Effect of Trunk Strangulation on the Growth of Young Pomelo Trees Grown under Plastic House

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Abstract : Young ' Tosa Buntan ' (*Citrus grandis* (L.) Osbeck) trees were sand-cultured in Wagner's pots. The trunk 15 cm above the graft union was strangulated with thin wire every month from April to June 1990. The durations of each treatment were 2 and 4 months. The shoot growth was strongly inhibited at the upper part from the strangulation position of the trees (UP), while that at the lower part (LP) was enhanced in all the treatment periods. However, the wire rings were covered with bark tissues at June-October treatment, resulting in sprouting new shoots at the UP during the summer season. Root growth was slightly inhibited at May- and June-treatments as compared with the other treatments. The girdle depth just after the release of wire ring was deeper and the healing of girdle was later at the late treatments than those at the early treatments. The upper part of the trees was extremely defoliated during the fall season, especially for 4 month treatments. No significant differences in the number of inflorescences and flower buds were observed at the UP of the trees among the treatments.

Key words : Pomelo, Strangulation, Wire ring, Healing.

Introduction

Pomelos cultivated in Japan certainly originated from the Malay Peninsula and East Indian archipelagos[1)] . Pomelos are one of thermo-sensitive citrus varieties; therefore, they often grew vigorously when exposed to warm condition such as that in the plastic house (PH).

Flower bud of pomelo trees was induced by exposing to low temperature during winter[2)] . However, the pomelo trees in a PH are not subjected to full experience of low temperature during winter. Thus, some cultural practices such as soil drying, root pruning, branch bending etc. have been used as a substitute of low temperature for promoting the flower bud formation[3)] .

This study was conducted in order to evaluate the appropriate time and duration of trunk strangulation in the early season of growth cycle for the growth at the top and root parts of young pomelo trees grown in a PH.

Material and Methods

One-year-old ' Tosa Buntan' (*Citrus grandis* (L.) Osbeck) pomelo trees grafted on trifoliate orange (*Poncirus trifoliata* Raf.) rootstocks grown in a PH were used in this trial. The root

volume was measured before transplanting to Wagner's pots (27x50cm) in mid-March 1990; the rinsed root part was immersed in a vessel which was filled with water, and the volume of overflowed water was measured. Fine sand was used as cultural medium in the pots and one liter of nutrient solution containing 100ppm N, 20ppm P_2O_5, and 20ppm K_2O were applied to each pot every 3 to 5 days during the trial.

The minimum night temperature of the PH was set at 5 ℃ by heating, and the maximum temperature was controlled below 35 ℃ by opening the side-windows during the trial.

The trunk 15 cm above the graft union was strangulated with wire of 1.6 mm in diameter on 30 April, 20 May and 20 June in 1990, respectively. The strangulated trunk was dented at a 2/3 depth of the wire diameter. The strangulation duration was 2 and 4 months at each treatment. Twenty eight pots were used with 4 replications for each treatment including the control trees. The trunk of the control trees were marked at 15 cm above the graft union and the growth of trees at the UP and LP were measured separetely.

The depth of girdle just after the release of the wire ring, the monthly changes in girdle size, the trunk girth and the shoot length at a month interval were measured, respectively.

Floral shoots were classified into two groups of leafless and leafy inflorescences. All the trees were dug out and the root volumes were measured in late March in the following year as described above.

Results

The minimum temperature in the PH was 5.6 to 6.2 ℃ higher than that in the field condition from January to February 1991, and the maximum temperature in the PH was 4.3 to 10.7 ℃ higher from March 1990 to the ensuing February (Fig. 1).

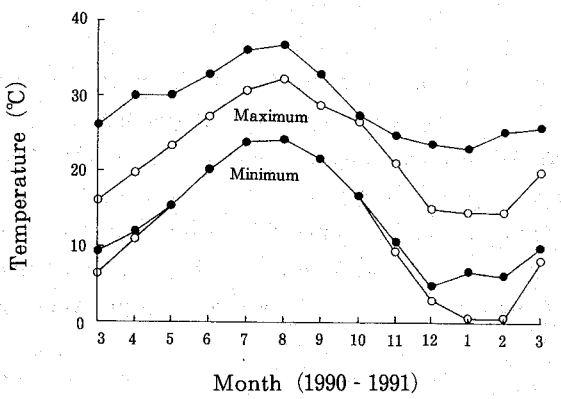

Fig. 1. Monthly maximum and minimum temperatures in the plastic house.
● Plastic house ○ Field

The shoot elongation at the UP of the trunk was about 1/3 in April and May treatments, and about 2/3 in June treatment as compared to that of the control trees. However, the shoot elongation at the LP was greater at the early treatments than that at the late treatments. There were no significant differences in the strangulation duration for April- and May-

treatments (Fig. 2).

The rates of shoot growth at the UP to that at the LP at the releasing time of wire ring were 1.0 to 1.4 times for April-June, May-July and June-October treatments, respectively, while that was 0.5 times for April-August and May-September and 2.0 times for June-August treatment (Fig. 2).

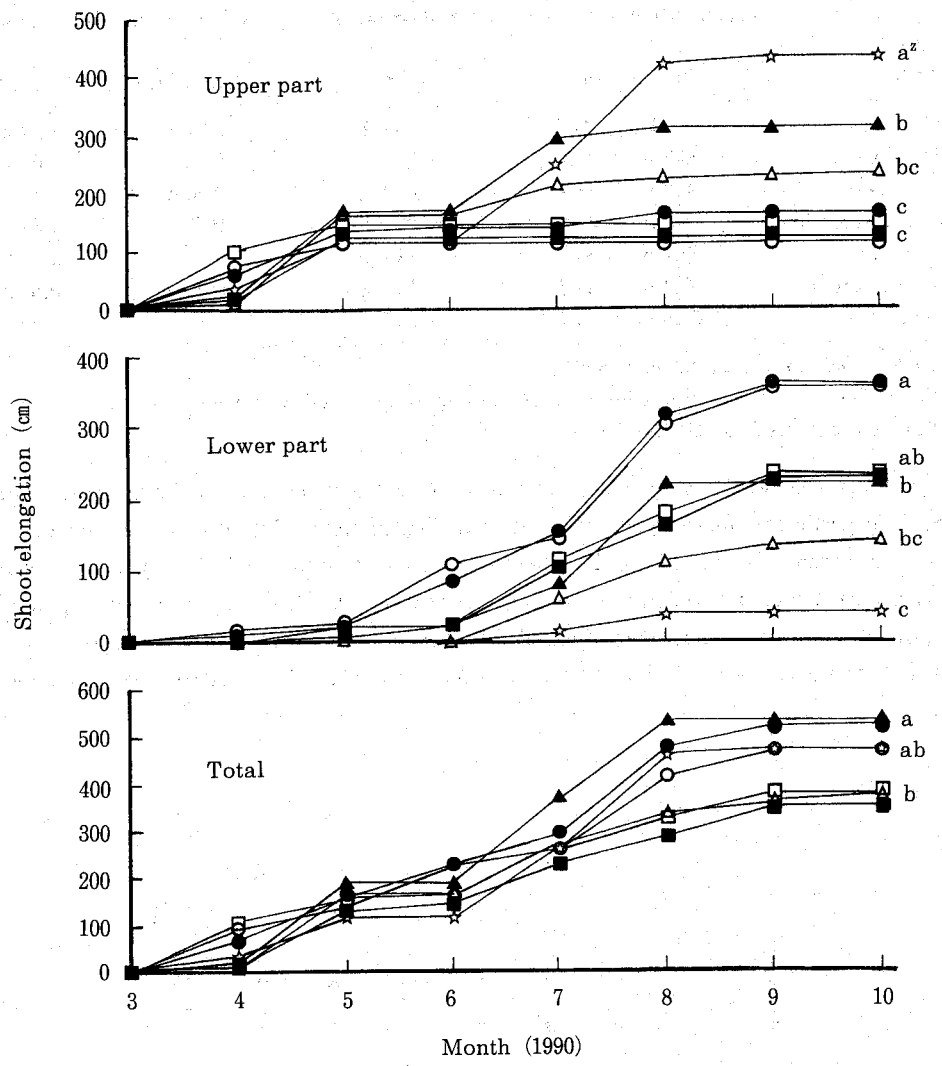

Fig. 2. Seasonal changes in shoot growth at the upper and lower parts as influenced by trunk strangulation.

[z]Different letters in the same figure indicate significance at 5 % level by Duncan's multiple range test.

Strangulation period

○ Apr. - June ● Apr. - Aug. □ May - July
■ May - Sep. △ June - Aug. ▲ June - Oct
☆ Control

The enlargement rate of trunk girth from mid-April to mid-January in the following year was higher at the control and June-October treatment than that at the other treatments (Table 1).

Table 1. Effect of trunk strangulation on trunk growth and girdle size

Strangulation period 1990	Trunk circumfer. (mm) 20 Jan. 1991	Enlargement[z] (%)	Girdle circ. /Trunk circ. Released day	Girdle circ. /Trunk circ. 20 Jan. 1991
April – June	46.6 b[y] (34.5)[x]	35.1 b	0.91 a	1.19 a
April – August	50.3 b (37.2)	35.2 b	0.75 c	1.05 ab
May – July	50.0 b (35.1)	42.5 b	0.86 b	1.12 a
May – September	46.6 b (36.2)	28.7 b	0.76 c	0.88 cd
June – August	52.4 b (36.7)	42.8 b	0.76 c	0.93 bcd
June – October	53.4 b (36.6)	45.9 ab	0.66 d	0.81 d
Control	60.8 a (36.7)	65.7 a	—	—

[z] From 20 April 1990 to 20 January 1991.
[y] Different letters within columns indicate significance at 5% level by Duncan's multiple range test.
[x] Trunk circumference on 20 April 1990.

The girdle in the bark became deeper as the treatment delayed and as the duration was prolonged. The girdle at June-August treatment was healed more slowly as compared to that at April-August treatment (Fig. 3). Most part of the wire ring except for the wire knot was covered with bark tissue in the fall at June-October treatment. Therefore, the covering bark was ripped out when the wire ring was released. The healing degree of girdle by mid-January was higher at both the earliest and shortest treatments than that at the other treatments (Table 1 and Fig. 3).

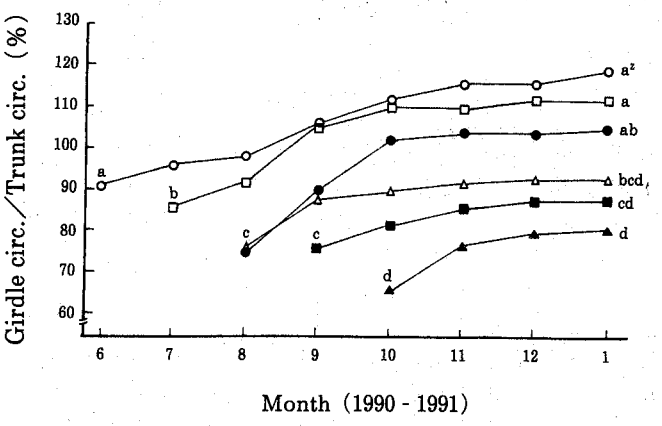

Fig. 3. Seasonal changes in girdle size as influenced by trunk strangulation.
[z]The same as Fig. 2.
Strangulation period
○ Apr. - June ● Apr. - Aug. □ May - July
■ May - Sep. △ June - Aug. ▲ June - Oct.

The number of nodes in mid-November was 150 to 230 per tree, and the node proportion of the UP to LP for April- and May-treatments were 0.4 to 0.6, while that was 1.7 at June treatment and 5.2 at the control (Table 2).

Table 2. Effect of trunk strangulation on node number and defoliation rate at the upper and lower parts from the strangulation position[z]

Strangulation period 1990	Number of nodes			Number of leaves			Defoliation rate (%)		
	Upper[y]	Lower[x]	Total	Upper[y]	Lower[x]	Total	Upper[y]	Lower[x]	Total
April – June	56.0 c[w]	145.0 ab	201.0 ab	40.7 b	141.3 a	182.0 a	26.9 b	2.5 a	9.4 de
April – August	73.3 c	156.3 a	229.7 a	12.3 b	152.0 a	164.3 ab	84.4 a	2.7 a	28.6 bcd
May – July	59.3 c	89.7 b	149.0 b	38.3 b	88.7 abc	127.0 abc	32.3 b	1.0 ab	15.8 cde
May – September	64.3 c	101.3 ab	165.7 ab	12.7 b	101.3 ab	114.0 bc	85.1 a	0.0 b	32.9 bc
June – August	96.7 bc	57.7 cd	154.3 b	13.0 b	57.3 bc	70.3 c	84.9 a	0.5 ab	53.3 a
June – October	134.0 ab	78.3 cd	212.3 ab	47.3 b	77.0 bc	124.3 abc	61.2 a	2.0 ab	39.5 ab
Control	157.7 a	30.3 d	188.0 ab	154.0 a	30.3 c	184.3 a	2.0 c	0.0 b	2.0 e

[z] Investigated on 12 November 1990.
[y,x,w] The same as Table 1.

As shown in Table 2, the rate of defoliation by mid-November was extremely high at the UP especially for 4 month treatments except for June-October treatment. Moreover, the number of leaves dropped at the UP was the highest at June treatment.

The root volume in early March 1991 was 2.5 to 6.2 times that in late March 1990. Root growth was the highest at both the control and April-June treatment, while the June-August treatment was the lowest. Thus, the root development was suppressed as the strangulation duration was prolonged except for June treatment (Table 3).

Table 3. Effect of trunk strangulation on root growth

Strangulation period	Root volume[z] (ml)	Rate of increase[y] (%)
April – June	476.7 b[x]	615.8 a (101.6)[w]
April – August	416.7 b	442.4 ab (73.0)
May – July	426.7 b	452.1 ab (74.6)
May – September	286.7 cd	326.4 bc (53.8)
June – August	236.7 d	251.4 c (41.5)
June – October	376.7 bc	364.3 bc (60.1)
Control	606.7 a	606.3 a (100.0)

[z] Investigated on 28 March 1991.
[y] From 20 March 1990 to 28 March 1991.
[x] The same as Table 1.
[w] Values within parenthesis indicate the percentage of the control.

The number of inflorescences and flower buds at the UP were the greatest in the control trees; however, there were no significant differences among the treatments (Table 4). Meanwhile, the numbers of inflorescences and flower buds were larger at the LP when the strangulation was early. In treated trees most of the flowers were leafless at the UP, but there were many leafy flowers at the LP (Table 4). However, the proportion of leafless to leafy flowers were almost equal at both UP and LP in the control trees. There was no significant difference in the number of leafless inflorescences among the treatments, nonetheless, the number of leafy inflorescences was higher at the UP in the control trees than that in the treated trees (Table 4).

Table 4. Effect of trunk strangulation on the number of inflorescences and flower buds at the upper and lower parts from the strangulation position[z]

Strangulation period 1990	Number of inflorescences							Number of flower		
	Upper[y]			Lower[x]			Total	Upper[y]	Lower[x]	Total
	Leafless	Leafy	Total	Leafless	Leafy	Total				
April – June	33.7	0.0 b[w]	33.7 b	39.7 ab	28.6	68.3	102.0 a	255.3 b	481.7 a	737.0 a
April – August	28.3	0.0 b	28.3 b	49.0 a	8.0	57.0	85.3 ab	173.7 b	366.0 ab	539.7 abc
May – July	32.0	0.0 b	32.0 b	13.0 ab	15.0	28.0	60.0 ab	177.0 b	195.3 ab	372.3 b
May – September	29.0	1.3 b	30.3 b	13.0 ab	24.6	37.6	67.9 ab	175.7 b	252.0 ab	427.7 abc
June – August	35.0	0.0 b	35.0 b	6.0 b	4.3	10.3	45.3 b	220.3 b	69.0 b	289.3 c
June – October	46.7	4.0 b	50.7 b	7.0 ab	12.0	19.0	69.7 ab	338.3 b	133.0 ab	471.3 abc
Control	52.7	36.4 a	89.1 a	11.7 ab	8.0	19.7	108.8 a	589.6 a	117.0 ab	706.6 ab

[z] Investigated on 10 February 1991.
[y,x,w] The same as Table 1.

Discussion

It was relatively easy to strangulate the trunks of one-year-old ' Tosa Buntan ' trees at which the bark tissues did not harden fully yet.

The force of strangulation that the wire ring was dented at about 1 mm depth from the bark surface seems to affect markedly tree growth at the UP as compared with strapping at the same season[4]. In the strapping treatment, the number of leaves was slightly greater at the UP than that at the LP during a half year[4]. In this trial, extreme defoliations were observed and only a few leaves remained at the UP of the trees. This may be due to the depression of the vascular bundle inside the bark at which girdle was not healed. The rapid leaf fall at June-October treatment may be due to cutting the new bark tissue which covered the wire ring, and low healing after October. Slow healing of girdles after releasing the wire ring at June-August treatment compared to that at April-August treatment may have been due to the high proportion of shoot growth at the UP to that at the LP at June-August treatment as compared to the low proportion at April-August treatment. Thus, a severe defoliation at the treatments were due to weakening of tree vigor.

The following treatments could prevent weakening of tree vigor by trunk strangulation.

That is, a light strangulation to the vigorous trees in mid-season when the trees grow rapidly, not releasing the wire ring, and treating the girdle with healing materials for wound[5-7] to enhance rapid development of callus.

The time of root growth in citrus generally delayed more than that of the shoot growth in the growing season[8, 9] Accordingly, the root development of the experimental trees could begin actively from May to June. The degree of root development in the strangulated trees were lower than that in the control trees, suggesting that strangulation in April-June disturbed translocation of photosynthates from the leaves to the roots.

Inoue *et al.*[10] reported that the root growth was ceased by ringing in mid-June within several days. Moreover, ringing in early September, after the growth of summer shoot was stopped, not only depressed root growth, but also prevented the initiation of new roots in Satsuma mandarin. Our result showed that May- and June-strangulation for 2 and 4 months duration depressed root growth and inhibited the initiation of fall flush.

Few generative shoots sprouted on previously vigorous upright shoots in 'Tosa Buntan' grown in a PH, whereas a lot of generative shoots sprouted in branches strangulated in the previous year[4,11,12]. In this trial, many flower buds appeared on shoots sprouted at the UP in the strangulated trees; however, the number of flower buds were greater in the control than that in the treated trees. Sand cultivation in Wagner's pots easily dries and exposes the root zone to water stress which promotes to induce flowering[13]. These conditions certainly occurs more easily in the control trees whose root volumes were 20 to 60 % greater than those of the strangulated trees.

The effect of trunk strangulation on flowering was not clear as the results from this trial, but the tree size and tree form as well as the root growth were markedly inhibited by the trunk strangulation.

References

1) HODGSON, R. W. Horticultural varieties of citrus. In " The Citrus Industry " ed. by REUTHER, W., WEBBER H. J. and BATCHELAR, L. D. Vol. I. p. 533-539, Div. of Agric. Sci., Univ. of California, Berkeley (1967).

2) NAKAJIMA, Y., SUSANTO, S. and HASEGAWA, K.: Effect of winter-chilling treatment on flower bud induction in young pomelo trees. *J. Japan. Soc. Hort. Sci.*, **61** (2), 287-293 (1992).

3) NAKAJIMA, Y., SUSANTO, S. and HASEGAWA, K.: Influence of water stress in autumn on flower induction and fruiting in young pomelo (*C. grandis* (L.) Osbeck) trees. *J. Japan. Hort. Sci.*, **61** (4), in press (1992).

4) NAKAJIMA, Y., SUGINO, H. and SUSANTO, S.: Effect of stem strangulating with thin wire on flowering and fruiting in young pummelo (*Citrus grandis* (L.) Osbeck) trees grown under structure. *Studia Citrologica*, **15**, 1-6 (1989). (In Japanese with English summary).

5) LAVEE, S., HASKAL, A. and Ben Tal, Y.: Girdling olive trees, a partial solution to biennial bearing. I. Methods, timing and direct tree response. *J. Hort. Sci.*, **58** (2), 209-218 (1983).

6) SAMISH, R. M., TAMIR, P. and SPIEGEL, P.: The effect of various dressings on the healing of pruning wounds in apple trees. *Proc. Amer. Soc. Hort. Sci.*, **70**, 5-9 (1956).

7) SHEAR, G. M.: Lanolin as a wound dressing for trees. *Proc. Amer. Soc. Hort. Sci.*, **34**, 286-288 (1936).

8) BEVINGTON, K. B. and CASTLE, W. S.: Annual root growth pattern of young citrus trees in relation to shoot growth, soil temperature and soil water content. *J. Amer. Soc. Hort. Sci.*, **110**, 840-845 (1985).
9) TAKAHASHI, Y.: Morphology and ecology of citrus. In " The Citrus ", 5th ed., p. 70-102, Yokendo Co. Japan (1972). (In Japanese).
10) INOUE, H., IKOMA, Y. and KATAOKA, I.: Effects of ringing and temperature on flower bud differentiation of Satsuma mandarin. *J. Japan. Soc. Hort. Sci.*, **60** (2), 275-284 (1991). (In Japanese with English summary).
11) NAKAJIMA, Y., MIZUTA, A., SUGINO H. and SUSANTO, S.: Effect of branch strangulating with thin wire on fruit development in pummelo (*Citrus grandis* (L.) Osbeck) trees grown under structure. *Studia Citrologica*, **15**, 7-12 (1989). (In Japanese with English summary).
12) NAKAJIMA, Y. and YAMANISHI, O. K.: Effect of main branch strangulating in late growing season on flowering and fruiting of young 'Tosa Buntan' pummelo (*Citrus grandis* (L.) Osbeck) trees grown in plastic house. Abstr. Japan. Soc. Hort. Sci. Summer Meet. p. 27 (1991). (In Japanese).
13) SOUTHWICK, S. M. and DAVENPORT, T. L.: Characterization of water stress and low temperature effects on flower induction in citrus. *Plant Physiol.*, **81**, 26-29 (1986).

ハウスブンタン幼樹の生育に及ぼす樹幹括約の影響

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要 約

トサブンタン幼樹をワグネルポットで砂耕し,1990年4月から6月まで1か月毎に細い針金で接木部位の上15cmの樹幹を括約した。各処理はそれぞれ2か月と4か月間継続した。新梢伸長は括約部上位で激しく抑制されたが,括約部下位では逆に促進された。一方,6月4か月処理では,針金リングが樹皮に完全に巻き込まれ,括約部上位から夏枝の伸長が盛んになった。地下部の成長は5－6月処理で僅かに抑制された。針金リングを除去した直後の小溝は括約時期が遅い程深く,その後の小溝の回復も括約時期が遅い程遅くなった。括約部上位では秋季に激しく落葉したが,特に4か月処理樹で高い落葉率となった。括約部上位の花房及び花らいの発生数は処理間に有意差を示さなかった。

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