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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : PROSIDING

Judul Karya Ilmiah	:	**Strangulation Improves Flowering and Fruiting of 'Nambangan' Pummelo Trees**	
Jumlah Penulis	:	3 Orang	
Status Pengusul	:	Penulis Pertama	
Identitas Prosiding	:	a. Nama Prosiding	: International Symposium on Tropical and Subtropical Fruit
		b. ISBN/ISSN	: 97890660506993/0567-7572
		c. Tahun Terbit, Lokasi	: Februari 2013, Bogor
		d. Halaman/Penerbit	: 427-432 / ISHS
		e. Repository/Web	: https://www.ishs.org/ishs-article/975_55
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Jabatan Fumgsional/Pangkat : Lektor Kepala, Pembina IV/a
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Unit Kerja : Universitas Djuanda

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STRANGULATION IMPROVES FLOWERING AND FRUITING OF 'NAMBANGAN' PUMMELO TREES

Authors
A. Rahayu, S. Susanto, Setyono

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 strangula¬tion should be applied using 2.0-3.0 mm of wire for not more than 3 months duration.

Citation
Rahayu, A., Susanto, S. and Setyono, (2013). STRANGULATION IMPROVES FLOWERING AND FRUITING OF 'NAMBANGAN' PUMMELO TREES. Acta Hortic. 975, 427-432
DOI: 10.17660/ActaHortic.2013.975.55
https://doi.org/10.17660/ActaHortic.2013.975.55

Keywords
flowering, fruiting, pummelo, strangulation

Language
English

Full text
https://doi.org/10.17660/ActaHortic.2013.975.55

Acta Horticulturae 975
IV International Symposium on Tropical and Subtropical Fruits

Article number
975_55

Pages
427-432

Groups
- Division Horticulture for Development
- Division Tropical and Subtropical Fruit and Nuts
- Division Physiology and Plant-Environment Interactions of Horticultural Crops in Field Systems
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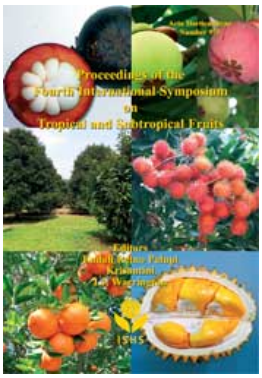

Publicaton date
February 2013

Number of articles
84

Volumes
1

Pages
678

Symposium venue
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Symposium date
November 3, 2008

Symposium
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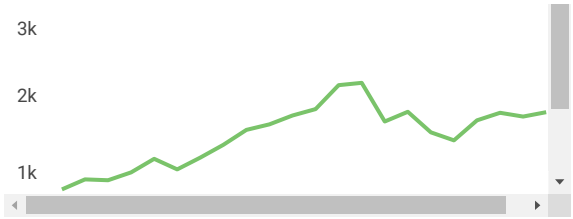

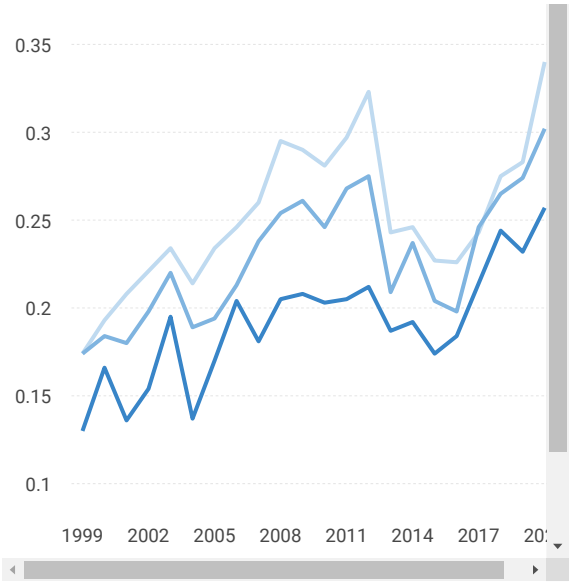

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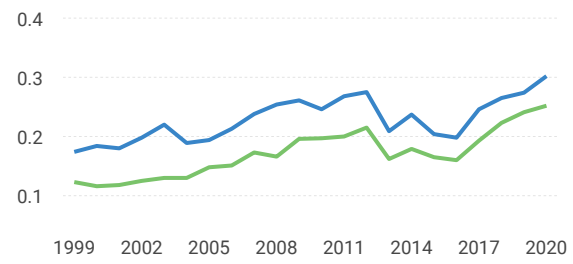

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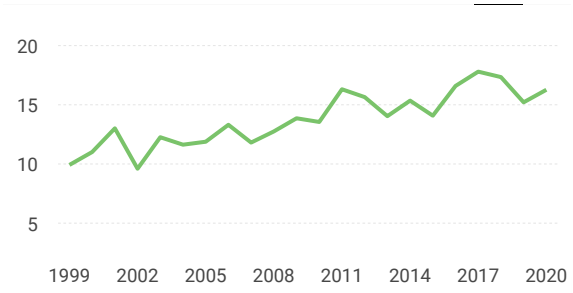

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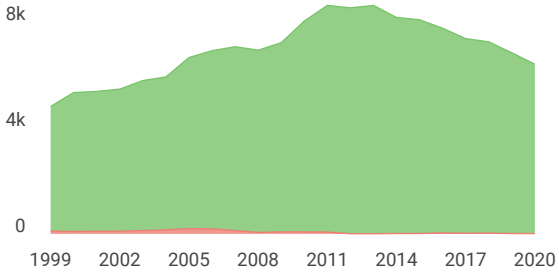

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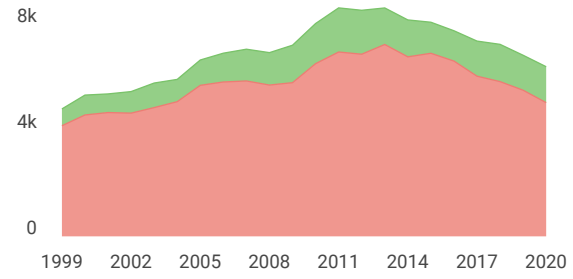

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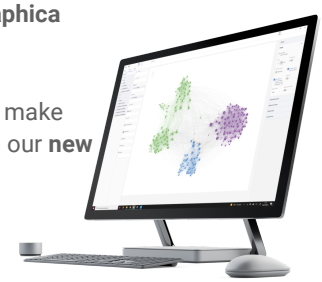

Strangulation Improve Flowering and Fruiting of 'Nambangan' Pummelo Trees

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Key words: strangulation, flowering, fruiting, pummelo

Abstract

A series experiment 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 the 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 the 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 the experiment 1 showed that strangulation significantly improved flowering. About 89-100% of the treated trees produced flower, meanwhile all control trees were not flowered. The flower and fruit numbers and carbohydrate content in leaves produced were significantly higher on the trees treated with wire size of 2 .0 mm in 3 months duration. From experiment 2, the result showed that strangulation application using 3.0 mm wire size produced slightly more flower as compared with 2.0 mm. The result of experiment 3 showed that different duration of strangulation produced no significant different in the flower number 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. National Biology Institute noted 15 pummelo cultivars in Indonesia, one of them is 'Nambangan' (Sarwono, 1991). This cultivar has a good taste, sweet, a slightly sour and fresh, pink-red color flesh, and long shelf life, 3-4 months (Pusat Penelitian dan Pengembangan Hortikultura, 2004). 'Nambangan' doesn't have bitter taste, with relatively thin peel and specific aroma. These leading of 'Nambangan' make it competitively with other imported fruits in supermarket.

'Nambangan' pummelo bears seasonally. Trees flowering on September-October will be fruiting on April-June in the following year. This phenomenon causes over production in the on season that makes the prices down. On the other season the production is limited.

To prevent the fluctuations of pummelo fruit production, regulation of flowering is needed. Some of methods that generally applied to improve and regulate flowering were application of plant growth regulator (Susanto and Poerwanto, 1999), low temperature (Susanto et al., 1991), water stress (Nakajima et al., 1993) and strangulation (Susanto et al., 2002). Strangulation is relatively easier and more simple to apply as compare 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 positively correlated with flowering (Garcia-Luis et al., 1995; Yamanishi and Hasegawa, 1995).

Strangulation proved effectively increasing flowering on the previous researches (Yamanishi and Hasegawa, 1995; Yamanishi et al., 1993), but not appropriate treatment of strangulation could decrease and delay growth, that made trees suffer after the treatments.

The objective of the research was to investigate the appropriate wire size and length of period of strangulation to improve flowering without damaged of the '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 two years old 'Nambangan' pummelo trees at experiment 1, seven and eight years old on experiment 2 and 3. Trees were spaced at 5 m x 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 the experiment 1, strangulation was applied using wire size 1.6 mm and 2.0 mm with period of strangulation 1, 2 and 3 months. In the experiment 2, the pummelo branch strangulated using 2.0 mm and 3.0 mm wire size for three months. In the experiment 3, strangulation was done for 3, 5 and 7 months. There was 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 leaves samples were taken in the morning. Each sample for different treatments were put in different plastic bags. Nitrogen analysis used 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 at each experiment were tested for significance by ANOVA. Variables that shown significant then were analyzed by Duncan Multiple Range Test ($p \leq 0.05$) on experiment 1 and 2, and by Tukey Test ($p \leq 0.05$) on experiment 3. In experiment 1, it was also used a Contras Test to show different level 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).

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 $P \leq 0.05$, ** significant at $P \leq 0.01$, NS: non significant

[z] Data from 16 WAS (weeks after strangulation)

[y] Data from 19 WAS

Experiment 2. There was no significant difference between strangulated branches with the 2.0 mm and 3.0 mm wire size, in the number of vegetative and reproductive shoots, flower buds, open flowers, fruits and leaves nitrogen and carbohydrate content. But the strangulated branches tended to have more reproductive shoots, flower buds, open flowers and fruits than unstrangulated branches (Figure 1).

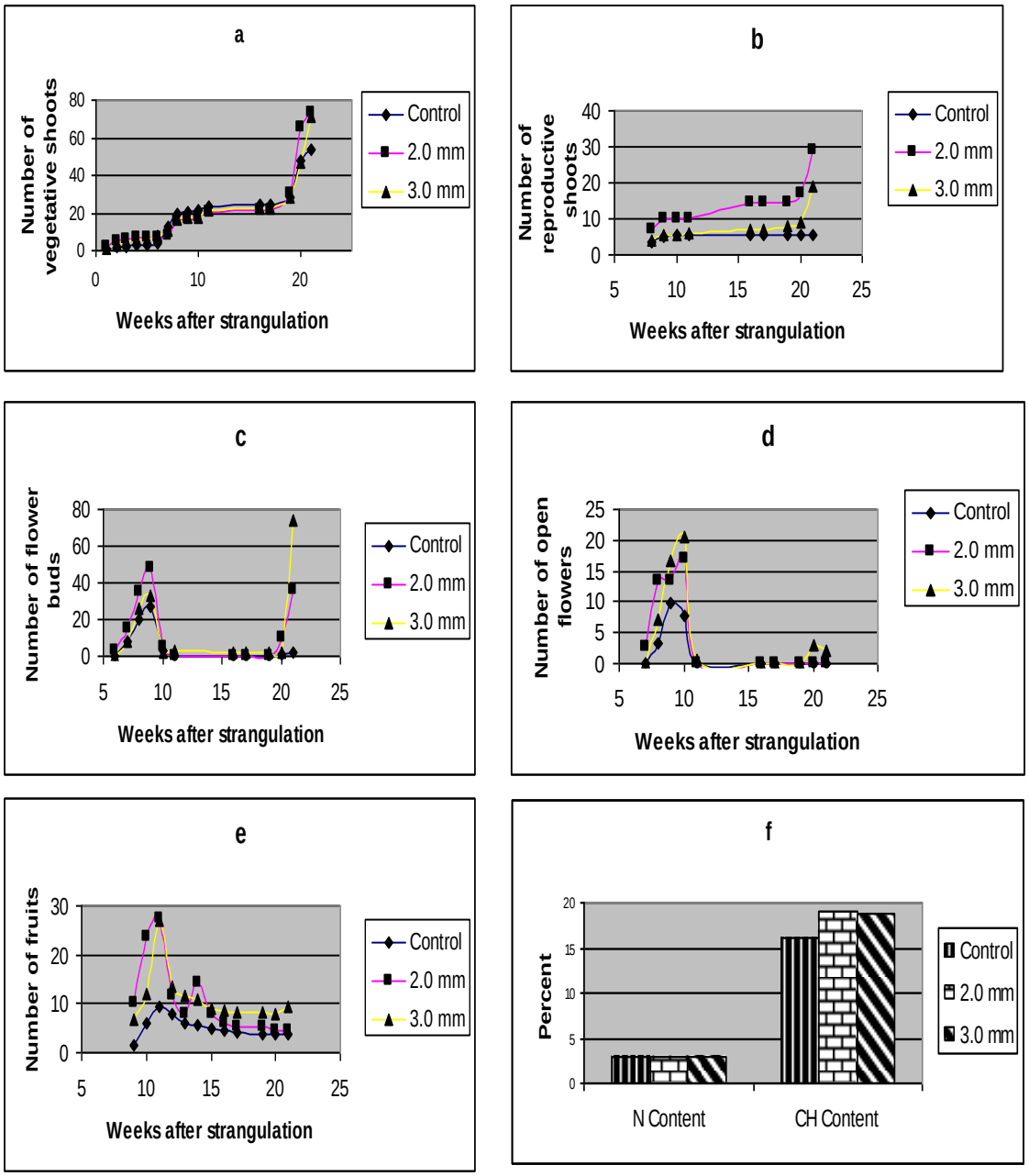
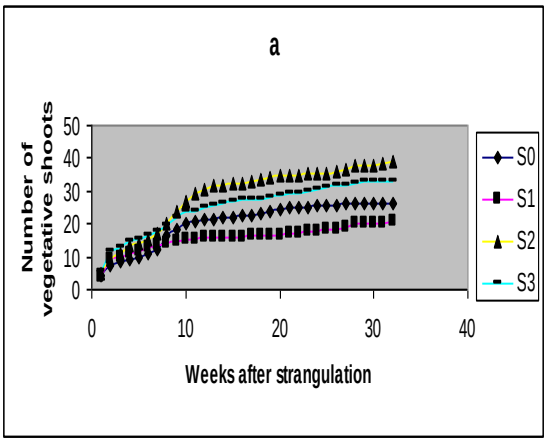


Fig. 1. (a) Development of the number of vegetative shoots; (b) Development of the number of reproductive shoots; (c) Development of the number of flower buds; (d) Development of the number of open flowers; (e) Development of the number of fruits; (g) Leaves nitrogen and carbohydrate content on experiment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

Experiment 3. The number of vegetative shoots, flower, leaves N and carbohydrate content were not significantly different among various period of strangulation. Meanwhile the number of reproductive shoots and fruits on branches strangulated for 5 months higher than not strangulated branches (Figure 2.). Almost all control trees were not flowering.


a
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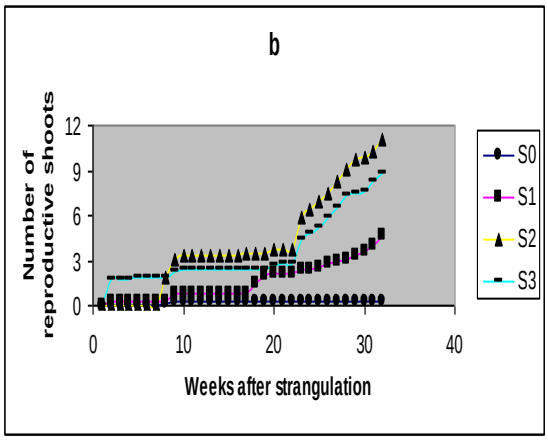
b
Number of reproductive shoots
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Weeks after strangulation
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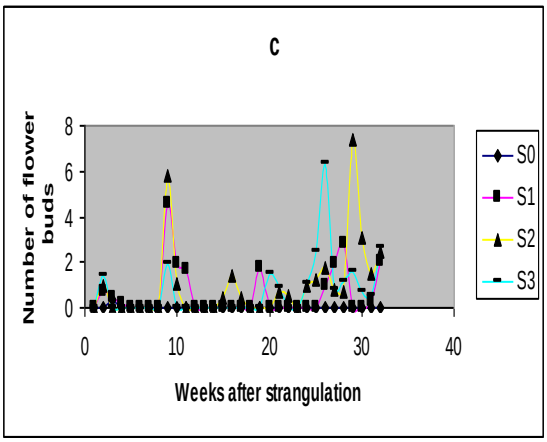
S1
S2
S3


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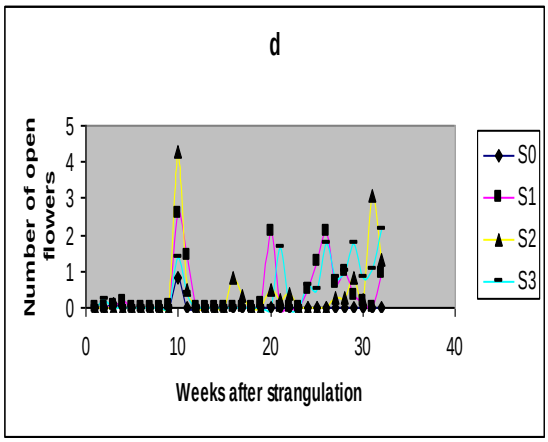
d
Number of open flowers
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Weeks after strangulation
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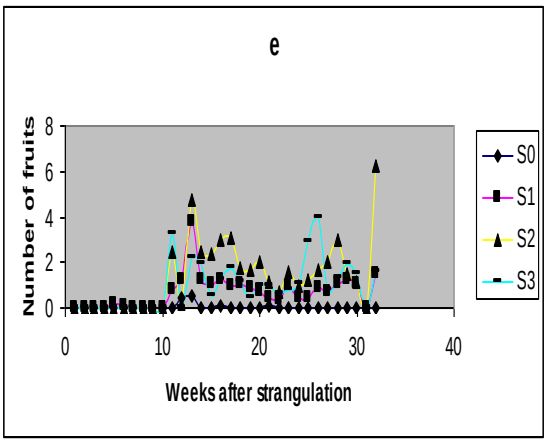
e
Number of fruits
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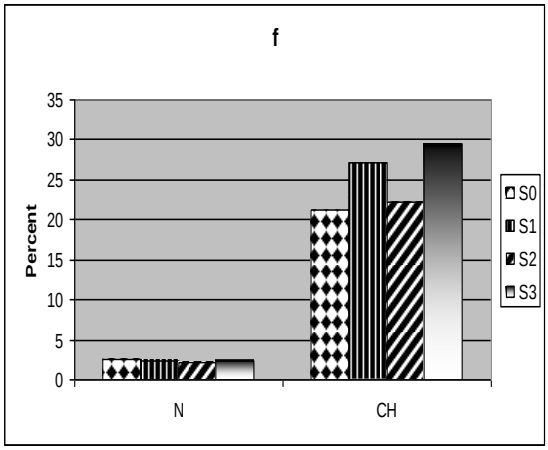
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Percent
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Fig. 2. (a) Development of the number of vegetative shoots; (b) Development of the number of reproductive shoots; (c) Development of the number of flower buds; (d) Development of the number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

DISCUSSION

Based on the results of the experiment 1, 2 and 3, indicated that strangulation improved flowering and fruiting. The tightening of phloem from the main trunk by wire actually blocks the transport of sugars to the roots; large amounts of carbohydrate produce by photosynthesis will accumulate in vegetative organs above the part of strangulated branches or to be utilized for flowering. This condition related to leaves carbohydrate and nitrogen contents. The strangulated branches have higher carbohydrate and lower nitrogen than control, which would induce trees to flowering and fruiting (Yamanishi and Hasegawa, 1995). The similar results reported by Mustafa and Saleh (2006) on girdled 'Balady' mandarin, and Yahata et al. (2004) on girdled 'Satsuma' mandarin. Reduces 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 used for strangulation of pummelo branches, compared with 1.6 mm and 3 mm wire size. Presumably the 1.6 mm wire size is not strong enough to inhibit translocation of assimilates downward, so less effective than the 2.00 mm wire size. While, the 3.0 mm wire size didn't induce flowering better than the 2.0 mm wire size, but made greater damaged at the bark of the tree. This disorder need more time to recovery.

Prolonged of period of strangulation from one to two and three months on Experiment 1, increased leaves carbohydrate content, so enhanced flowering. Meanwhile in experiment 3, lengthened period of strangulation from three to five and seven months, was not significantly increasing the number of reproductive shoots. Possibly accumulation of carbohydrate in long time 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 on 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 3 months period.

ACKNOWLEDGEMENTS

This research was supported by Directorate General of Higher Education, Ministry of Education Republic Indonesia through Competitive Research Programmed.

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