Effect of number and criteria of young fruits *in loco* on yield of mango

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Abstract – Introduction. The aim of our research was to optimize the number of young mango (*Mangifera indica* L. cv. 'Arumanis') fruits that could be maintained per panicle and to improve the criteria for the selection of fruit to be maintained *in loco* to allow a high yield to be achieved. **Materials and methods**. The factors investigated were the number of young fruits maintained per panicle (either 2, 4 or 6), while the criteria of young fruits to be maintained were: the number of biggest fruit, fruits attached at the base of the panicle, and fruits distributed evenly from the base to the top of the panicle. **Results**. Our study shows that maintaining six young fruits per panicle gave the highest weight of harvested mango fruits per plant (33 kg) and the lowest weight per fruit (466 g). Maintaining the biggest mango fruit on the panicle resulted in the highest weight per fruit (496 g). **Conclusion**. Increasing the number of young fruits maintained per panicle from 2 to 6 linearly increased the weight of fruits per plant, although it decreased the weight per fruit linearly.

Indonesia / *Mangifera indica* / cultivation / thinning / defruiting / yields / weight / fruits

Effet, sur le rendement du manguier, du nombre et des caractéristiques des jeunes fruits laissés sur l'arbre.

Résumé – Introduction. Le but de notre étude a été d'optimiser le nombre de jeunes mangues (*Mangifera indica* L. cv. 'Arumanis') qui pourraient être maintenues sur panicule et d'améliorer les critères de sélection des fruits laissés en place afin d'atteindre de hauts rendements. **Matériel et méthodes**. Les facteurs étudiés ont été le nombre de jeunes fruits conservés par panicule (2, 4, ou 6) et les caractéristiques des jeunes fruits maintenus : nombre de gros fruits, position basale des fruits sur la panicule et distribution uniforme des fruits de la base vers le sommet de la panicule. **Résultats**. Notre étude a montré que le maintien de six jeunes fruits par panicule a conduit au poids de mangues récoltées par plant le plus élevé (33 kg) et au fruit le moins lourd (466 g). Le maintien des plus grosses mangues sur panicule a permis d'obtenir les fruits les plus lourds (496 g). **Conclusion**. Le maintien de deux à six jeunes fruits sur la panicule a linéairement augmenté le poids de mangues par plant mais il a diminué de façon linéaire le poids individuel du fruit.

Indonésie / *Mangifera indica* / pratique culturale / éclaircissage / suppression de fruits / rendement / poids / fruits

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1. Introduction

Mango (*Mangifera indica* L.) is an important tropical fruit liked by consumers for its rich taste, aroma and color. Mango can be consumed as fresh fruit and in other forms such as juice, *selai* (jam) and *sale* (sun-dried mango chips). In addition, the seed can be made into a powder for use as an alternative food. An increase in human populations, public income and awareness of the importance of the nutritious value of fruit has resulted in an increase in the production of mango fruits. Mango agribusiness would benefit if fruit quality could reach the quality required for export: higher competition in the world fruit market and increasing mango production must be accompanied by an increase in fruit quality, such as weight per fruit. Mango exports from Indonesia equaled 216,013 t (US$ 104,258,500) out of 2,243,440 t (total world production in 2009). Fruit consumption in Indonesia increases by 12–15% every year [1].

Increasing fruit number and weight can be achieved in several ways. One of them is by maintaining good quality of young fruits in optimum numbers on the tree (*in loco*). These young fruits should be provided with sufficient nutrients and protection against pests and diseases, so that the fruits maintained *in loco* can grow and develop well and give high yield.

In mango, fruit number is naturally reduced through fruit fall, which is often heavy (98%) [2]. Bonghi *et al.* listed several causes for fruit fall, the main ones being nutrient deficiency, water stress and hormonal imbalance [3].

Removing fruits in certain numbers according to specified criteria while maintaining a few fruits is the basic principle of thinning. Thinning reduces the number of unmarketable fruits or below-standard fruits [4]. There are some specified criteria based on phothosynthate distribution that would make fruit growth, following thinning, effective: the biggest fruit, fruits attached at the base of the panicle, and fruits distributed evenly at the panicle. Fruit thinning can also serve to increase individual fruit weight, reduce branch breakage, support plant vigor, reduce fluctuations in production, and make pest and disease control easier. When mango fruits were thinned to one or two per panicle, fruit number, fruit weight and yield per tree at harvest were all increased and trees subjected to thinning showed earlier recovery of starch reserves and better vegetative grow than the control [5].

The aims of our research were to study: (1) the effect of the number of young fruits maintained *in loco* on mango yield; (2) the criteria of young fruits maintained *in loco* on mango yield; (3) the interaction between the number and criteria of young fruits maintained *in loco* on mango yield.

2. Materials and methods

Our research was conducted in a mango orchard of the Local Technical Implementing Unit at the Plant Variation and Horticultural Seed Developing Agency in Kesugengan Lor Village, Depok District, Cirebon Regency, West Java, Indonesia. The research materials were 15-year-old mango trees cv. 'Arumanis'.

The research was a factorial experiment with two factors arranged in a randomized complete block design. The first factor was the number of young fruits maintained in a panicle, namely 2, 4 and 6 fruits. The second factor was the criteria for the maintained young fruits, namely: the biggest fruit, fruits attached at the base of the panicle, and fruits distributed evenly from the base to the top of the panicle. There were nine combinations of treatments with three replications, so 27 trees in total. Twenty panicles were sampled from each tree. There were 80 panicles per tree on average between treatments. All panicles were treated in the same way.

The 27 trees which served as samples grew and flowered uniformly; they were irrigated using furrow irrigation along tree rows. The mean temperature was 23.2 °C, mean yearly rainfall was 2001 mm, and the average duration of sunshine was 7 h per day. Fertilizer (1 kg of N-P-K 15-15-15 per tree) was applied once every 6 months. There were no serious pests or diseases.

Young flowers and fruits were allowed to senesce naturally until 14 days after anthesis. At that time (fruits were marble-sized) fruit thinning was applied according to the treatments. Fruit thinning was performed by using sterile secateurs.

The observed variables consisted of number of harvested fruits per panicle, weight of harvested fruits per panicle, number of harvested fruits per tree, weight of harvested fruits per tree, and weight per fruit. Data were analyzed using analysis of variance (ANOVA) with the statistical program SAS version 9. Following ANOVA, means were separated using Duncan's multiple range test at $p < 0.05$ and regression.

3. Results and discussion

The results showed that the number of young fruits maintained *in loco* in a panicle influenced the number of harvested fruits per panicle, number of harvested fruits per tree, weight of harvested fruits per panicle, weight of harvested fruits per tree, and weight per fruit (*table I*).

The highest weight of harvested fruit per panicle and per tree was achieved by maintaining six fruits per panicle, although it resulted in the lowest weight per fruit. The highest weight per fruit was achieved by maintaining the biggest fruits (*table I*).

The highest number of harvested fruits per panicle (0.97) and number of harvested fruits per tree (57) were obtained by maintaining six young fruits *in loco*. This means that fruit still abort, which would have taken place about 15–45 days after fruit set. Increasing the number of young fruits maintained *in loco* linearly increased the number of harvested fruits per panicle and per tree. The highest number of harvested fruits per tree was caused by the highest number of harvested fruits per panicle. According to Pescie and Strik, fruit yield is positively and linearly correlated with the number of fruits per panicle [4]. A higher number of fruits per panicle would support higher yield in mango. Wright *et al.* also stated that larger yields corresponded to greater numbers of fruit [6].

Maintaining six young fruits *in loco* allowed obtaining the greatest weight of harvested fruits per panicle (451 g) and weight of harvested fruits per tree (33 kg) but the lowest weight per fruit (466 g) (*table I*). The price of mango per kg that has a fruit weight of 466 g, 491 g or 508 g is almost the same. Thus, maintaining six young fruits *in loco* would give the best return to growers.

Increasing the number of young fruits maintained *in loco* from two to six linearly increased the number of harvested fruits per panicle, number of harvested fruits per tree, weight of harvested fruits per panicle, and weight of harvested fruits per tree (*table II*). Forshey found that number of fruits per tree was positively and linearly correlated with the yield of fruits per tree in apple [7], similar to what we found for mango.

The higher the number of young fruits maintained *in loco*, the greater the need for assimilate supply that must be distributed to all fruits, resulting in lower weight per fruit. Pescie and Strik [4] noted that, by increasing the number of kiwi fruits, the weight per fruit would be reduced. The same thing was stated by Forshey [7] and Stover [8], who indicated that the weight per fruit was negatively correlated with the number of fruits. This is related to the increasing competition for the same nutrients and resources caused by the increasing number of fruits.

Yeshitela *et al.* showed that fruit thinning influenced the weight per fruit of 'Sensasion' mango [5]. The highest weight per fruit was reached when there was only one fruit maintained per panicle. Racsko stated that fruit thinning results in reduced competition for photosynthates [9]. A reduction in fruit numbers is associated with increased fruit growth. Tahir and Hamid reported that fruit thinning increased the weight per fruit of guava, which was related in particular to the leaf nutrient content of N, P and K [10]. The leaf N, P and K content in fruit of thinned plants *versus* unthinned plants (control) was 1.67% and 1.31%, 0.29% and 0.12%, and 1.08% and 0.71%, respectively.

Crabtree *et al.* also noted that pawpaws from hand-thinned trees weighed significantly more than those from control trees (47% and 23% greater weight in 2006 and

Table I.
Mango yield obtained according to the number and criteria of young fruits maintained on thinned panicles.

Number of young fruits maintained *in loco*	Number of harvested fruits per panicle	Number of harvested fruits per tree	Weight of harvested fruits per panicle (g)	Weight of harvested fruits per tree (kg)	Weight per fruit (g)
2	0.67 c	26 b	341 c	13 b	508 a
4	0.79 b	48 ab	390 b	23 ab	491 b
6	0.97 a	57 a	451 a	33 a	466 c
F value	548.46**	696.23**	45.70**	848.59**	79.69**

Criteria of young fruits maintained *in loco*	Number of harvested fruits per panicle	Number of harvested fruits per tree	Weight of harvested fruits per panicle (g)	Weight of harvested fruits per tree (kg)	Weight per fruit (g)
The biggest	0.81 a	42 a	398 a	21 a	496 a
At the base of the panicle	0.81 a	44 a	393 a	21 a	487 b
Distributed evenly on panicle	0.82 a	44 a	392 a	21 a	483 b
F value	0.702	0.453	2.282	0.153	7.79**
F value of interaction	3.00	1.210	3.000	2.086	1.207

* Significant at $p < 0.05$; ** Significant at $p < 0.01$.
Means followed by different letters within a column are significantly different at $P < 0.05$ according to Duncan's multiple range test (DMRT).

Table II.
Coefficients for the regression equations ($Y = a + b X$) with the Y factor for each observed variable as a function of number of maintained young mango fruit (X) on a thinned panicle.

Y	a	b	R^2
Number of harvested fruits per panicle	0.5246	0.0708	0.9727
Number of harvested fruits per tree	12.6520	7.0375	0.9470
Weight of fruits per panicle	284.85	27.451	0.9689
Weight of fruits per tree	3.3478	5.0483	0.9543
Weight per fruit	530.76	– 10.402	0.9364

2008, respectively) [11]. Fruit thinning increases fruit weight by reducing competition among and within clusters. Stover *et al.* noted that thinning increased fruit size because of enhanced cell division [12]. In date palm, Soliman *et al.* showed that removing 30% of the total number of strands from the center of each bunch four weeks after pollination produced the highest fruit quality [13]. Solomakhin and Blanke found that mechanical thinning had a positive effect on apple fruit size (15% larger), firmness (8.4 $kg{\cdot}cm^{-2}$ in Gala *vs.* 7.6 $kg{\cdot}cm^{-2}$ in the unthinned control), sweetness (124 g $sugar{\cdot}kg^{-1}$ vs. 117 g $sugar{\cdot}kg^{-1}$ in the control), malic acid content (4 $g{\cdot}kg^{-1}$ *vs.* 3.4 $g{\cdot}kg^{-1}$ in the control) and anthocyanin content (17% more than the control) [14].

The weight per fruit was influenced by the criterion of maintained young fruits. The highest weight per fruit (496 g) was possible by maintaining the biggest fruit. The biggest fruit would mobilize phothosynthates more strongly [15] such that fruit growth would be better, and finally it would have higher fruit weight. The lowest weight per fruit (483 g) was possible by maintaining the fruit that was evenly distributed between the base and the top of panicle. This indicated that the largest fruit is a better criterion than other criteria to retain fruit on a thinned tree. There are very few studies that deal with criteria of fruit in thinning, particularly in mango.

In a panicle there are many growing and developing fruits, but those that grow faster than the others are termed dominant fruits [16]. Dominant fruits had a higher capacity to compete in obtaining photosynthates so they had greater weight. The presence of different competitive capacities among fruits can result in the variation of fruit weight in a panicle. Yeshitela *et al.* [5] confirmed this fact in mango by claiming that fruit should be thinned in every panicle.

Our results show that the highest weight per fruit was possible by maintaining the largest young fruit; they are similar to the findings of Bangerth, whose study showed that fruit set of the largest fruit was generally earlier than smaller ones [16]. The fruits that set earlier were more dominant than those that set later. Since larger fruits had a greater capacity to mobilize more phothosynthates due to their higher sink strength, their growth was better [15]. This research also showed that the highest weight of harvested fruits per tree was possible by maintaining six young fruits, which was related to the highest number of harvested fruits per tree. Duran Zuazo stated that fruit yield of mango is correlated mainly with the number of harvested fruits [17].

4. Conclusion

Our results showed that:

– maintaining six young mango fruits per panicle gave the highest weight of harvested mango fruits per tree (33 kg). However, the weight per fruit was lowest;

– maintaining the biggest mango fruit resulted in the highest weight per fruit (496 g);

– increasing the number of young fruits maintained *in loco* from two to six linearly

increased the weight of fruits per tree ($Y = 5.0483\ X + 3.3478$; $R^2 = 0.9543$), although it decreased the weight per fruit linearly ($Y = -10.402\ X + 530.76$; $R^2 = 0.9364$).

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Efecto del número y de las características de los jóvenes frutos que se dejan en el árbol sobre el rendimiento del mango.

Resumen – Introducción. El objetivo de nuestro estudio fue optimizar el número de jóvenes mangos (*Mangifera indica* L. cv. 'Arumanis') que podrían mantenerse sobre panícula y mejorar los criterios de selección de los frutos dejados en el lugar con el fin de alcanzar altos rendimientos. **Material y métodos**. Los factores estudiados fueron el número de jóvenes frutos conservados por panícula (2, 4 ó 6) y las características de los jóvenes frutos mantenidos: número de frutos grandes, posición basal de los frutos sobre la panícula y distribución uniforme de los frutos desde la base hacia la cima de la panícula. **Resultados**. Nuestro estudio mostró que dejar seis frutos por panícula condujo al mayor peso de mangos cosechados por planta (33 kg) y al fruto menos pesado (466 g). Dejar los mangos más grandes sobre panícula permitió obtener los frutos más pesados (496 g). **Conclusión**. Dejar entre dos y seis jóvenes frutos sobre la panícula aumentó linealmente el peso de mangos por planta, pero disminuyó de manera lineal el peso individual del fruto.

Indonesia / *Mangifera indica* / cultivo / aclareo / supresión de frutos / rendimiento / peso / frutas