer induced flowering in mangosteen.

The high relationship between fruits quadrat^{-1} and fruit number pt^{-1} was found in both years (Figure 3 a and b). This indicated that the

Figure 1. Placing the quadrat in the mangosteen tree with its prongs pointing towards the trunk with outer edge of the quadrat at the edge of the canopy.
[Color figure can be viewed in the electronic version]

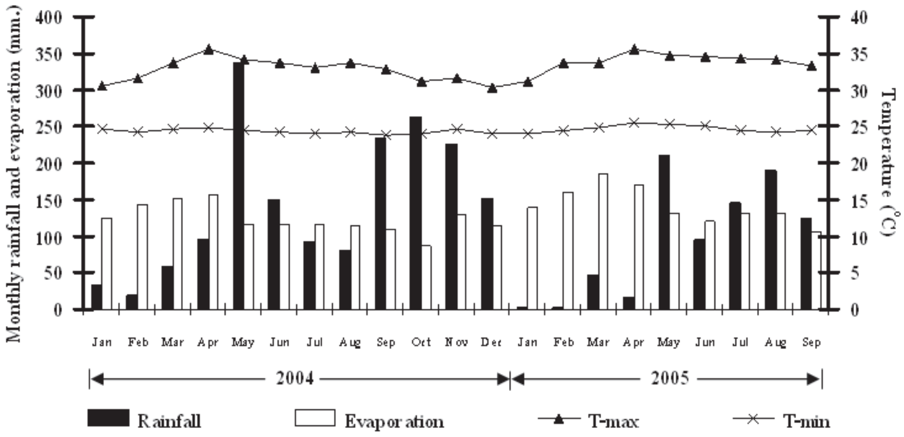

Figure 2. Monthly rainfall, evaporation, maximum and minimum temperature during January 2004 - September 2005. Data from Koh Hong Meteorological Station, Hat Yai, Songkhla, Thailand.

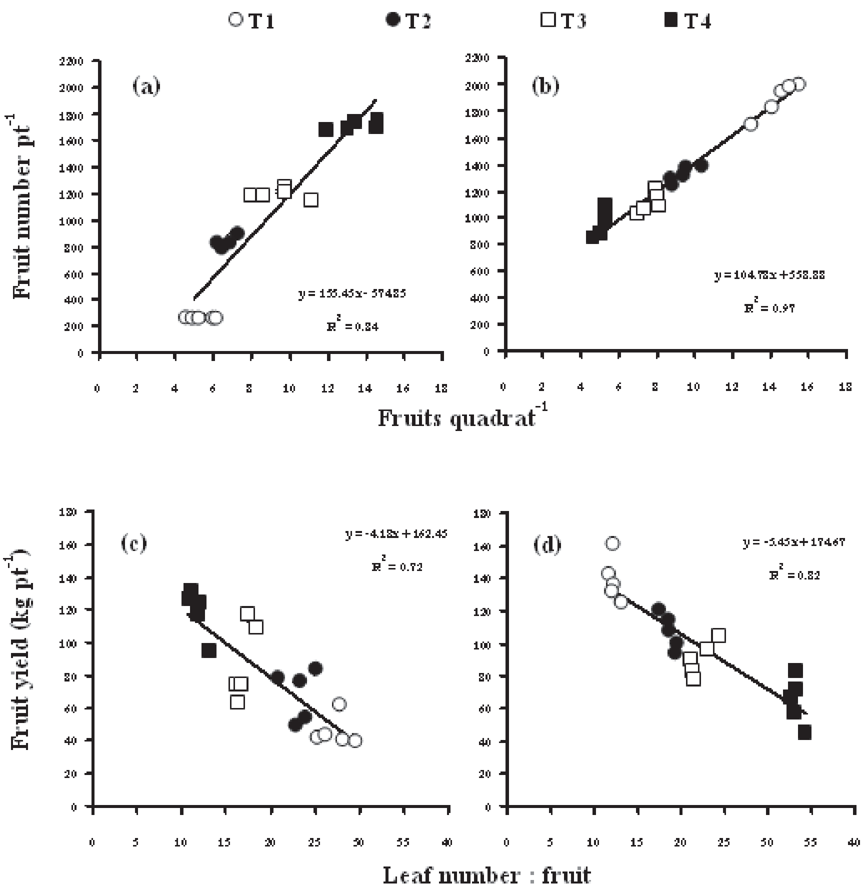

Figure 3. Relationship between fruit quadrat^{-1} and fruit number pt^{-1} in year 2004 (a) and 2005 (b), and relationship between leaf number: fruit and fruit yield in year 2004 (c) and 2005 (d).

estimation of fruit on tree could be done by using fruits quadrat^{-1}. Similarly, leaf number: fruit was also significantly related to fruit yield in both years (Figure 3 c and d). Data in Table 1 show that leaves quadrat^{-1} of the trees were significantly different among the treatments only in 2004, but they were not significantly different in 2005. Leaf number quadrat^{-1} trended to be higher in years 2005. This was due to high leaf-flushing during rainy season at the end of year 2004. In both years, fruits quadrat^{-1} and leaf number: fruit were significantly different among the treatments. In 2004, it was apparent that fruits quadrat^{-1} of high crop load trees on T4 (13.50) was highest, followed by those of T3 (9.00), T2 (7.44) and T1 (5.55), respectively. Leaf number: fruit in T1, T2, T3 and T4 were 27.34, 22.94, 17.01 and 11.60, respectively; and they were also significantly different. In 2005, fruits quadrat^{-1} and leaf number: fruit of all treatments exhibited in the opposite way. These changes were concurrent with the changes of yield pt^{-1} in 2004 and 2005 (Figure 4). These results indicated that fruits quadrat^{-1} and leaf number: fruit could be used to estimate optimum crop load. According to the data in Table 1 and Figure 4, optimum fruits quadrat^{-1} and leaf number: fruit should be 9 and 18, respectively. This was due to moderate crop load in T3 providing optimum yield of large fruit size with no adverse effect on yield in the following year.

Figure 4 shows the difference of fruit yield among the treatments in both years. In 2004, the average fruit yield in the T4 treatment (119.84 kg pt^{-1}) was significantly different from of the remaining treatments: T3 (84.23 kg pt^{-1}), T2 (66.68 kg pt^{-1}) and T1 (40.73 kg pt^{-1}). However, most of harvested fruit in T4 was small size, the yield of large fruit size was only 39% of total yield, whereas the high percentage of large fruit size yield was found in the treatment of T1 (87%), T2 (64%) and T3 (66%). It was remarkable that on the tree with very light crop, the fruits were of large size; but the heavy crop load tree provided small fruits. This incidence was due to competition between fruits for water and nutrients in the heavy crop load tree. Vock *et al.* (1997) suggested that fruit size is a major determinant of market price, therefore, fruit must be thinned to maximize returns.

Table 1. Average leaves quadrat^{-1}, fruits quadrat^{-1} and leaf number: fruit in the 4 treatments (counting at 6 weeks after flowering in year 2004 and 2005)

Treatments	leaves quadrat^{-1}	fruits quadrat^{-1}	Leaf number: fruit
Year 2004			
T1	151.25 ab*	5.55 c	27.34 a
T2	146.55 b	7.44 b	22.94 b
T3	152.65 ab	9.00 b	17.01 c
T4	154.90 a	13.50 a	11.60 d
C.V. (%)	3.34	13.70	6.00
Year 2005			
T1	176.25 ns	14.40 a	12.26 d
T2	174.83	9.33 b	18.78 c
T3	172.30	7.69 c	22.48 b
T4	170.38	5.10 d	33.26 a
C.V. (%)	6.4	7.02	4.05

*** = Means in each column with the same letter are not significantly different by DMRT, $p \leq 0.05$**

ns = no significant difference

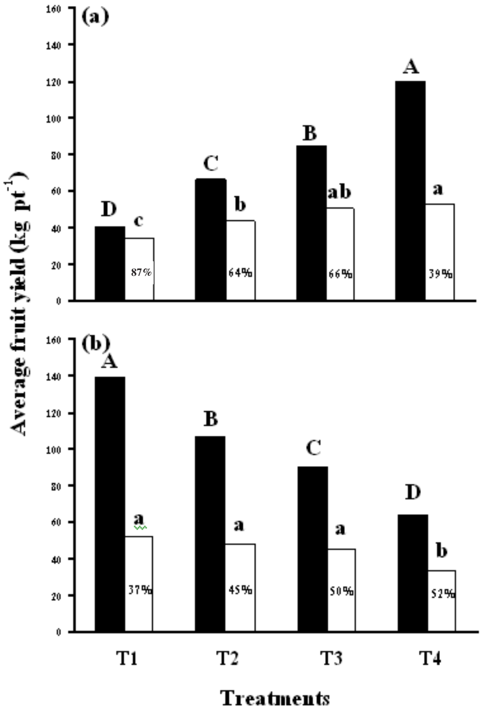

Figure 4. Average total fruit yield (■) and yield of acceptable fruit size or >70 g (□) in the 4 treatments in 2004 (a) and 2005 (b). Number on each column shows the percentage of > 70 g fruits. (Different letters on each column indicates significant difference by DMRT, p≤0.05)

In 2005, there was a consequent impact from high crop load in 2004. Therefore, the tree in the T4 treatment exhibited the significantly by lowest yield in 2004. Forshey (1986) suggested that is a heavy crop tree, all products of the leaves might be used in fruit growth and little was left for flower bud initiation in the following year. Inglese *et al*. (2001) investigated the effect of crop load on dry matter accumulation in peach and found that high crop load was correlated with tree dry matter production and an increase of crop load decreased vegetative and root growth. Then, heavy crop reduced dry matter accumulation of trees; this led to adverse effect in the consecutive year. It was evident that the trees with high fruit yield exhibited low percent of large fruit size or only 37%. The higher percentages yield of large fruit size were found in the T2, T3 and T4 treatments, 45%, 50% and 52%, respectively. The yields of large fruit size in T2 and T3 treatments were not significantly different in both years. In 2004, the yields of large fruit size in T3 and T2 were 45 and 42 kg pt^{-1}, respectively. Likewise, the yields of large fruit size in T3 and T2 in the following year were 42 and 44 kg pt^{-1}, respectively, and they were not significantly different. This seemed to be the optimum level of crop load, because there was no alternate bearing in the following year. On the other hand, there was an incidence of alternate bearing in the T4 treatment, whereas the yield of T1 treatment turned to be highest in 2005. This evidence showed that fluctuation of yield between "on" year and "off" year will occur, if there was no adjustment of crop load. In case of mangosteen for export in Thailand, optimizing crop load or number of fruits on the tree, is one of a number of contributing factors for enhancing fruit quality. High yield of large fruit size needed to be maintained year by year, because >70 g fruit is an acceptable size for export leading to maximize returns. Therefore, for improvement of fruit quality with high fruit size, the farmer should access fruit density and leaf number: fruit for crop load adjustment. From the results, it is suggested that using a quadrat cube to assess fruit density and leaf number: fruit is a convenient method. Although the method of counting flowering shoots and keeping at 35-50% of total shoots is recommended by Department of Agriculture (2003), it is difficult to estimate the crop load by eye when fruits are very small.

The results suggest that 9 fruits quardrat^{-1} leading to optimum crop load in mangosteen. If the average number of fruits quadrat^{-1} is over 9, the fruits will be thinned by hand thinning or chemical thinning. However, the labour cost of hand thinning is a limitation in mangosteen production. Chemical thinning will be an alternative method. Besides, the purpose of chemical application is not only thinning, but it is increase the yield of large fruit size, as reported in pear (Stern and Flaishman, 2003), apple (Greene, 1995; Stover *et al*., 2002), kiwifruit (Famiani *et al*., 1999) and persimmon (Itai *et al*., 1995). In mangosteen, this aspect needs to be investigated further to reduce the labour cost of hand-thinning.

Conclusion

In mangosteeen, the assessment of fruit density and leaf number: fruit using a framework of quadrat cube (0.5x0.5x0.5 m) is a convenient method. Fruit density is related to crop load levels, and leaf number: fruit is also related to fruit yield. Therefore, the assessment of fruit density and leaf number: fruit is of benefit in crop load management. To optimize crop load, the average fruits quadrat^{-1} and leaf number: fruit are suggested at 9 and 18:1, respectively.

Acknowledgement

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References

Berman, M.E. and De Jong, T.M.1996. Water stress and crop load effects on fruit fresh and dry weights in peach (*Prunus persica*). Tree Physiol. 16: 859-864.

Blanco, A., Pequerul, A., Monge, V.E. and Gomez-Aparisi, J. 1995. Crop-load effects on vegetative growth, mineral nutrient concentration and leaf water potential in Catharine peach. J. Hort. Sci. 70: 623-629.

Department of Agriculture. 2003. Good agricultural practice, mangosteen production system for the farmer. Ministry of Agriculture and Cooperative, Thailand. (in Thai)

Famiani, F., Battistelli, A., Moscatello, S., Boco, M. and Antognozzi, E. 1999. Thidiazuron affects fruit growth, ripening and quality of *Actinidia deliciora*. J. Hort. Sci. and Biotech. 74: 145-149.

Forshey, C.G. 1986. Chemical Fruit Thinning of Apples. New York's Food and Life Science Bulletin. No.116. Cornell Univ., USA.

Greene, D.W. 1995. Thidiazuron effects on fruit set, fruit quality and return bloom of apple. HortScience 30: 1238-1240.

Inglese, P., Caruso, T., Gugliuzza, G. and Pace, L.S. 2001. The effect of crop load and root stock on dry matter and carbohydrate partitioning in peach trees (*Prunus persica* Batsch). Acta Hort. 557: 447-455.

Itai, A., Tanabe, K., Tamura, F., Susaki, S., Yonemori, K. and Sugiura, A. 1995. Synthetic cytokinins control persimmon fruit shape, size and quality. J. Hort. Sci. 70: 863-873.

Lechaudel, M., Genard, M., Lescourret, F., Urban, L. and Jannoyer, M. 2002. Leaf-to-fruit ratio affects water and dry matter content of mango fruit. J. Hort. Sci. and Biotech. 77: 773-777.

Naor, A., Klein, I., Hupest, H., Grinblat, Y. and Peres, M. 1999. Water stress and crop level interactions in relation to nectarine yield, fruit size distribution and water potential. J. Amer. Soc. Hort. Sci. 124: 189-193.

Phonrong, K. 2005. Effects of crop load on yield and fruit quality of mangosteen. M.Sc. Thesis. Prince of Songkla University. (in Thai)

Rowe, R.N. and Johnson, R. 1992. The interactions between fruit number, tree size and the yield and fruit size of Fantasia nectarine. Acta Hort. 315: 171-176.

Stern, R.A. and Flaishman, M.A. 2003. Benzeladenine effects on fruit size, fruit thinning and return yield of "Spadona" and "Coscia" pear. Scientia Hort. 98: 499-504.

Stover, E., Fargione, M., Risio, R. and Yang, X. 2002. Crop load reduction and fruit size following multi-step thinning of 'Empire' apple. Hort Science 37: 130-133.

Vock, N., Turner, J. O., Smith, D. and Mayers, P. 1997. Citrus Information Kit. Center for Subtropical Fruit, Maroochey Research Station, Nambour, Australia.