Strangulation Improves Flowering and Fruiting of 'Nambangan' Pummelo Trees

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Abstract

'Nambangan' Pummelo has a good taste, sweet, a slightly sour and fresh, pink-red color flesh, and long shelf life, i.e., 3-4 months. Fruit production of this cultivar is fluctuated due to irregular flowering. A series of experiments was conducted to study the effect of strangulation on flowering and fruiting of 'Nambangan' pummelo trees. Three experiments were conducted at Cikabayan Research Station IPB from October 2000 to July 2007. In experiment 1 strangulation was applied using wire size 1.6 and 2.0 mm with a period of strangulation 1, 2, and 3 months. In experiment 2, the pummelo trees were strangulated using 2.0 and 3.0 mm wire size for three months period. In experiment 3, the pummelo trees were subjected to 3, 5, and 7 months period of strangulation. The result of experiment 1 showed that strangulation significantly improved flowering; 89-100% of the treated trees produced flowers, whereas all control trees were not flowered. The flower and fruit numbers, and leaf-carbohydrate contents were significantly higher on the trees treated with wire size of 2 .0 mm for 3 months duration. Strangulation using 3.0 mm wire size produced slightly more flowers as compared with 2.0 mm. Different duration of strangulation produced no significant difference in the flower numbers and carbohydrate content in leaves. Meanwhile, it was noted that application of seven-month strangulation duration caused severe damage on the phloem tissues. It is recommended that to improve flowering and fruiting of pummelo trees without significant damages, the strangulation should be applied using 2.0-3.0 mm of wire for not more than 3 months duration.

INTRODUCTION

Pummelo (*Citrus grandis* (L.) Osbeck) is a species of *Citrus* that has a good prospect to be more developed in Indonesia. The National Biology Institute has recorded 15 pummelo cultivars in Indonesia, one of them is 'Nambangan' (Sarwono, 1991). Fruit of this cultivar has a good taste, sweet, a slightly sour and fresh, pink-red color flesh, and long shelf life, i.e., 3-4 months (Pusat Penelitian dan Pengembangan Hortikultura, 2004). 'Nambangan' does not have bitter taste, with relatively thin peel and specific aroma. These superior characters of 'Nambangan' fruits make them competitive to other imported fruits in supermarkets.

'Nambangan' pummelo bears seasonally. Trees flowering in September-October will be fruiting in April-June in the following year. This phenomenon causes over production during the on season that makes the prices lower. In the off season the production is limited. The behavior of the seasonal fruiting makes the prices high at off-season, and lower at on season when the supply is abundant.

To prevent the fluctuations of pummelo fruit production, regulation of flowering is needed. Some of the methods that are generally applied to improve and regulate flowering were application of plant growth regulator (Susanto and Poerwanto, 1999), exposing plants to low temperatures (Susanto et al., 1991), water stress (Nakajima et al., 1993) and strangulation (Susanto et al., 2002). Strangulation is relatively simpler and easier to do compared with other methods.

The best-known effect of strangulation is presumably brought about by accumulation of assimilates above the strangulated parts. On the other hand, the side beneath the strangulated area suffers from shortage of assimilates. High accumulation of carbohydrate

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positively correlated with flowering (Garcia-Luis et al., 1995; Yamanishi and Hasegawa, 1995).

Strangulation has been reported to effectively increase flowering (Yamanishi and Hasegawa, 1995; Yamanishi et al., 1993), but not appropriate techniques of strangulation could decrease and delay plant growth, that made trees suffer after the treatments.

The objective of the research was to investigate the appropriate wire size and length of strangulation period to improve flowering without damaging 'Nambangan' pummelo trees.

MATERIALS AND METHODS

A series of experiments were conducted at Cikabayan Research Station of IPB and the Center for Biotechnology of Food Crops Bogor, from October 2000 to July 2007.

Trials were conducted on 2-year-old 'Nambangan' pummelo trees in experiment 1, 7- and 8-year-old in experiment 2 and 3. Trees were spaced at 5×5 m. Strangulation was carried out by tightening wire on primary branch, then pulled it as depth as wire diameter.

All experiments used Randomized Complete Block Design. In experiment 1, strangulation was applied using wire size 1.6 and 2.0 mm with period of strangulation 1, 2 and 3 months. In experiment 2, the pummelo branch was strangulated using 2.0 and 3.0 mm wire size for three months. In experiment 3, strangulation was done for 3, 5 and 7 months. There was a control treatment (unstrangulated branches) in each experiment.

Fertilizers were applied a week before the experiments started, with 0.38 kg N, 0.20 kg P_2O_5, 0.51 kg K_2O, and 20 kg organic fertilizers per tree. Insects and disease were controlled according to the recommendation of the local agricultural development.

Measurements were carried out on the number of vegetative shoots, reproductive shoots, flower buds, open flowers and fruits. Nitrogen and carbohydrate leaves content were analyzed before the trees starts flowering. Analyzed leaf samples were taken in the morning. Each sample for different treatments were put in different plastic bags. Nitrogen analysis used the Kjeldahl method. The analysis of carbohydrate leaves content followed a procedure adapted from Nelson-Somogy method, which used HCl 0.7 N solution for carbohydrate hydrolysis. The result of hydrolysis was read by spectrophotometer at 500 nm wave length.

Differences between treatments for each experiment were tested for significance by ANOVA. Variables that shown significant then were analyzed by Duncan Multiple Range Test ($p \leq 0.05$) in experiment 1 and 2, and by Tukey Test ($p \leq 0.05$) in experiment 3. In experiment 1, a Contras Test was also used to show different levels between strangulation and control treatment.

RESULT

Experiment 1

Strangulation significantly decreased the number of vegetative shoots (16 WAS = weeks after strangulation) and leaves N content. On the other hand strangulated plants have more reproductive shoots (19 WAS), flower buds (19 WAS), open flowers (19 WAS), and leaves carbohydrate content. All control trees were not flowering. Wire size did not significantly influence the number of vegetative shoots and nitrogen and carbohydrate content. Plants strangulated with 2.0 mm wire size had more reproductive shoots, flower buds and open flower than 1.6 mm wire size. Plants strangulated for 2 and 3 months have less vegetative shoots and leaves N content, but more leaves carbohydrate content (Table 1).

Experiment 2

The strangulated branches tended to have more reproductive shoots, flower buds, open flowers and fruits than unstrangulated branches (Fig. 1). However, there were no significant differences between 2 and 3 mm wire sizes in terms of the number of

vegetative and reproductive shoots, flower buds, open flowers, fruits and leaves nitrogen and carbohydrate content (Fig. 1).

Experiment 3

The number of vegetative shoots, flower, leaves N and carbohydrate content were not significantly different among various periods of strangulation. Meanwhile the number of reproductive shoots and fruits on branches strangulated for 5 months were higher than control (Fig. 2). In addition, almost all control trees were not flowering.

DISCUSSION

Results of the experiment 1, 2 and 3 demonstrated that strangulation improved flowering and fruiting. The tightening of phloem from the main trunk by wiring actually blocks the transport of sugars to the roots, which caused larger amounts of carbohydrate produced by photosynthesis accumulating in vegetative organs above the part of strangulated branches, thus can be utilized for flowering. This condition related to leaves carbohydrate and nitrogen contents theory. The strangulated branches have higher carbohydrate and lower nitrogen than control, which induced trees to flowering and fruiting (Yamanishi and Hasegawa, 1995). Similar results were reported by Mustafa and Saleh (2006) on girdled 'Balady' mandarin, and by Yahata et al. (2004) on girdled 'Satsuma' mandarin. Reduction in leaves nitrogen concentration on strangulated branches could be attributed to nitrogen dilution in growing leaves or to the remobilization of nitrogen from leaves to developing fruits (Rufat and DeJong, 2001).

According to the results on experiment 1 and 2, the 2.0 mm wire size seems more suitable for strangulating pummelo branches than with 1.6 and 3 mm wire size. Presumably the 1.6 mm wire size was not strong enough to inhibit translocation of assimilates downwards. The 3.0 mm wire size did not induce flowering better than the 2.0 mm wire size, but resulted in a greater damage at the barks of the trees which would take more time to recover.

Prolonged periods of strangulation from one to two and three months in Experiment 1 increased leaves carbohydrate content and enhanced flowering. Meanwhile in experiment 3, lengthened period of strangulation from three to five and seven months did not significantly increase the number of reproductive shoots. Possibly accumulation of carbohydrate in long period would decrease photosynthetic capacity, because it would affect proteins of the Calvin cycle activity on thylakoids. A decrease of photosynthetic capacity, resulting from reduced sink activity and carbohydrate accumulation, associated with a decrease in nitrogen content per leaf area unit (Urban et al., 2004).

In conclusion, it has been demonstrated that to improve flowering and fruiting of pummelo trees without significant damages, strangulation should be applied using 2.0 mm of wire size for a 3-months period.

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Tables

Table 1. The average number of vegetative shoots, reproductive shoots, flower buds, open flowers, leaves carbohydrate and nitrogen content.

Treatment	Vegetative shoots[z]	Reproductive shoots[y]	Flower buds[y]	Open flowers[y]	Carbohydrate content (%)	N content (%)
Control	71.0	-	-	-	11.2	2.8
Wire size						
1.6 mm	43.0[a]	2.7[a]	8.5[a]	8.3[a]	14.1[a]	2.4[a]
2.0 mm	40.7[a]	5.9[b]	20.2[b]	17.5[b]	16.6[a]	2.3[a]
Length of strangulation						
1 month	51.1[b]	3.3[a]	12.2[a]	11.1[a]	13.4[a]	2.6[b]
2 months	37.3[a]	3.6[a]	14.0[a]	12.4[a]	15.8[a]	2.4[a]
3 months	37.2[a]	6.1[a]	16.9[a]	15.1[a]	16.9[b]	2.4[a]
Contras test						
Control vs. treatment	**	*	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS

* Significant at P≤0.05, ** significant at P≤0.01, NS: non-significant.
[z] Data from 16 WAS (weeks after strangulation).
[y] Data from 19 WAS.

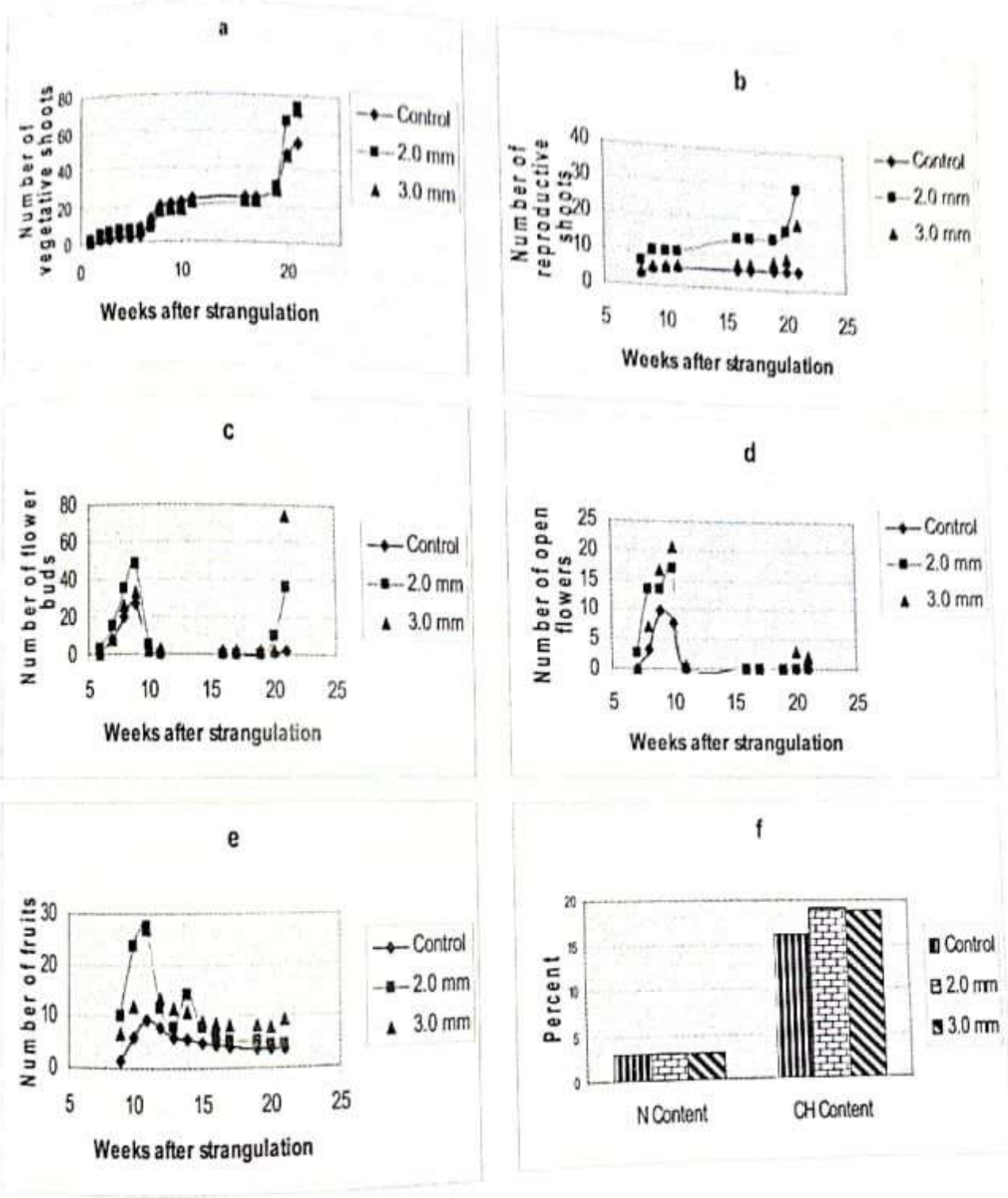

Fig. 1. (a) Development of the number of vegetative shoots; (b) development of the number of reproductive shoots; (c) development of the number of flower buds; (d) development of the number of open flowers; (e) development of the number of fruits; (f) leaves nitrogen and carbohydrate content on experiment 2.

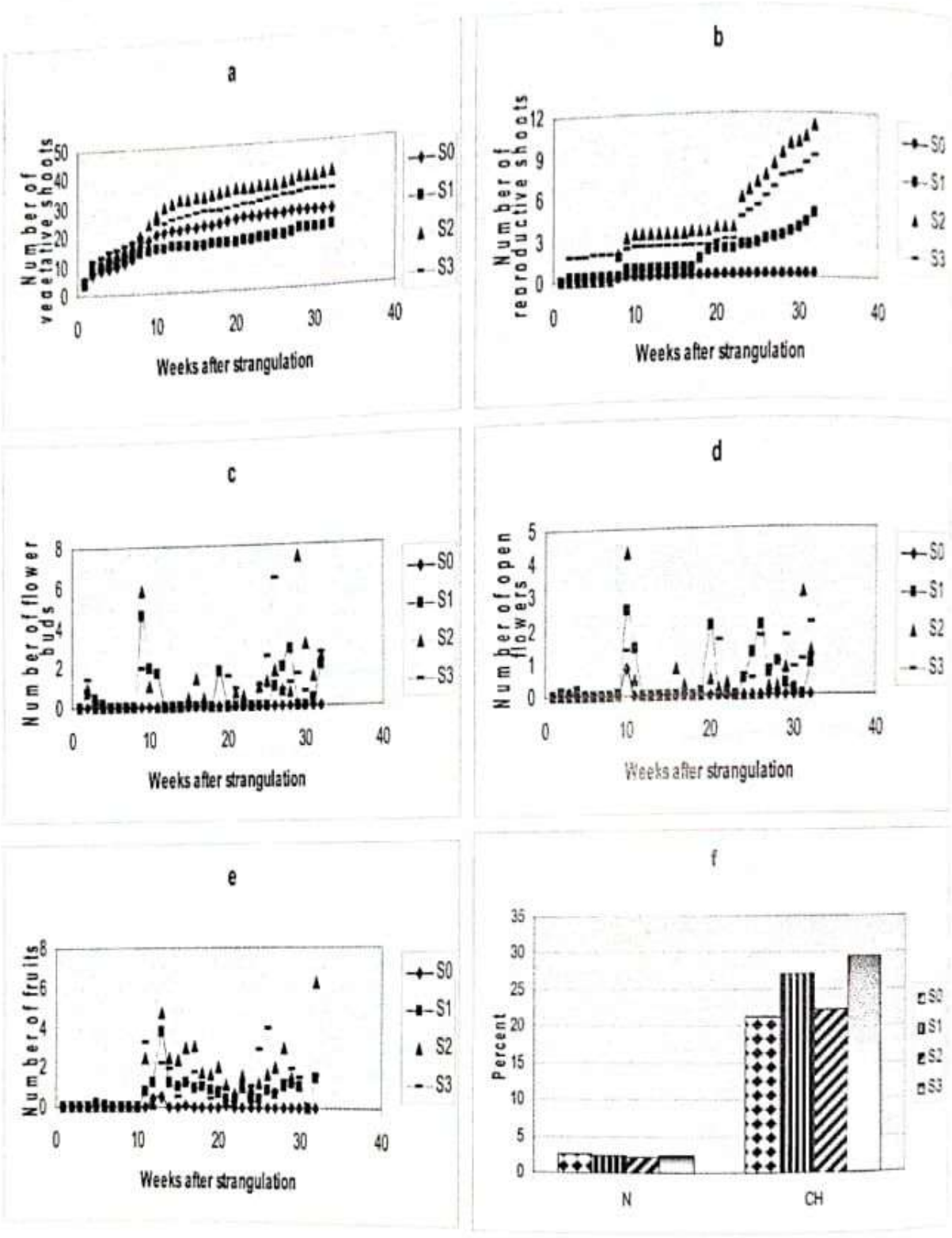

Fig. 2. (a) Development of the number of vegetative shoots; (b) development of the number of reproductive shoots; (c) development of the number of flower buds; (d) development of the number of open flowers; (e) development of the number of fruits; (f) leaves nitrogen and carbohydrate content on experiment 3. (S0: control, S1: 3 months, S2: 5 months, and S3: 7 months period of strangulation).